K.S.INSTITUTE OF TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

COURSE FILE

NAME OF THE STAFF	:BEENA K
SUBJECT CODE/NAME	:17CS81/INTERNET OF THINGS
SEMESTER/YEAR	: VIII Sem/IV Year B Section
ACADEMIC YEAR	: 2020-21
BRANCH	:COMPUTER SCIENCE & ENGINEERING

FACULTY IN-CHARGE

HOD

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

K.S. INSTITUTE OF TECHNOLOGY

KSIT

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

Vision of the Institute

To impart quality technical education with ethical values, employable skills and research to achieve excellence

Mission of the Institute

- To attract and retain highly qualified, experienced & committed faculty.
- To create relevant infrastructure.
- Network with industry & premier institutions to encourage emergence of new ideas by providing research & development facilities to strive for academic excellence.
- To inculcate the professional & ethical values among young students with employable skills & knowledge acquired to transform the society.

Vision of the Department

To create competent professionals in Computer Science and Engineering with adequate skills to drive the IT industry

Mission of the Department

- Impart sound technical knowledge and quest for continuous learning.
- To equip students to furnish Computer Applications for the society through experiential learning and research with professional ethics.
- Encourage team work through inter-disciplinary project and evolve as leaders with social concerns.

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K.S. INSTITUTE OF TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

Program Educational Objectives

PEO1: Excel in professional career by acquiring knowledge in cutting edge technology and contribute to the society as an excellent employee or as an entrepreneur in the field of Computer Science & Engineering.

PEO2: Continuously enhance their knowledge on par with the development in IT industry and pursue higher studies in Computer Science & Engineering.

PEO3: Exhibit professionalism, cultural awareness, team work, ethics, and effective communication skills with their knowledge in solving social and environmental problems by applying computer technology.

Program Specific Outcomes (PSO)

PSO1: Ability to understand, analyze problems and implement solutions in programming languages, as well to apply concepts in core areas of Computer Science in association with professional bodies and clubs.

PSO2: Ability to use computational skills and apply software knowledge to develop effective solutions and data to address real world challenges.

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Program Outcomes

PO1: **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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#14, Raghuvanahalli, Kanakapura Main Road, Bengaluru-5600109

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Course: Internet of Things Technology			
Type: Core	Course Code:17CS81 Academic Year:2020-2021		
Name:Beena K	Sem &Sec: 8 "B"		
No of Hours per week			
Theory (Lecture Class)	Practical/Field Work/Allied Activities	Total/Week	Total teaching hours
4	0	4	50
Marks			
Internal Assessment	Examination	Total	Credits
40	60	100	4

Aim/Objective of the Course:

1. Assess the genesis and impact of IoT applications, architectures in real world.
2. Illustrate diverse methods of deploying smart objects and connect them to network.
3. Compare different Application protocols for IoT.
4. Infer the role of Data Analytics and Security in IoT.
5. Identify sensor technologies for sensing real world entities and understand the role of IoT in various domains of Industry.

Course Learning Outcomes:

After completing the course, the students will be able to,

CO#	Course Outcomes	K Level
17CS81.1	**Illustrate** the impact and challenges posed by IoT networks leading to new architectural models.	Applying (K3)
17CS81.2	**Identify** the deployment of smart objects and the technologies required to connect them to the network.	Applying (K3)
17CS81.3	**Choose** the role of IoT protocols for efficient network communication.	Applying (K3)
17CS81.4	**Identify** different sensor technologies for sensing real world entities and identify the applications of IoT in Industry.	Applying (K3)
17CS81.5	**Develop** the need for Data Analytics and Security in IoT.	Applying (K3)

Syllabus Content:	
Module-1: **What is IoT**, Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack? LO: At the end of this session the student will be able to, 1. Illustrate the genesis of IoT and Digitization of IoT 2. Outline the IoT challenges and Network Architecture 3. Illustrate the Core IoT Functional Stack	CO1 10hrs PO1-2 PO2-2 PO3-3 PO4-2 PO6-2 PO7-3 PO10-1 PO11-1 PO12-3 PSO1-3 PSO2-3
Module-2: **Smart Objects:** The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies. LO: At the end of this session the student will be able to, 1. Identify the Sensors, Actuators and Smart Objects. 2. Make use of Smart Networks in connecting smart objects. 3. Utilize the Communications criteria for IoT Access Technologies	CO2 10hrs PO1-2 PO2-3 PO3-3 PO4-2 PO6-3 PO7-2 PO10-1 PO11-2 PO12-2 PSO1-3 PSO2-3
Module 3: **IP as the IoT Network Layer**, The Business Case for IP, The need for Optimization, Optimizing IP for IoT, Profiles and Compliances, Application Protocols for IoT, The Transport Layer, IoT Application Transport Methods. LO: At the end of this session the student will be able to, 1. Identify the business case for IP 2. Identify the need for Optimizing IP for IoT 3. Make use of the Transport Layer, Application Transport Methods	CO3 10hrs PO1-3 PO2-3 PO3-3 PO4-3 PO6-1 PO7-1 PO10-1 PO12-3 PSO1-3 PSO2-3

Module 4: **Data and Analytics for IoT**, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics, Securing IoT, A Brief History of OT Security, Common Challenges in OT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures: OCTAVE and FAIR, The Phased Application of Security in an Operational Environment LO: At the end of this session the student will be able to, 1. Select different techniques for Data Analytics for IoT 2. Utilizing IoT application in Machine Learning, Big Data Analytics 3. Model the Formal Risk Analysis Structures such as OCTAVE and FAIR	CO4 10hrs PO1-3 PO2-3 PO3-3 PO4-3 PO5-3 PO6-3 PO7-2 PO9-3 PO10-1 PO11-2 PO12-2 PSO1-3 PSO2-3
Module 5: **IoT Physical Devices and Endpoints** - Arduino UNO: Introduction to Arduino, Arduino UNO, Installing the Software, Fundamentals of Arduino Programming. IoT Physical Devices and Endpoints - RaspberryPi: Introduction to RaspberryPi, About the RaspberryPi Board: Hardware Layout, Operating Systems on RaspberryPi, Configuring RaspberryPi, Programming RaspberryPi with Python, Wireless Temperature Monitoring System Using Pi, DS18B20 Temperature Sensor, Connecting Raspberry Pi via SSH, Accessing Temperature from DS18B20 sensors, Remote access to RaspberryPi, Smart and Connected Cities, An IoT Strategy for Smarter Cities, Smart City IoT Architecture, Smart City Security Architecture, Smart City Use-Case Examples. LO: At the end of this session the student will be able to, 1. Develop an application with Arduino Programming using RaspberryPi 2. Develop RaspberryPi programming with Python 3. Model a strategies for Smarter Cities with Use-Case Example.	CO5 10hrs PO1-3 PO2-3 PO3-3 PO4-3 PO5-3 PO6-1 PO7-1 PO10-1 PO11-2 PO12-2 PSO1-3 PSO2-3

Text Books: -

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743)

2. Srinivasa K G, "Internet of Things",CENGAGE Leaning India, 2017

Reference Books:

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1stEdition, VPT, 2014. (ISBN: 978-8173719547)

2. Raj Kamal, "Internet of Things: Architecture and Design Principles", 1st Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224)
Useful Websites: 1. www.cisco.com/c/en_in/solutions/internet-of-things/overview.html 2. www.ibm.com/in-en/internet-of-things
Useful Journals: • Internet of Things - Journal – Elsevier • IEEE Xplore: IEEE Internet of Things Journal • IoT Research Projects and Journals – Postscapes
Teaching and Learning Methods: 1. Lecture class: 50 hrs. 2. Self-study: Nil. 3. Field visits/Group Discussions/Seminars: Nil. 4. Practical classes: nil
Assessment: Type of test/examination: Written examination **Continuous Internal Evaluation(CIE)** : 40 marks (Average of best two of total three tests will be considered) **Semester End Exam(SEE)** : 60 marks (students have to answer all main questions) Test duration: 1 :30 hr Examination duration: 3 hrs

CO to PO Mapping

PO1: Science and engineering Knowledge **PO2:** Problem Analysis **PO3:** Design & Development **PO4:**Investigations of Complex Problems **PO5:** Modern Tool Usage **PO6:** Engineer & Society	**PO7:**Environment and Society **PO8:**Ethics **PO9:**Individual & Team Work **PO10:** Communication **PO11:**Project Management & Finance **PO12:**Life long Learning

PSO1: Ability to understand, analyze problems and implement solutions in programming languages, as well to apply concepts in core areas of Computer Science in association with professional bodies and clubs.

PSO2: Ability to use computational skills and apply software knowledge to develop effective solutions and data to address real world challenges.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
17CS81	K3	K3	K5	K5	K6	K4	K2	K3	K3	K2	K3	K3
17CS81.1	2	2	3	2	-	2	3	-	-	1	1	3
17CS81.2	2	3	3	2	-	3	2	-	-	1	2	2
17CS81.3	3	3	3	3	-	1	1	-	-	1	-	3
17CS81.4	3	3	3	3	3	3	2	-	3	1	2	2
17CS81.5	3	3	3	3	3	1	1	-	-	1	2	2
17CS81	2.60	2.80	3.00	2.60	3	2.00	1.80	-	3	1.00	1.75	2.40

CO	PSO1	PSO2
18CS81		
17CS81.1	3	3
17CS81.2	3	3
17CS81.3	3	3
17CS81.4	3	3
17CS81.5	3	3
17CS81	3	3

3	Substantial (High) Correlation
2	Moderate (Medium) Correlation
1	Slight (Low) Correlation
-	No correlation.

Course Incharge

Module Coordinator

HOD

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K. S INSTITUTE OF TECHNOLOGY, BENGALURU-560109

TENTATIVE CALENDAR OF EVENTS: EVEN SEMESTER (2020-2021)

SESSION: **APR 2021 - AUG2021**

Week No.	Month	Day						Days	Activities
		Mon	Tue	Wed	Thu	Fri	Sat		
1	APR	19 *	20	21	22	23	24	6	19*-Commencement of Higher Semester 24 Wednersday Time Table
2	APR/MAY	26	27	28	29	30	1H	5	1 May Day
3	MAY	3	4	5	6	7	8	6	8 Monday Time Table
4	MAY	10	11	12	13H	14H	15DH	3	13 Idul Fitr 14Basava Jayanti
5	MAY	17	18	19	20	21	22TA	6	22 Tuesday Time Table
6	MAY	24 T1	25T1	26T1	27	28	29DH	5	
7	MAY/JUN	31	1	2	3	4	5ASD	6	5 Wednersday Tme Table
8	JUN	7	8	9	10	11	12DH	5	
9	JUN	14	15	16	17	18	19	6	19 Monday Time Table
10	JUN	21	22	23	24	25TA	26DH	5	
11	JUN/JUL	28 T2	29T2	30T2	1	2	3	6	3 Thursday time Table
12	JUL	5	6	7	8	9ASD	10DH	5	
13	JUL	12	13	14	15	16	17	6	17 Tuesday Time Table
14	JUL	19	20	21H	22	23	24DH	4	21 Bakrid / Eid al Adha
15	JUL	26	27	28TA	29 T3	30T3	31T3	6	
16	AUG	2LT	3LT	4LT	5LT	6	7*ASD	6	7 Wednersday Tme Table 7* Last working day
Total No of Working Days : 86									

Total Number of working days (Excluding holidays and Tests)=73

H	Holiday
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	15
Tuesday	15
Wednesday	15
Thursday	14
Friday	14
Total	**73**

L Gun 5/3/21

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109

K. S INSTITUTE OF TECHNOLOGY, BENGALURU-560109

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING -CALENDAR OF EVENTS: EVEN SEMESTER (2020-2021)

SESSION: APR 2021 - AUG2021

Week No.	Month	Day: Mon	Tue	Wed	Thu	Fri	Sat	Days	Activities	Department Activities
1	APR	19 *	20	21	22	23	24	6	19*-Commencement of Higher Semester 24 Wednesday Time Table	
2	APR/MAY	26	27	28	29	30	[redacted]	5	1 May Day	
3	MAY	3	4	5	6	7	8	6	8 Monday Time Table	
4	MAY	10	11	12	[redacted]		15DH	3	13 Idul Fitr 14 Basava Jayanti	Internship Opportunities: 12-5-21
5	MAY	17	18	19	20	21	22TA	6	22 Tuesday Time Table	Internship talk on skill Development.18-05-2021
6	MAY	24 T1	25T1	26T1	27	28	29DH	5		Project II phase Review 1 presentation:21-5-21,22-5-21,Internship awareness program:28-5-21
7	MAY/JUN	31	1	2	3	4	5ASD	6	5 Wednesday Tme Table	"Artificial Intelligence & Machine Learning": 3-6-21.
8	JUN	7	8	9	10	11	12DH	5		
9	JUN	14	15	16	17	18	19	6	19 Monday Time Table	
10	JUN	21	22	23	24	25TA	26DH	5		Project II phase Review 2 presentation:21-6-21,24-6-21,25-6-21,26-6-21
11	JUN/JUL	28 T2	29T2	30T2	1	2	3	6	3 Thursday time Table	
12	JUL	5	6	7	8	9ASD	10DH	5		
13	JUL	12	13	14	15	16	17	6	17 Tuesday Time Table	Project Phase II Review 3 Presentation:16-7-21, 17-7-21, Webinar on Design Innovation for Successful Career in the field of Aviation :17-7-21
14	JUL	19 * T3(VIII)	20 * T3(VIII)	[redacted]	22	23	24DH	4	20 *VIII Sem Last working day 21 Bakrid / Eid al Adha	
15	JUL	26	27	28TA	29	30	31	6		
16	AUG	2	3	4	5 T3	6 T3	7*T3	6	7 Wednersday Tme Table 7* IV &VI Last working day	

Total No of Working Days : 86

Total Number of working days (Excluding holidays and Tests)=73

H	Holiday
T1,T2, T3	Tests 1,2, 3
ASD	Attendance & Sessional Display
DH	Declared Holiday
LT	Lab Test
TA	Test attendance

Monday	15
Tuesday	15
Wednesday	15
Thursday	14
Friday	14
Total	73

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Bengaluru -560 109

KSIT BANGLORE

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

STUDENTS DETAILS

Year/Semester/Section: IV/VIII/B

SL. No	UI Number	Students name	Hostel/ day scholar	Total Arrears	Gender	Mail ID	Student Phone Number	Parents Phone Number
1.	1KS17CS052	PARTH.P.SHAH	Day Scholar	Nil	Male	p.parthshah99@gmail.com	8553418198	9341268948
2.	1KS17CS053	PAVANI.M	Day Scholar	Nil	Female	pavani.22m@gmail.com	9448207322	9980798025
3.	1KS17CS055	POOJA.R	Day Scholar	Nil	Female	poojaram.12619@gmail.com	7829499750	9902099820
4.	1KS17CS056	PRASHANTH.K	Day Scholar	2	Male	prashanthreddy1999.pr@gmail.com	7760761493	9686058849
5.	1KS17CS057	PRAVEEN	Day Scholar	2	Male	praveend2622@gmail.com	9110853123	9972924756
6.	1KS17CS058	PRAVEEN.A	Day Scholar	1	Male	praveen99may@gmail.com	9113687241	9448506214
7.	1KS17CS059	PRAVEEN.S	Day Scholar	1	Male	praveens31493@gmail.com	9113647708	7829768098
8.	1KS17CS060	RAJASHREE SHIVAKUMAR	Day Scholar	Nil	Female	rajashreesgowda1001@gmail.com	9743309583	9035683965
9.	1KS17CS061	RAKSHITH.R	Day Scholar	Nil	Male	raokarthikrao@gmail.com	9110849552	9448677789
10.	1KS17CS062	ROHITH.K	Day Scholar	3	Male	rohithkumarm4a1@gmail.com	7337744390	9108115082
11.	1KS17CS063	ROHITH.R	Day Scholar	5	Male	rohi1999@gmail.com	7760687628	9945385425
12.	1KS17CS064	ROOPASHREE.N	Day Scholar	Nil	Female	nroopashree16@gmail.com	9945347445	9632826605
13.	1KS17CS065	ROSHINI.R	Day Scholar	Nil	Female	roshinirk55@gmail.com	9611621675	9632703875
14.	1KS17CS066	RUCHITHA.G.K	Day Scholar	Nil	Female	ruchithagk99@gmail.com	9740527763	9448509456
15.	1KS17CS067	S.MONIKA	Day Scholar	Nil	Female	s.monikasmile311@gmail.com	7996060625	7353612345

SL. No	UI Number	Students name	Hostel/ day scholar	Total Arrears	Gender	Mail ID	Student Phone Number	Parents Phone Number
16.	1KS17CS069	SAI KUMAR.L.S	Day Scholar	Nil	Male	saikumar9742@gmail.com	8792964779	9916543655
17.	1KS17CS070	SAI SNEHA.S.V	Day Scholar	Nil	Female	saisneha61@gmail.com	9448337333	9448010613
18.	1KS17CS071	SAKSHI KUMARI	Day Scholar	Nil	Female	getmeonsakshi.rajput@gmail.com	9620783685	9742878709
19.	1KS17CS072	SANDESH NAIKAL	Day Scholar	Nil	Male	sandesh.naikal3@gmail.com	7204696710	9535400056
20.	1KS17CS074	SHARANYA.H	Day Scholar	6	Female	sharanya.harish@gmail.com	7259219937	9945310195
21.	1KS17CS075	SHASHANK SHET.K	Day Scholar	Nil	Male	shashankshetk@gmail.com	9986428818	9886562436
22.	1KS17CS076	SHREYAS.R	Day Scholar	1	Male	shreyasramesh08@gmail.com	9535114220	9742426067
23.	1KS17CS077	SHRI HARSHA KULKARNI	Day Scholar	2	Male	harshak1720@gmail.com	7899077361	9845550843
24.	1KS17CS078	SINDHU.H.S	Day Scholar	Nil	Female	sindhuhs444@gmail.com	9113557643	9108792012
25.	1KS17CS079	SINDHU.M	Day Scholar	Nil	Female	sindhum777@gmail.com	7899047177	9886535002
26.	1KS17CS081	SPOORTHI.R	Day Scholar	Nil	Female	spoorthiranganath3@gmail.com	9113624580	9845312626
27.	1KS17CS082	SPOORTHI.V	Day Scholar	Nil	Female	spoorthi.v8@gmail.com	9632781226	7760991099
28.	1KS17CS083	SRIKALA.K.M	Day Scholar	Nil	Female	srikalakmindia1999@gmail.com	7899506506	8105690199
29.	1KS17CS084	SRUSHTI.A	Day Scholar	Nil	Female	srushti.arun8@gmail.com	8660161983	9448417597
30.	1KS17CS085	SUJANA.G.N	Day Scholar	1	Female	sujana782@gmail.com	8217220382	9945002416
31.	1KS17CS086	SUPREETHA.R.KASHYAP	Day Scholar	Nil	Female	supreetha.kashyap99@gmail.com	9449265451	9341226507
32.	1KS17CS087	SUPRIYA.K	Day Scholar	Nil	Female	supriya19981126@gmail.com	9901755278	7411635640
33.	1KS17CS088	SURAKSHITHA.M	Day Scholar	Nil	Female	msurakshitha34@gmail.com	8310500255	9448757760
34.	1KS17CS089	SWATI PAI	Day Scholar	Nil	Female	swatipai2406@gmail.com	8217606386	9480345950

SL. No	UI Number	Students name	Hostel/ day scholar	Total Arrears	Gender	Mail ID	Student Phone Number	Parents Phone Number
35.	1KS17CS090	T.K.DHANUSHREE	Day Scholar	Nil	Female	tkdhanushree@gmail.com	9902426515	9731706618
36.	1KS17CS091	TALUPULA SIVA SAI CHAITHANYA	Day Scholar	5	Male	chaithanya240315@gmail.com	7760419858	9885352528
37.	1KS17CS092	TEJAS.C.S	Day Scholar	Nil	Male	tejascs111@gmail.com	8143640322	9845148684
38.	1KS17CS093	THARUN.K	Day Scholar	Nil	Male	tharunk6476@gmail.com	9880475198	9900104427
39.	1KS17CS094	VARSHINI.N.PRAKASH	Day Scholar	2	Female	varshini.nprakash@gmail.com	9110272001	9886893176
40.	1KS17CS095	VARSHITHA.S	Day Scholar	Nil	Female	varshithas.512@gmail.com	8792192928	9743785614
41.	1KS17CS096	VARUN ATTIGANAL VENKATESH	Day Scholar	1	Male	varunvenky99@gmail.com	8970370853	9945977180
42.	1KS17CS097	VARUN.R.REDDY	Day Scholar	3	Male	varun013.vr@gmail.com	7337758586	9164811611
43.	1KS17CS098	VIKRAM SHIVAPPA CHATTARAKI	Day Scholar	1	Male	vikramsc22@gmail.com	7619305413	9448827366
44.	1KS17CS099	VINAY RAMARAO BIRADAR	Day Scholar	2	Male	vbiradar9999@gmail.com	7892998800	9448917024
45.	1KS17CS100	VISHAL.M.S	Day Scholar	Nil	Male	vishms1999@gmail.com	8971711619	9945258057
46.	1KS17CS101	VYBHAVI.J	Day Scholar	Nil	Female	vybhavipj@gmail.com	9591929024	9844046497
47.	1KS16CS110	VARNA.M	Day Scholar	1	Female	varnamunegowda@gmail.com	9743688213	9972379799
48.	1KS15CS128	SHARADHA.A	Day Scholar	3	Female	sharadashouri57@gmail.com	9916634599	7829770359
49.	1KS15CS125	ADARSH SHRESTHA	Day Scholar	9	Male	newa.adarsh.stha@gmail.com	9916196488	7406281259
50.	1KS17CS401	BHARATHI.R	Day Scholar	Nil	Female	bharathiraghavendra04@gmail.com	9591384307	9916196488

Signature of the class Coordinator

Signature of the HOD

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K.S. INSTITUTE OF TECHNOLOGY, BENGALURU-109

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

INDIVIDUAL ONLINE TIME TABLE FOR THE YEAR 2020-2021 (EVEN SEMESTER)

W.E.F: 19/04/2021

NAME OF THE FACULTY: Mrs. BEENA.K **DESIGNATION: ASST. PROF.**

PERIOD	1	2	11.00 AM-11.15 AM	3	4	1.15 PM-1.45 PM	5	6
TIME / DAY	9:00 AM-10:00 AM	10.00 AM-11.00 AM		11.15 AM-12.15 PM	12.15 PM-1.15 PM		1.45 PM-2.45 PM	2.45 PM-3.45 PM
MON			TEA BREAK	CNS&CL (17CS61 / 15CS61)		LUNCH BREAK	PROJECT WORK PHASE II (17CSP85/15CSP85)	
TUE	IOT (B) (17CS81/15CS81)	IOT (B) (17CS81/15CS81)					TECHNICAL SEMINAR (17CSS86/ 15CSS86)	
WED		IOT (B) (17CS81/15CS81)			IOT (B) (17CS81/15CS81)		INTERNSHIP (17CS84/15CS84)	
THUR					CNS&CL (17CS61 / 15CS61)			CNS&CL (17CS61 / 15CS61)
FRI	CNS&CL (17CS61 / 15CS61)						MAD LAB (18CSMP68) (B1,B2 &B3)	

TIME TABLE INCHARGE

HOD 17/4/21.

Head of the Department, Dept. of Computer Science & Engg. K.S. Institute of Technology Bengaluru -560 109

K.S. INSTITUTE OF TECHNOLOGY, BENGALURU-109

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

VIII SEMESTER ONLINE TIME TABLE FOR THE YEAR 2020-21 (EVEN SEMESTER)

W.E.F: 19-04-2021 | **CLASS TEACHER:Mrs.BEENA K**

SEC: 'B' | **CLASS ROOM: OB LH-306**

PERIOD	1	2		3	4		5	6
TIME / DAY	9:00 AM-10:00 AM	10.00 AM-11.00 AM	11.00 AM-11.15 AM	11.15 AM-12.15 PM	12.15 PM-1.15 PM	1.15 PM-1.45 PM	1.45 PM-2.45 PM	2.45 PM-3.45 PM
MON	BDA (17CS82/15CS82)	BDA (17CS82/15CS82)	TEA BREAK	SMS (17CS834/15CS834)	SMS (17CS834/15CS834)	LUNCH BREAK	PROJECT WORK PHASE II (G1,G2,G3,G4,G5,G6)(17CSP85/15CSP85)	
TUE	IOT (17CS81/15CS81)	IOT (17CS81/15CS81)		SMS (17CS834/15CS834)	BDA (17CS82/15CS82)		TECHNICAL SEMINAR (G1,G2,G3,G4,G5,G6) (17CSS86/ 15CSS86)	
WED	BDA (17CS82/15CS82)	IOT (17CS81/15CS81)		SMS (17CS834/15CS834)	IOT (17CS81/15CS81)		INTERNSHIP (G1,G2,G3,G4,G5,G6)(17CS84/15CS84)	

Subject Code	Subject Name		Faculty Name
17CS81/15CS81	INTERNET OF THINGS AND APPLICATIONS		Mrs. BEENA.K
17CS82/15CS82	BIG DATA ANALYTICS		Dr. RAM P RUSTAGI
17CS834/15CS834	SYSTEM MODELING AND SIMULATION		Mr. KUMAR. K
17CS84/15CS84	INTERNSHIP / PROFESSIONAL PRACTICE		Mr. PRASHANTH H.S (G4,G5,G6) & Mrs. BEENA .K (G1,G2,G3)
17CSP85/15CSP85	PROJECT WORK PHASE II	GROUP G1 HEAD:Dr. REKHA B VENKATAPUR GROUP G1 BATCHES : (2020_CSE_23,25,24,06,14)	GROUP G4 HEAD: Mr. K.VENKATA RAO GROUP G4 BATCHES: (2020_CSE_19,22,18,02,17)
		GROUP G2 HEAD: Dr. DEEPA S.R GROUP G2 BATCHES: (2020_CSE_11,20,09,27)	GROUP G5 HEAD: Mr. HARSHAVARDHAN J. R GROUP G5 BATCHES: (2020_CSE_10,26,04,07,21)
		GROUP G3 HEAD:Mrs. VANEETA . M GROUP G3 BATCHES: (2020_CSE_15,05,12,16)	GROUP G6 HEAD: Dr. DAYANANDA . R. B GROUP G6 BATCHES: (2020_CSE_13,08,01,03)
17CSS86/15CSS86	SEMINAR		Dr. DEEPA .S.R & Mr. KUSHAL KUMAR B.N(G1,G2,G3) Mrs. SOUGANDHIKAH N & Mr. KRISHNA GUDI(G4,G5,G6)

B.N 17/4/21 S.R 17/04/2021
TIME TABLE INCHARGE

17/4/21
HOD
Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

Kumar. K
PRINCIPAL
PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109.

INTERNET OF THINGS TECHNOLOGY
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017 - 2018)
SEMESTER – VIII

Subject Code	**17CS81**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Module – 1	**Teaching Hours**
What is IoT, Genesis of IoT, IoT and Digitization, IoT Impact, Convergence of IT and IoT, IoT Challenges, IoT Network Architecture and Design, Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack.	**10 Hours**
Module – 2	
Smart Objects: The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies.	**10 Hours**
Module – 3	
IP as the IoT Network Layer, The Business Case for IP, The need for Optimization, Optimizing IP for IoT, Profiles and Compliances, Application Protocols for IoT, The Transport Layer, IoT Application Transport Methods.	**10 Hours**
Module – 4	
Data and Analytics for IoT, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics, Securing IoT, A Brief History of OT Security, Common Challenges in OT Security, How IT and OT Security Practices and Systems Vary, Formal Risk Analysis Structures: OCTAVE and FAIR, The Phased Application of Security in an Operational Environment	**10 Hours**
Module – 5	
IoT Physical Devices and Endpoints - Arduino UNO: Introduction to Arduino, Arduino UNO, Installing the Software, Fundamentals of Arduino Programming. IoT Physical Devices and Endpoints - RaspberryPi: Introduction to RaspberryPi, About the RaspberryPi Board: Hardware Layout, Operating Systems on RaspberryPi, Configuring RaspberryPi, Programming RaspberryPi with Python, Wireless Temperature Monitoring System Using Pi, DS18B20 Temperature Sensor, Connecting Raspberry Pi via SSH, Accessing Temperature from DS18B20 sensors, Remote access to RaspberryPi, Smart and Connected Cities, An IoT Strategy for Smarter Cities, Smart City IoT Architecture, Smart City Security Architecture, Smart City Use-Case Examples.	**10 Hours**

Course Outcomes: After studying this course, students will be able to

- Interpret the impact and challenges posed by IoT networks leading to new architectural models.
- Compare and contrast the deployment of smart objects and the technologies to connect them to network.

K S INSTITUTE OF TECHNOLOGY BENGALURU
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

NAME OF THE STAFF : **BEENA K**
SUBJECT CODE/NAME : **17CS81/ INTERNET OF THINGS TECHNOLOGY**
SEMESTER/SEC/YEAR : **VIII / B/ IV**
ACADEMIC YEAR : **2020-2021**

Sl. No.	Topic to be covered	Mode of Delivery	Teaching Aid	No. of Periods	Cumulative No. of Periods	Proposed Date
MODULE 1						
1	What is IoT, Genesis of IoT, IoT and Digitization	L+D	Microsoft Teams	2	2	20/4/21
2	IoT Impact	L+ D	Microsoft Teams	1	3	21/4/21
3	Convergence of IT and IoT	L+ D	Microsoft Teams	1	4	21/4/21
4	IoT Impact	L+D	Microsoft Teams	1	5	24/4/21
5	IoT Challenges	L+D	Microsoft Teams	1	6	24/4/21
6	IoT Network Architecture and Design	L+D	Microsoft Teams	1	7	27/4/21
7	Drivers Behind New Network Architectures	L+D	Microsoft Teams	1	8	27/4/21
8	Comparing IoT Architectures	L+D	Microsoft Teams	1	9	28/4/21
9	A Simplified IoT Architecture, The Core IoT Func-tional Stack	L+D	Microsoft Teams	1	10	28/4/21
10	IoT Data Management and Compute Stack	L+D	Microsoft Teams	1	11	4/5/21

			MODULE 2			
11	Smart Objects: The "Things" in IoT	L+D	Microsoft Teams	1	12	4/5/21
12	Sensors	L+ D	Microsoft Teams	1	13	5/5/21
13	Actuators	L+ D	Microsoft Teams	1	14	5/5/21
14	Smart Objects	L+D	Microsoft Teams	1	15	11/5/21
15	Sensors Networks	L+D	Microsoft Teams	1	16	11/5/21
16	Connecting Smart Objects	L+D	Microsoft Teams	1	17	12/5/21
17	Communication Criteria	L+D	Microsoft Teams	1	18	12/5/21
18	IoT Access Technologies	L+D	Microsoft Teams	1	19	18/5/21
			MODULE 3			
19	IP as the IoT Network Layer	L+D	Microsoft Teams	1	20	18/5/21
20	The Business Case for IP	L+D	Microsoft Teams	1	21	19/5/21
21	The need for Optimization	L+D	Microsoft Teams	1	22	19/5/21
22	Optimizing IP for IoT	L+D	Microsoft Teams	1	23	22/5/21
23	Profiles and Compliances	L+D	Microsoft Teams	1	24	22/5/21
24	IA TEST 1	-	-	1	25	24/5/21
25	Application Protocols for IoT	L+D	Microsoft Teams	1	26	1/6/21
26	The Transport Layer	L+D	Microsoft Teams	2	28	1/6/21,2/6/21

28	Data and Analytics for IoT, An Introduction to DataAnalytics for IoT	L+D	Microsoft Teams	1	31	8/6/21
29	Machine Learning	L+D	Microsoft Teams	1	32	9/6/21
30	Big Data Analytics Tools and Technology	L+D	Microsoft Teams	1	33	9/6/21
31	Edge Streaming Analytics	L+D	Microsoft Teams	1	34	15/6/21
32	Network Analytics	L+D	Microsoft Teams	1	35	15/6/21
33	Securing IoT	L+D	Microsoft Teams	1	36	16/6/21
34	A Brief History of OT Security, Common Chal-lenges in OT Security	L+D	Microsoft Teams	1	37	16/6/21
35	How IT and OT Security Practices and SystemsVary, Formal Risk Analysis Structures: OCTAVE andFAIR	L+D	Microsoft Teams	1	38	22/6/21
36	The Phased Application of Security in an Opera-tional Environment	L+D	Microsoft Teams	1	39	22/6/21
MODULE 5						
37	IoT Physical Devices and Endpoints - ArduinoUNO: Introduction to Arduino	L+D	Microsoft Teams	1	40	23/6/21
38	Arduino UNO, Installing the Software	L+D	Microsoft Teams	1	41	23/6/21
39	IA TEST 2	-	-	1	42	28/6/21
40	Fundamentals of Arduino Programming.	L+D	Microsoft Teams	1	43	6/7/21

27	IoT Application Transport Methods	L+D	Microsoft Teams	2	30	2/6/21,8/6/21
	MODULE 4					
28	Data and Analytics for IoT, An Introduction to DataAnalytics for IoT	L+D	Microsoft Teams	1	31	8/6/21
29	Machine Learning	L+D	Microsoft Teams	1	32	9/6/21
30	Big Data Analytics Tools and Technology	L+D	Microsoft Teams	1	33	9/6/21
31	Edge Streaming Analytics	L+D	Microsoft Teams	1	34	15/6/21
32	Network Analytics	L+D	Microsoft Teams	1	35	15/6/21
33	Securing IoT	L+D	Microsoft Teams	1	36	16/6/21
34	A Brief History of OT Security, Common Chal-lenges in OT Security	L+D	Microsoft Teams	1	37	16/6/21
35	How IT and OT Security Practices and SystemsVary, Formal Risk Analysis Structures: OCTAVE andFAIR	L+D	Microsoft Teams	1	38	22/6/21
36	The Phased Application of Security in an Opera-tional Environment	L+D	Microsoft Teams	1	39	22/6/21
	MODULE 5					
37	IoT Physical Devices and Endpoints - ArduinoUNO: Introduction to Arduino	L+D	Microsoft Teams	1	40	23/6/21
38	Arduino UNO, Installing the Software	L+D	Microsoft Teams	1	41	23/6/21
39	IA TEST 2	-	-	1	42	28/6/21
40	Fundamentals of Arduino Programming.	L+D	Microsoft Teams	1	43	6/7/21

41	IoT Physical Devices and Endpoints - RaspberryPi: Introduction to RaspberryPi, About the RaspberryPiBoard: Hardware Layout	L+D	Microsoft Teams	1	44	6/7/21
42	Operating Systems on RaspberryPi	L+D	Microsoft Teams	1	45	7/72/1
43	Configuring RaspberryPi, Programming Raspber-ryPi with Python	L+D	Microsoft Teams	1	46	7/7/21
44	Wireless Temperature Monitoring System Using Pi	L+D	Microsoft Teams	1	47	13/7/21
45	DS18B20 Temperature Sensor, Connecting Raspber-ry Pi via SSH	L+D	Microsoft Teams	1	48	13/7/21
46	Accessing Temperature from DS18B20 sensors,Remote access to RaspberryPi	L+D	Microsoft Teams	2	50	14/7/21
47	Smart and Connecting Cities, AnIoT Strategy for Smarter Cities, Smart City IoT Architecture, SmartCity Security, Smart City Use-Case Examples	L+D	Microsoft Teams	2	52	17/7/21
48	IA TEST 3	-	-	1	53	19/7/21

Text Books

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", 1stEdition, Pearson Education (Cisco Press Indian Reprint). (ISBN: 978-9386873743)
2. Srinivasa K G, "Internet of Things",CENGAGE Leaning India, 2017

Reference Books

1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1stEdition, VPT, 2014. (ISBN: 978-8173719547)
2. Raj Kamal, "Internet of Things: Architecture and Design Principles", 1st Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224)

Useful Websites

www.ibm.com/in-en/internet-of-things

www.cisco.com/c/en_in/solutions/internet-of-things/overview.html

Details of Teaching Aids:

PPts using Microsoft Teams

Signature of Faculty

Signature of Module Coordinator

Signature of HOD

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology

KSIT

K.S. Institute of Technology, Bangalore

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

ASSIGNMENT QUESTIONS

Academic Year	**2020-21**		
Batch	**2017-21**		
Year / Semester / Section	**IV/ VIII/ B**		
Course Code - Title	**15/17CS81**		
Name of the Instructor	**Mrs BEENA K**	**Dept**	**CSE**

Assignment No: 1 **Total Marks: 10**

Date of Issue: 16.05.2021 **Date of Submission: 22.05.2021**

Sl. No.	Assignment Questions	K-Level	CO	Marks
1	Define Internet of Things. How does the vision reflect in use of IoT in smart street lighting	Applying (K3)	CO1	3
2	Explain the architectural view of a cloud-based IoT platform for smart home with neat diagram.	Applying (K3)	CO1	3
3	Illustrate different IoT access technologies.	Applying (K3)	CO2	4

Course in charge

Module Coordinator

HOD

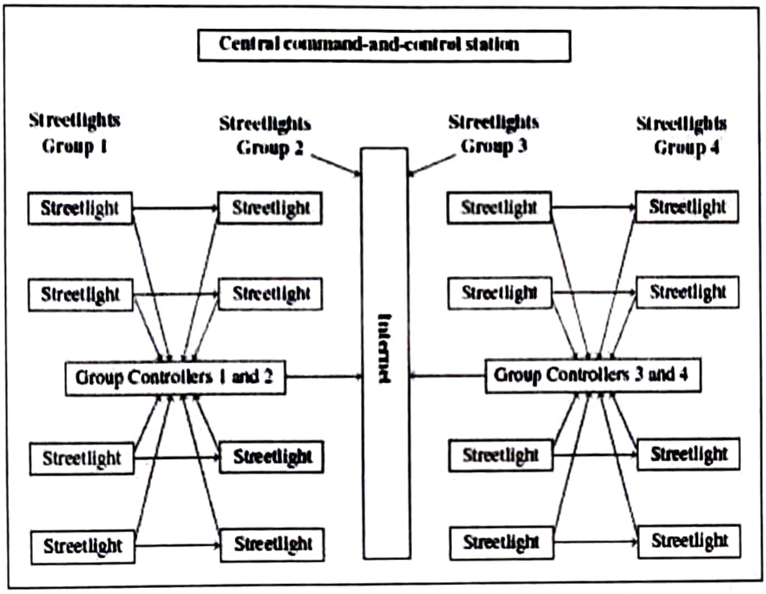
Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

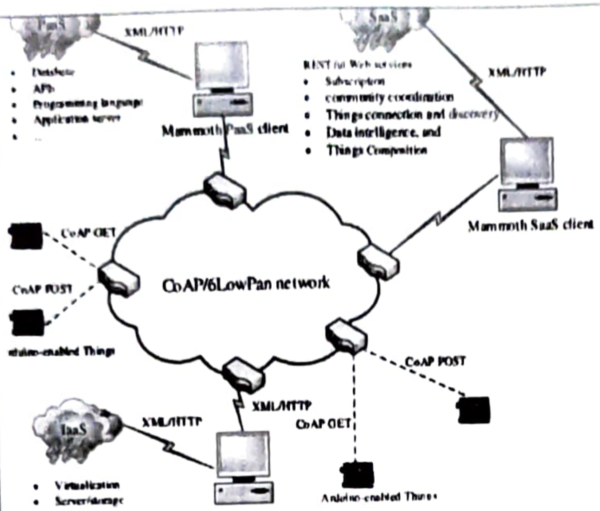
K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

ASSIGNMENT – (1) 2020 – 21 EVEN SEMESTER

SCHEME AND SOLUTION

Degree : **B.E**
Branch : **Computer Science and Engineering**
Course Title : **IoT Technology**
Semester : **VIII**
Course Code : **15/17CS81**
Max Marks : **10**

Q.NO.	POINTS	MARKS
1	<u>Internet of Things with respect to the vision reflect use in smart lighting.</u>  The Internet of Things is the network of devices such as vehicles, and home applications that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data.	3M

<table>
<tr>
<td>2</td>
<td>

Explain the architectural view of a cloud-based IoT platform for smart home</td>
<td>3M</td>
</tr>
<tr>
<td>3</td>
<td>The Internet of Things is the network of devices such as vehicles, and homeapplications that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data.

IEEE 802.15.4
IEEE 802.15.4 is a wireless access technology for low-cost and low-data-rate devices that are powered or run on batteries. In addition to being low cost and offering a reasonable battery life, this access technology enables easy installation using a compact protocol stack while remaining both simple and flexible

IEEE 802.15.4g and 802.15.4e
The IEEE frequently makes amendments to the core 802.15.4 specification,before integrating them into the next revision of the core specification. When these amendments are made, a lowercase letter is appended. Two such examples of this are 802.15.4e-2012 and 802.15.4g-2012, both of which are especially relevant to the subject of IoT. Both of these amendments were integrated in IEEE 802.15.4-2015 but are often still referred to by their amendment names.

The IEEE 802.15.4e amendment of 802.15.4-2011 expands the MAC layerfeature set to remedy the disadvantages associated with 802.15.4, includingMAC reliability, unbounded latency, and multipath fading. In addition to making general enhancements to the MAC layer, IEEE 802.15.4e also madeimprovements to better cope with certain application domains, such as factory and process automation and smart grid.

IEEE 1901.2a
While most of the constrained network technologies relate to wireless,</td>
<td>4M</td>
</tr>
</table>

	IEEE1901.2a-2013 is a wired technology that is an update to the original IEEE 1901.2 specification. This is a standard for Narrowband Power Line Communication (NB-PLC). **IEEE 802.11ah** In unconstrained networks, IEEE 802.11 Wi-Fi is certainly the most successfully deployed wireless technology. This standard is a key IoT wireless access technology, either for connecting endpoints such as fog computing nodes, high-data-rate sensors, and audio or video analytics devices or for deploying Wi-Fi backhaul infrastructures, such as outdoor Wi-Fi mesh in smart cities, oil and mining, or other environments. **LoRaWAN** In recent years, a new set of wireless technologies known as Low-Power Wide-Area (LPWA) has received a lot of attention from the industry. **NB-IoT and Other LTE Variations** Existing cellular technologies, such as GPRS, Edge, 3G, and 4G/LTE, are not particularly well adapted to battery-powered devices and small objects specifically developed for the Internet of Things.	

Course in charge **Module Coordinator** **HOD**

Head of the Department
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DEPARTMENT OF
COMPUTER SCIENCE AND ENGINEERING
ASSIGNMENT QUESTIONS

Academic Year	2020-21		
Batch	2017-2021		
Year/Semester/section	IV/VIII/B		
Course Code-Title	15/17CS81-Internet of Things Technology		
Name of the Instructor	Beena K	Dept	CSE

Assignment No: 2 **Total marks:10**
Date of Issue: 16/06/2021 **Date of Submission: 18/6/2021**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Explain** working of IP as the IoT network layer	K3(APPLYING)	CO3	1
2.	**Make use of** Business case for,IP,	K3(APPLYING)	CO3	1
3.	**Discuss** need for optimization	K3(APPLYING)	CO3	1
4.	**Describe** LoRaWAN standard and alliance MAC layer and security,application protocols for IoT	K3(APPLYING)	CO2	2
5.	**Discuss** the various methods used in IoT application transport	K3(APPLYING)	CO3	2
6.	**Apply** neural network concept in machine learning with a detailed example	K3(APPLYING)	CO4	2
7.	**Develop** an explanation for 6LOWPAN protocol header comparison and fragmentation with a neat diagram.	K3(APPLYING)	CO3	1

Course in charge Module Coordinator HOD

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

ASSIGNMENT –(2)2020 – 21 EVEN SEMESTER

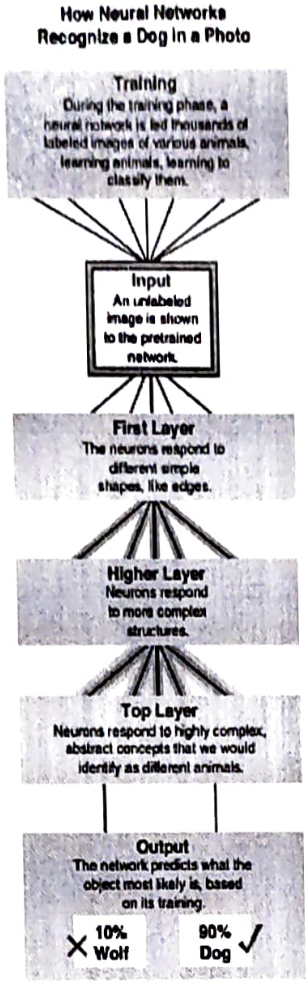
SCHEME AND SOLUTION

Degree	: **B.E**		**Semester**	: **VIII**
Branch	: **Computer Science and Engineering**		**Course Code**	: **15/17CS81**
Course Title	: **IoT Technology**		**Max Marks**	: **10**

Q.NO.	POINTS	MARKS
1	**The Business Case for IP:** This section discusses the advantages of IP from an IoT perspective and introduces the concepts of adoption and adaptation. **The Need for Optimization:** This section dives into the challenges of constrained nodes and devices when deploying IP. This section also looks at the migration from IPv4 to IPv6 and how it affects IoT networks. **Optimizing IP for IoT:** This section explores the common protocols and technologies in IoT networks utilizing IP, including 6LoWPAN, 6TiSCH, and RPL. **Profiles and Compliances:** This section provides a summary of some of the most significant organizations and standards bodies involved with IP connectivity and IoT. (Explain each with an example)	1M
2	The key advantages of the IP suite for the Internet of Things: 1) **Open and standards-based:** 2) **Versatile:** 3) **Ubiquitous:** 4) **Scalable:** 5) **Manageable and highly secure:** 6) **Stable and resilient:** 7) **Consumers' market adoption:** 8) **The innovation factor: (Explain each point with an example)**	1M
3	The following sections take a detailed look at why optimization is necessary for IP. Both the nodes and the network itself can often be constrained in IoT solutions. 1) **Constrained Nodes** 2) **Constrained Networks.** **IP Versions. (Explain each with an example)**	1M
4	Higher-layer IoT protocols are transported. Specifically, includes the following sections: **The Transport Layer:** IP-based networks use either TCP or UDP. However, the constrained nature of IoT networks requires a closer look at the use of these traditional transport mechanisms.	2M

	IoT Application Transport Methods: This section explores the various types of IoT application data and the ways this data can be carried across a network. **Application layer protocol not present:** In this case, the data payload is directly transported on top of the lower layers. No application layer protocol is used. **Supervisory control and data acquisition (SCADA):** SCADA is one of the most common industrial protocols in the world, but it was developed long before the days of IP, and it has been adapted for IP networks. **Generic web-based protocols:** Generic protocols, such as Ethernet, Wi-Fi, and 4G/LTE, are found on many consumer- and enterprise-class IoT devices that communicate over non-constrained networks. **IoT application layer protocols:** IoT application layer protocols are devised to run on constrained nodes with a small compute footprint and are well adapted to the network bandwidth constraints on cellular or satellite links or constrained 6LoWPAN networks. Message Queuing Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP), covered later in this chapter, are two well-known examples of IoT application layer protocols	
5	**Application layer protocol not present:** In this case, the data payload is directly transported on top of the lower layers. No application layer protocol is used. **Supervisory control and data acquisition (SCADA):** SCADA is one of the most common industrial protocols in the world, but it was developed long before the days of IP, and it has been adapted for IP networks. **Generic web-based protocols:** Generic protocols, such as Ethernet, Wi-Fi, and 4G/LTE, are found on many consumer- and enterprise-class IoT devices that communicate over non-constrained networks. **IoT application layer protocols:** IoT application layer protocols are devised to run on constrained nodes with a small compute footprint and are well adapted to the network bandwidth constraints on cellular or satellite links or constrained 6LoWPAN networks. Message Queuing Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP), covered later in this chapter, are two well-known examples of IoT application layer protocols	2M
6	<u>Neural network concept in machine learning with a detailed example.</u> Neural networks are ML methods that mimic the way the human brain works. When you look at a human figure, multiple zones of your brain are activated to recognize colors, movements, facial expressions, and so on. Your brain combines these elements to conclude that the shape you are seeing is human. Neural networks mimic the same logic. The information goes through different algorithms (called units), each of which is in charge of processing an aspect of the information. The resulting value of one unit computation can be used directly or fed into another unit for further processing to occur. In this case, the neural network is said to have several layers. The great efficiency of neural networks is that each unit processes a	2M

	simple test, and therefore computation is quite fast. This model is demonstrated in Figure below.	



Neural Network Example

7	IPv6 header compression for 6LoWPAN was defined initially in RFC 4944 and subsequently updated by RFC 6282. This capability shrinks the size of IPv6's 40-byte headers and User Datagram Protocol's (UDP's) 8-byte headers down as low as 6 bytes combined in some cases. Note that header compression for 6LoWPAN is only defined for an IPv6 header and not IPv4. The 6LoWPAN protocol does not support IPv4, and, in fact, there is no standardized IPv4 adaptation layer for IEEE 802.15.4.6LoWPAN header compression is stateless, and conceptually it is not too complicated. However, a number of factors affect the amount of compression, such as implementation of RFC 4944 versus RFC 6922, whether UDP is included, and various IPv6 addressing scenarios. It is beyond the scope of this book to cover every use case and how the header fields change for each. However, this chapter provides an example that shows the impact of 6LoWPAN header compression. At a high level, 6LoWPAN works by taking advantage of shared information known by all nodes from their participation in the local network	1M

	Fragmentation The maximum transmission unit (MTU) for an IPv6 network must be at least 1280 bytes. The term MTU defines the size of the largest protocol data unit that can be passed. For IEEE 802.15.4, 127 bytes is the MTU. You can see that this is a problem because IPv6, with a much larger MTU, is carried inside the 802.15.4 frame with a much smaller one. To remedy this situation, large IPv6 packets must be fragmented across multiple 802.15.4 frames at Layer 2 The fragment header utilized by 6LoWPAN is composed of three primary fields: Datagram Size, Datagram Tag, and Datagram Offset. The 1-byte Datagram Size field specifies the total size of the un fragmented payload. Datagram Tag identifies the set of fragments for a payload. Finally, the Datagram Offset field delineates how far into a payload a particular fragment occurs.	

Course in charge

Module Coordinator

HOD

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Dept. of Computer Science & Eng
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Bengaluru -560 109

K.S. Institute of Technology, Bangalore

DEPARTMENT OF
COMPUTER SCIENCE AND ENGINEERING
ASSIGNMENT QUESTIONS

Academic Year	2020-21		
Batch	2017-2021		
Year/Semester/section	IV/VIII/ A		
Course Code-Title	15CS81 / 17CS81 – IoT Technology		
Name of the Instructor	Mrs Beena K	Dept	CSE

Assignment No: 3 **Total marks:10**
Date of Issue: 12/07/2021 **Date of Submission: 18/07/2021**

Sl.No	Assignment Questions	K Level	CO	Marks
1.	**Discuss** Raspberry Pi learning board.	Applying (K3)	CO5	2
2.	**Discuss** Arduino UNO with its pins.	Applying (K3)	CO5	2
3.	**Identify** the different layers of IoT Smart City layered architecture	Applying (K3)	CO5	2
4.	**Identify** the elements of Hadoop with a neat diagram.	Applying (K3)	CO4	2
5.	**Discuss** data and analytics for IoT	Applying (K3)	CO4	2

Course in charge Module Coordinator HOD

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

ASSIGNMENT - 3 2020 – 21 EVEN SEMESTER

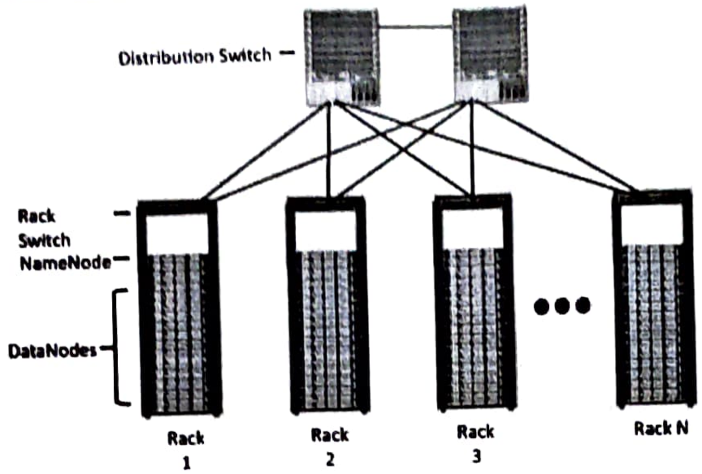
SCHEME AND SOLUTION

Degree	: **B.E**	**Semester**	: **VIII**
Branch	: **Computer Science and Engineering**	**Course Code**	: **15/17CS81**
Course Title	: **IoT Technology**	**Max Marks**	: **10**

Q.NO.	POINTS	MARKS
1	Raspberry Pi is a small single board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer. Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications. Raspberry Pi is slower than laptop or desktop but is still a computer which can provide all the expected features or abilities, at a low power consumption. Raspberry Pi Foundation officially provides Debian based Raspbian OS. Also, they provide NOOBS OS for Raspberry Pi. We can install several Third-Party versions of OS like Ubuntu, Archlinux, RISC OS, Windows 10 IOT Core, etc. Raspbian OS is official Operating System available for free to use. This OS is efficiently optimized to use with Raspberry Pi. Raspbian have GUI which includes tools for Browsing, Python programming, office, games, etc. Raspberry Pi is more than computer as it provides access to the on-chip hardware i.e. GPIOs for developing an application. By accessing GPIO, we can connect devices like LED, motors, sensors, etc and can control them too. It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit). The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB. <u>Hardware Components of Raspberry Pi are:</u> **HDMI (High-Definition Multimedia Interface):** It is used for transmitting uncompressed video or digital audio data to the Computer Monitor, Digital TV, etc. Generally, this HDMI port helps to connect Raspberry Pi to the Digital television. **CSI Camera Interface:** CSI (Camera Serial Interface) interface provides a connection in between Broadcom Processor and Pi camera. This interface provides electrical connections between two devices. **DSI Display Interface:** DSI (Display Serial Interface) Display Interface is used for connecting LCD to the Raspberry Pi using 15-pin ribbon cable. DSI	**2M**

	provides fast High-resolution display interface specifically used for sending video data directly from GPU to the LCD display. **Composite Video and Audio Output:** The composite Video and Audio output port carries video along with audio signal to the Audio/Video systems. **Power LED:** It is a RED colored LED which is used for Power indication. This LED will turn ON when Power is connected to the Raspberry Pi. It is connected to 5V directly and will start blinking whenever the supply voltage drops below 4.63V. **ACT PWR:** ACT PWR is Green LED which shows the SD card activity.	
2	Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.	2M
3	Smart city has 4 layers: sensing, communication, data, and service. **Layer 1: Sensing** The sensing layer has a varied set of IoT nodes that are spread across an urban area. These nodes collect data about various activities in the physical environment. An IoT node is a package that comprises sensors, microchips, power supply, and network elements. IoT nodes are categorized into 2 different categories based on their operating conditions: ➢ Constrained node: These nodes operate in a low-power environment. They have low processing power and a low data-transfer rate. ➢ Unconstrained node: These nodes have no operational constraints in terms of power consumption, processing rate, and data-transfer rate **Layer 2: Communications**	2M

	Every smart city system has a billion IoT nodes that are spread across the city. These IoT nodes should be addressed individually. This is made possible with IPv6, which provides a128-bit address field. However, the overheads that are introduced by IPv6 (in addressing the IoT nodes) are not compatible with constrained devices, and therefore 6LoWPAN (Low Power personal Area Network) was adopted. For seamless translation from IPv6 to 6LoWPAN and vice versa, a bridge router is attached to the 6LoWPAN network. An IPv6 packet that is intended for a node in 6LoWPAN gets converted into 6LoWPAN with the help of a bridge router and vice versa. **Layer 3: Data** This is the intelligence layer of smart-city architecture. A mega smart city can work effectively and efficiently only if the data about the city is organized systematically. **Layer 4: Service** This layer acts as a cross-department operation center. Various city boards such as, water-supply board, power-supply board, pollution-control board, transport department etc.. share information by using web portals/mobile applications that are built on this layer. This layer will not just serve government departments by sharing information but also the general public that has access to a subset of all the data. By using this data the public can build services to enhance the operations of the city.	
4	Hadoop is the most recent entrant into the data management market, but it is arguably the most popular choice as a data repository and processing engine. Hadoop was originally developed as a result of projects at Google and Yahoo!, and the original intent for Hadoop was to index millions of websites and quickly return search results for open source search engines. Initially, the project had two key elements: **Hadoop Distributed File System (HDFS):** A system for storing data across multiple nodes. **MapReduce:** A distributed processing engine that splits a large task into smaller ones that can be run in parallel. Both of these elements are still present in current Hadoop distributions and provide the foundation for other projects.	2M



Distributed Hadoop Cluster

	Much like the MPP and NoSQL systems discussed earlier, Hadoop relies on a scale-out architecture that leverages local processing, memory, and storage to distribute tasks and provide a scalable storage system for data. Both MapReduce and HDFS take advantage of this distributed architecture to store and process massive amounts of data and are thus able to leverage resources from all nodes in the cluster. For HDFS, this capability is handled by specialized nodes in the cluster, including NameNodes and DataNodes ➢ NameNodes: These are a critical piece in data adds, moves, deletes, and reads on HDFS. ➢ DataNodes: These are the servers where the data is stored at the direction of the NameNode.	
5	Four types of data analysis results: ➢ Descriptive: Descriptive data analysis tells you what is happening, either now or in the past. ➢ Diagnostic: When you are interested in the "why," diagnostic data analysis can provide the answer. ➢ Predictive: Predictive analysis aims to foretell problems or issues before they occur. ➢ Prescriptive: Prescriptive analysis goes a step beyond predictive and recommends solutions for upcoming problems	2M

Course in charge

Module Coordinator

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109

I SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

USN | | | | | | | | | |

SET - A

Degree : B.E.
Branch : Computer Science & Engg.
Course Title : IoT Technology
Duration : 90 Minutes

Semester: VIII
Course Code: 15/17CS81
Date: 24.05.2021
Max Marks: 30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1 (a)	**Illustrate** the actions at different levels in the CISCO IoT reference model.	6	CO1	Applying (K3)
(b)	**Explain** the architectural view of a cloud-based IoT platform for smart home with neat diagram.	6	CO1	Applying (K3)
(c)	**Identify** the different types of interaction pattern between sources and sinks in WSN.	6	CO1	Applying (K3)
	OR			
2 (a)	**Demonstrate** how might the cyber security affect the development and implementation of the Internet of Things (IoT), especially in the USA?	6	CO1	Applying (K3)
(b)	**Outline** the differences between the Internet of Things and Internet-Controlled devices	6	CO1	Applying (K3)
(c)	**Identify** the major constraints in sensor node hardware	6	CO1	Applying (K3)
	PART-B			
3 (a)	**Illustrate** with an example why an IDE is required for developing a device platform for an IoT application?	6	CO2	Applying (K3)
(b)	**Explain** the view of simplified IoT architecture.	6	CO2	Applying (K3)
4 (a)	**Identify** the use of Internet of Things with respect to the vision reflect use in smart lighting.	6	CO2	Applying (K3)
(b)	**Illustrate** different IoT access technologies.	6	CO2	Applying (K3)

Course in-charge

Module Coordinator

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I SESSIONAL TEST 2020 – 21 EVEN SEMESTER

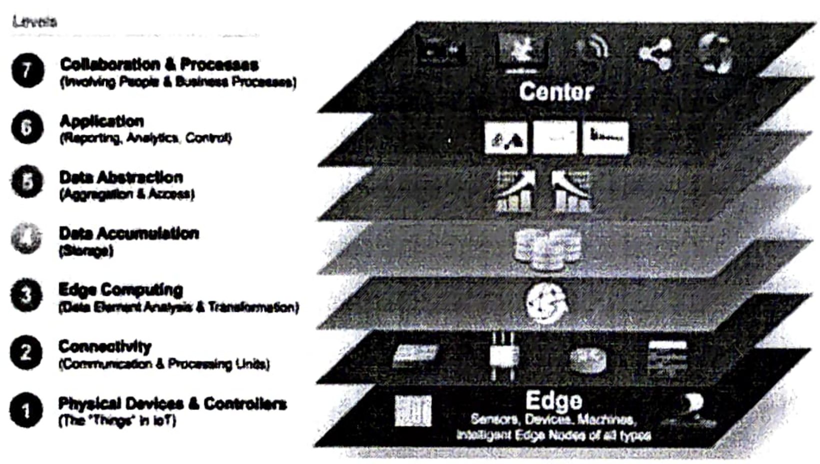
SET-A

SCHEME AND SOLUTION

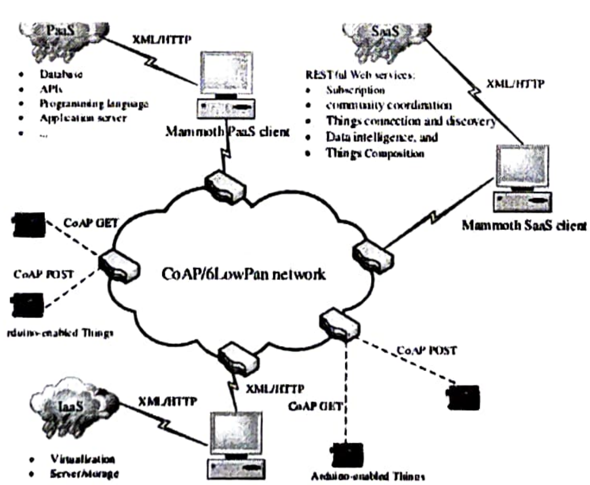
Degree	:	B.E	Semester	:	VIII
Branch	:	Computer Science and Engineering	Course Code	:	15 / 17CS81
Course Title	:	IoT Technology	Max Marks	:	30

<table>
<tr><th>Q.NO.</th><th>POINTS</th><th>MARKS</th></tr>
<tr><td>1(a)</td><td>

<u>IoT Reference Model</u>

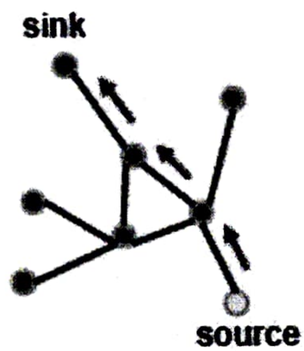


</td><td>3M</td></tr>
<tr><td></td><td>Explain different levels of IoT Reference Model</td><td>3M</td></tr>
<tr><td>1(b)</td><td>



</td><td>3M</td></tr>
</table>

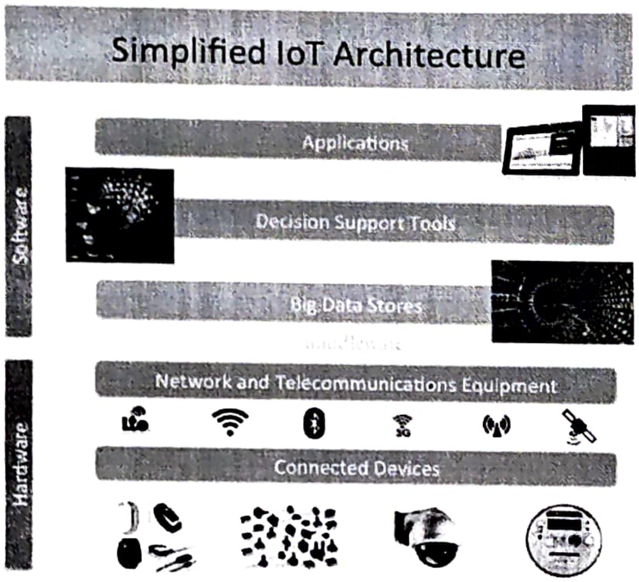
1 (c)	Explain the architectural view of a cloud-based IoT platform for smart home	3M
	Types of applications • Many of the WSN applications share some basic characteristics • In most of the applications there is a difference between sources of data Participants in a WSN	2M
	Source – Sensor that senses data in its environment – Can be equipped with different sensors • e.g. temperature, brightness, etc. – Reports the measurements to the sink • Sink (Base Station) – Interested in receiving data from the other sensor nodes – Can be either part of the WSN or an external device such as a Laptop or PDA – In general there is one base station, but depending on the application multiple base stations are possible	2M
	Actuators -Control some device based on data, usually also a sink.	2M



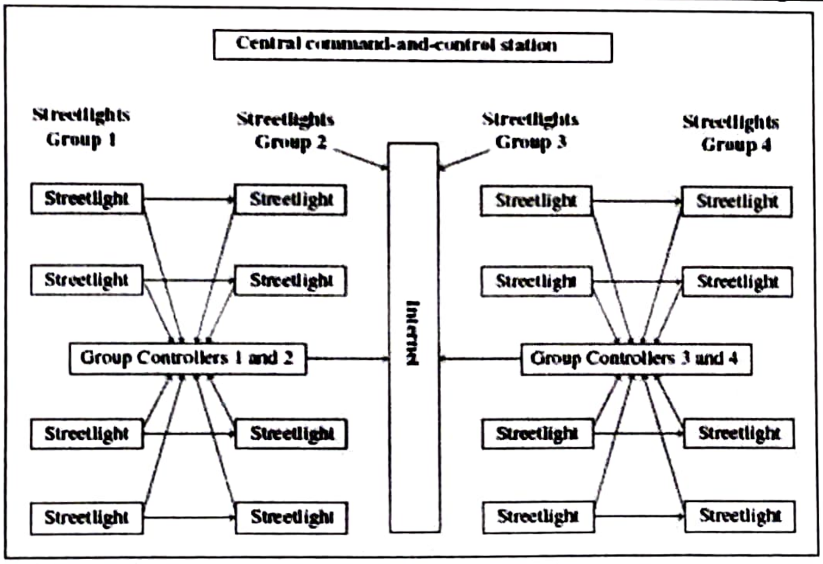
2 (a)	Cybersecurity involves protecting information systems, their components and contents, and the networks that connect them from intrusions or attacks involving theft, disruption, damage, or other unauthorized or wrongful actions. IoT objects are potentially vulnerable targets for hackers. Economic and other factors may reduce the degree to which such objects are designed with adequate cybersecurity capabilities built in. IoT devices are small, are often built to be disposable, and may have limited capacity for software updates to address vulnerabilities that come to light after deployment.	3M
	Access could also be used for destruction, such as by modifying the operation of industrial control systems, as with the Stuxnet malware that caused centrifuges to self-destruct at Iranian nuclear plants. Among other things, Stuxnet showed that smart objects can be hacked even if they are not connected to the Internet. The growth of smart weapons and other connected objects within DOD has led to growing concerns about their vulnerabilities to cyberattack and increasing attempts to prevent and mitigate such attacks, including improved design of IoT objects.	3M

2 (b)	The Internet of Things (IoT) lets devices talk directly to each other, make joint decisions, and exchange data between devices without the need for the cloud or servers. IoT is an evolution of the M2M (Machine to Machine) model with many devices involved, just like MM2MM (Many Machines to Many Machines). The word Things can represent physical devices and machines, as well as virtual services and functions. Meanwhile, multiple things talking directly to each other in a given network are referred to as Clusters of the IoT. To illustrate this idea, imagine a connected home which has several different types of connected devices, all talking to each other on the same network. Intermediary Things, also called hubs or relays, extend the reach of all connected things across multiple network and device categories or vendors. A hub or relay hosted in the cloud can be used to bridge clusters of things across locations and even continents, but is not necessary for the proper function of each cluster. Provide the list of Differences	1M 1M 4M
2 (c)	<u>The major constraints in sensor node hardware</u> WSNs (Wireless Sensor Networks), the security of WSNs has always been a hot topic, even after the coming of fog computing, edge computing and Internet of Things. Because of resource limitation and openness of WSNs, whether to use asymmetric cryptography to improve security or to use symmetric cryptography to save resources has even been a controversial focus in security researches of WSNs. In earlier years, researchers focused on the applications of symmetric key mechanism, but it has inherent shortcomings in key exchange. But their shared pairwise key is static, that is, the pairwise key of a pair of nodes is a fixed value, so once the key is broken, the session security will be lost forever. TinyPK and RSAbased LSSL have nearly implemented ephemeral key with the required authentications by key transport, but unfortunately, they are based on the RSA primitives which has been recognized as impracticable in WSNs. At the same time, Carman and Wander et al. pointed out that the cost of public key operations was enormous, a scalar multiplication takes about 0.81 seconds while a RSA-1024 private-key modular exponentiation takes nearly 10.99 seconds Detail Explanation	2M 1M 3M
Q.NO.	POINTS	MARKS
	PART-B	
3 (a)	Integrated development environments are designed to maximize programmer productivity by providing tight-knit components with similar user interfaces. IDEs present a single program in which all development is done. This program typically provides many features for authoring, modifying, compiling, deploying and debugging software. This contrasts with software development using unrelated tools, such as vi, GCC, or make. One aim of the IDE is to reduce the configuration necessary to piece together multiple development utilities, instead, it provides the same set of capabilities as one cohesive unit. Reducing setup time can increase developer productivity, especially in cases where learning to use the IDE is	2M 1M

	faster than manually integrating and learning all of the individual tools. Tighter integration of all development tasks has the potential to improve overall productivity beyond just helping with setup tasks. For example, code can be continuously parsed while it is being edited, providing instant feedback when syntax errors are introduced, thus allowing developers to debug code much faster and more easily with an IDE.	
	Explain why it is required in IoT Applications	3M
3 (b)	View of simplified IoT architecture.	3M



	Explanation	3M
4 (a)	Internet of Things with respect to the vision reflect use in smart lighting.	2M



	The Internet of Things is the network of devices such as vehicles, and home applications that contain electronics, software, sensors, actuators, and connectivity which allows these things to connect, interact and exchange data.	**4M**
4(b)	**IEEE 802.15.4** IEEE 802.15.4 is a wireless access technology for low-cost and low-data-rate devices that are powered or run on batteries. In addition to being low cost and offering a reasonable battery life, this access technology enables easy installation using a compact protocol stack while remaining both simple and flexible	**1M**
	IEEE 802.15.4g and 802.15.4e The IEEE frequently makes amendments to the core 802.15.4 specification, before integrating them into the next revision of the core specification. When these amendments are made, a lowercase letter is appended. Two such examples of this are 802.15.4e-2012 and 802.15.4g-2012, both of which are especially relevant to the subject of IoT. Both of these amendments were integrated in IEEE 802.15.4-2015 but are often still referred to by their amendment names. The IEEE 802.15.4e amendment of 802.15.4-2011 expands the MAC layer feature set to remedy the disadvantages associated with 802.15.4, including MAC reliability, unbounded latency, and multipath fading. In addition to making general enhancements to the MAC layer, IEEE 802.15.4e also made improvements to better cope with certain application domains, such as factory and process automation and smart grid.	**1M**
	IEEE 1901.2a While most of the constrained network technologies relate to wireless, IEEE 1901.2a-2013 is a wired technology that is an update to the original IEEE 1901.2 specification. This is a standard for Narrowband Power Line Communication (NB-PLC).	**1M**
	IEEE 802.11ah In unconstrained networks, IEEE 802.11 Wi-Fi is certainly the most successfully deployed wireless technology. This standard is a key IoT wireless access technology, either for connecting endpoints such as fog computing nodes, high-data-rate sensors, and audio or video analytics devices or for deploying Wi-Fi backhaul infrastructures, such as outdoor Wi-Fi mesh in smart cities, oil and mining, or other environments.	**1M**
	LoRaWAN In recent years, a new set of wireless technologies known as Low-Power Wide-Area (LPWA) has received a lot of attention from the industry.	**1M**

	NB-IoT and Other LTE Variations Existing cellular technologies, such as GPRS, Edge, 3G, and 4G/LTE, are not particularly well adapted to battery-powered devices and small objects specifically developed for the Internet of Things.	**1M**

Course in charge **Module Coordinator** **Head of the Department**

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I SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

USN | | | | | | | | | |

SET - B

Degree	: B.E.	Semester:	VIII
Branch	: Computer Science & Engg.	Course Code:	15/17CS81
Course Title	: IoT and Applications	Date:	24.05.2021
Duration	: 90 Minutes	Max Marks:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1 (a)	**Demonstrate** how might the cyber security affect the development andimplementation of the Internet of Things (IoT), especially in the USA?	6	CO1	Applying (K3)
(b)	**Outline** the differences between the Internet of Things and Internet-Controlleddevices	6	CO1	Applying (K3)
(c)	**Identify** the major concern in sensor node hardware	6	CO1	Applying (K3)
	OR			
2 (a)	**Illustrate** the actions at different levels in the CISCO IoT reference model.	6	CO1	Applying (K3)
(b)	**Explain** the architectural view of a cloud-based IoT platform for smart homewith neat diagram.	6	CO1	Applying (K3)
(c)	**Identify** the different types of interaction pattern between sources and sinksin WSN.	6	CO1	Applying (K3)
	PART-B			
3 (a)	**Identify** the use of Internet of Things with respect to the vision reflect use insmart lighting.	6	CO2	Applying (K3)
(b)	**Illustrate** different IoT access technologies.	6	CO2	Applying (K3)
4 (a)	**Illustrate** with an example why an IDE is required for developing a device platform for an IoT application?	6	CO2	Applying (K3)
(b)	**Explain** the view of simplified IoT architecture.	6	CO2	Applying (K3)

Course in-charge Module Coordinator HOD

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Bengaluru - 560

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
I SESSIONAL TEST 2020 – 21 EVEN SEMESTER

KSIT

SET-B

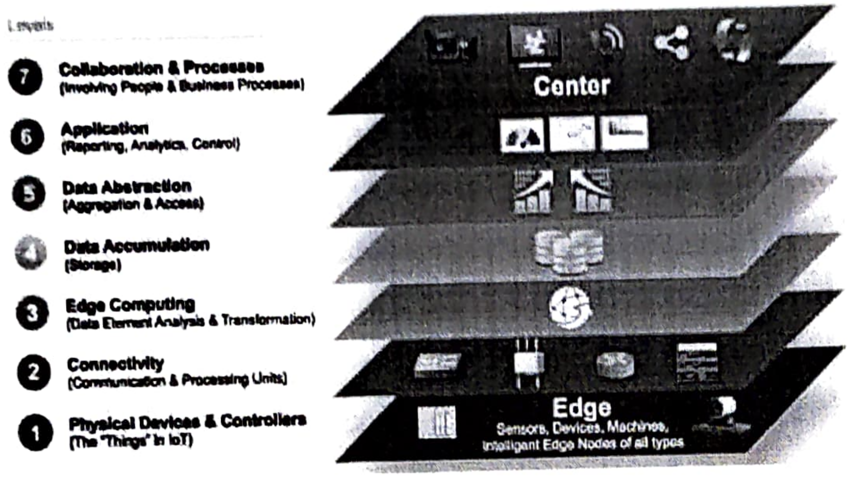
Degree : **B.E**		**Semester** : **VIII**	
Branch : **Computer Science and Engineering**		**Course Code** : **15 / 17CS81**	
Course Title : **IoT Technology**		**Max Marks** : **30**	

Q.NO.	POINTS	MARKS
1(a)	Cybersecurity involves protecting information systems, their components and contents, and the networks that connect them from intrusions or attacks involving theft, disruption, damage, or other unauthorized or wrongful actions. IoT objects are potentially vulnerable targets for hackers. Economic and other factors may reduce the degree to which such objects are designed with adequate cybersecurity capabilities built in. IoT devices are small, are often built to be disposable, and may have limited capacity for software updates to address vulnerabilities that come to light after deployment.	6 M
(b)	The Internet of Things (IoT) lets devices talk directly to each other, make joint decisions, and exchange data between devices without the need for the cloud or servers. IoT is an evolution of the M2M (Machine to Machine) model with many devices involved, just like MM2MM (Many Machines to Many Machines). The word Things can represent physical devices and machines, as well as virtual services and functions. Meanwhile, multiple things talking directly to each other in a given network are referred to as Clusters of the IoT. To illustrate this idea, imagine a connected home which has several different types of connected devices, all talking to each other on the same network. Intermediary Things, also called hubs or relays, extend the reach of all connected things across multiple network and device categories or vendors. A hub or relay hosted in the cloud can be used to bridge clusters of things across locations and even continents, but is not necessary for the proper function of each cluster. Provide the list of Differences	6 M
(c)	<u>The major constraints in sensor node hardware</u> WSNs (Wireless Sensor Networks), the security of WSNs has always been a hot topic, even after the coming of fog computing, edge computing and Internet of Things. Because of resource limitation and openness of WSNs, whether to use asymmetric cryptography to improve security or to use symmetric cryptography to save resources has even been a controversial focus in security researches of WSNs. In earlier years, researchers focused on the applications of symmetric key mechanism, but it has inherent shortcomings in key exchange. But their shared pairwise key is static, that is, the pairwise key of a pair of nodes is a fixed value, so once the key is broken, the session security will be lost forever. TinyPK and RSAbased LSSL have nearly implemented ephemeral key with the required authentications by key transport, but unfortunately, they are based on the RSA primitives which has been recognized as impracticable in WSNs. At the same	6 M

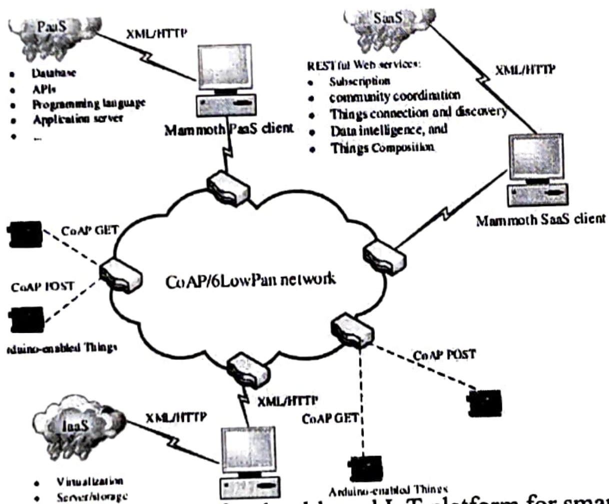
time, Carman and Wander et al. pointed out that the cost of public key operations was enormous, a scalar multiplication takes about 0.81 seconds while a RSA-1024 private-key modular exponentiation takes nearly 10.99 seconds

Detail Explanation

2 (a) **IoT Reference Model** 6M



(b) Explain different levels of IoT Reference Model 6 M



Explain the architectural view of a cloud-based IoT platform for smart home 6 M

(c)

Types of applications

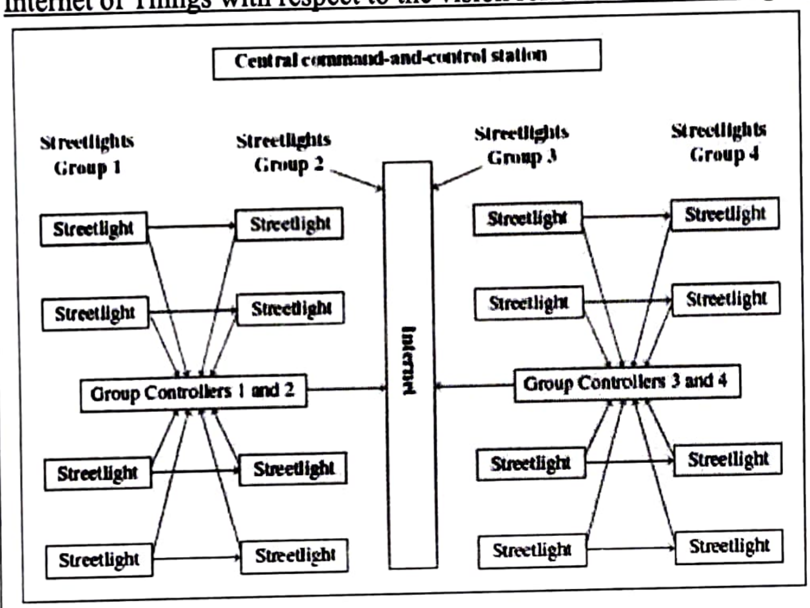
- Many of the WSN applications share some basic characteristics
- In most of the applications there is a difference between sources of data Participants in a WSN

Source
– Sensor that senses data in its environment
– Can be equipped with different sensors
• e.g. temperature, brightness, etc.
– Reports the measurements to the sink
• Sink (Base Station)
– Interested in receiving data from the other sensor nodes
– Can be either part of the WSN or an external device such as a Laptop or PDA
– In general there is one base station, but depending on the application multiple

base stations are possible

Actuators
-Control some device based on data, usually also a sink.

3 (a) <u>Internet of Things with respect to the vision reflect use in smart lighting.</u> 6 M



(b) **IEEE 802.15.4** 6 M

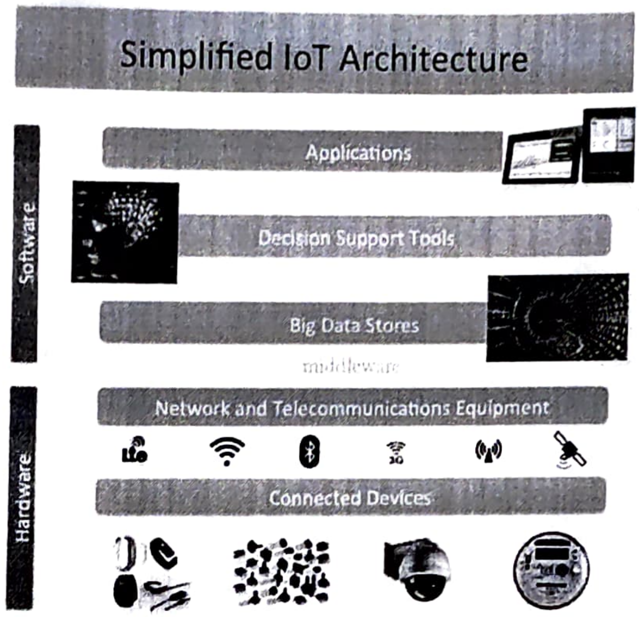
IEEE 802.15.4 is a wireless access technology for low-cost and low-data-rate devices that are powered or run on batteries. In addition to being low cost and offering a reasonable battery life, this access technology enables easy installation using a compact protocol stack while remaining both simple and flexible

IEEE 802.15.4g and 802.15.4e

The IEEE frequently makes amendments to the core 802.15.4 specification, before integrating them into the next revision of the core specification. When these amendments are made, a lowercase letter is appended. Two such examples of this are 802.15.4e-2012 and 802.15.4g-2012, both of which are especially relevant to the subject of IoT. Both of these

	amendments were integrated in IEEE 802.15.4-2015 but are often still referred to by their amendment names. The IEEE 802.15.4e amendment of 802.15.4-2011 expands the MAC layer feature set to remedy the disadvantages associated with 802.15.4, including MAC reliability, unbounded latency, and multipath fading. In addition to making general enhancements to the MAC layer, IEEE 802.15.4e also made improvements to better cope with certain application domains, such as factory and process automation and smart grid. **IEEE 1901.2a** While most of the constrained network technologies relate to wireless, IEEE 1901.2a-2013 is a wired technology that is an update to the original IEEE 1901.2 specification. This is a standard for Narrowband Power Line Communication (NB-PLC). **IEEE 802.11ah** In unconstrained networks, IEEE 802.11 Wi-Fi is certainly the most successfully deployed wireless technology. This standard is a key IoT wireless access technology, either for connecting endpoints such as fog computing nodes, high-data-rate sensors, and audio or video analytics devices or for deploying Wi-Fi backhaul infrastructures, such as outdoor Wi-Fi mesh in smart cities, oil and mining, or other environments. **LoRaWAN** In recent years, a new set of wireless technologies known as Low-Power Wide-Area (LPWA) has received a lot of attention from the industry **NB-IoT and Other LTE Variations** Existing cellular technologies, such as GPRS, Edge, 3G, and 4G/LTE, are not particularly well adapted to battery-powered devices and small objects specifically developed for the Internet of Things.		
4(a)	Integrated development environments are designed to maximize programmer productivity by providing tight-knit components with similar user interfaces. IDEs present a single program in which all development is done. This program typically provides many features for authoring, modifying, compiling, deploying and debugging software. This contrasts with software development using unrelated tools, such as vi, GCC, or make. One aim of the IDE is to reduce the configuration necessary to piece together multiple development utilities, instead, it provides the same set of capabilities as one cohesive unit. Reducing setup time can increase developer productivity, especially in cases where learning to use the IDE is Tighter integration of all development tasks has the potential to improve overall productivity beyond just helping with setup tasks. For example, code can be continuously parsed while it is being edited, providing instant feedback when syntax errors are introduced, thus allowing developers to debug code much faster and more easily with an IDE. Explain why it is required in IoT Applications	6 M	

4 (b)	View of simplified IoT architecture.	6 M



COURSE INCHARGE

MODULE COORDINATOR

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II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET - A

USN										

Degree	:	B.E	Semester	:	VIII
Branch	:	Computer Science and Engineering	Course Code	:	15 / 17CS81
Course Title	:	IoT Technology	Date	:	12.06.2021
Duration	:	90 Minutes	Max Marks	:	30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	Develop an explanation for 6LOWPAN protocol header compression and fragmentation with a neat diagram.	6	CO3	Applying (K3)
(b)	Choose and explain the key advantages of internet protocol.	6	CO3	Applying (K3)
(c)	Identify RPL encryption and authentication on constraint nodes.	6	CO3	Applying (K3)
	OR			
2(a)	Make use of tunneling legacy concept for SCADA over IP networks ad SCADA protocol translation with a neat diagram.	6	CO3	Applying (K3)
(b)	Identify MQTT framework and message format in detail.	6	CO3	Applying (K3)
(c)	Identify application protocols for IoT	6	CO3	Applying (K3)
	PART-B			
3(a)	Identify and explanation for 802.15.4 physical layer, MAC layer and security.	6	CO2	Applying (K3)
(b)	Identify the elements of Hadoop with a neat diagram	6	CO4	Applying (K3)
	OR			
4(a)	Identify LoRaWAN standard and alliance MAC layer and security.	6	CO2	Applying (K3)
(b)	Apply neural network concept in machine learning with a detailed example.	6	CO4	Applying (K3)

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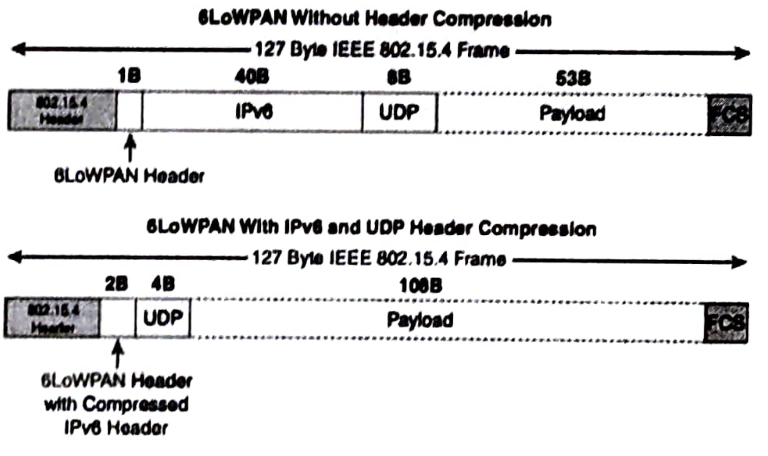
II SESSIONAL TEST 2020 – 21 EVEN SEMESTER

SET-A

SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VIII**
Branch	:	**Computer Science and Engineering**	**Course Code**	:	**15 / 17CS81**
Course Title	:	**IoT Technology**	**Max Marks**	:	**30**

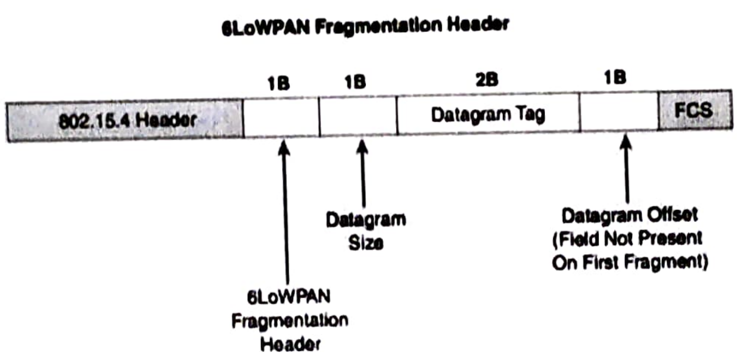
Q.NO.	POINTS	MARKS
1(a)	<u>**6LOWPAN protocol header compression**</u> IPv6 header compression for 6LoWPAN was defined initially in RFC 4944 and subsequently updated by RFC 6282. This capability shrinks the size of IPv6's 40-byte headers and User Datagram Protocol's (UDP's) 8-byte headers down as low as 6 bytes combined in some cases. Note that header compression for 6LoWPAN is only defined for an IPv6 header and not IPv4. The 6LoWPAN protocol does not support IPv4, and, in fact, there is no standardized IPv4 adaptation layer for IEEE 802.15.4.6LoWPAN header compression is stateless, and conceptually it is not too complicated. However, a number of factors affect the amount of compression, such as implementation of RFC 4944 versus RFC 6922, whether UDP is included, and various IPv6 addressing scenarios. It is beyond the scope of this book to cover every use case and how the header fields change for each. However, this chapter provides an example that shows the impact of 6LoWPAN header compression. At a high level, 6LoWPAN works by taking advantage of shared information known by all nodes from their participation in the local network. In addition, it omits some standard header fields by assuming commonly used values. Figure below highlights an example that shows the amount of reduction that is possible with 6LoWPAN header compression.  *6LoWPAN Header Compression*	3M

Fragmentation

The maximum transmission unit (MTU) for an IPv6 network must be at least 1280 bytes. The term MTU defines the size of the largest protocol data unit that can be passed. For IEEE 802.15.4, 127 bytes is the MTU. You can see that this is a problem because IPv6, with a much larger MTU, is carried inside the 802.15.4 frame with a much smaller one. To remedy this situation, large IPv6 packets must be fragmented across multiple 802.15.4 frames at Layer 2

3M

The fragment header utilized by 6LoWPAN is composed of three primary fields: Datagram Size, Datagram Tag, and Datagram Offset. The 1-byte Datagram Size field specifies the total size of the un fragmented payload. Datagram Tag identifies the set of fragments for a payload. Finally, the Datagram Offset field delineates how far into a payload a particular fragment occurs. Figure below provides an overview of a 6LoWPAN fragmentation header.



6LoWPAN Fragmentation Header

1 (b) <u>The key advantages of internet protocol.</u>

List – 3M + Explain – 3M

■ Open and standards-based: Operational technologies have often been delivered as turnkey features by vendors who may have optimized the communications through closed and proprietary networking solutions.

■ Versatile: A large spectrum of access technologies is available to offer connectivity of “things” in the last mile. Additional protocols and technologies are also used to transport IoT data through backhaul links and in the data center.

■ Ubiquitous: All recent operating system releases, from general-purpose computers and servers to lightweight embedded systems (TinyOS, Contiki, and so on), have an integrated dual (IPv4 and IPv6) IP stack that gets enhanced over time.

■ Scalable: As the common protocol of the Internet, IP has been massively deployed and tested for robust scalability. Millions of private and public IP infrastructure nodes have been operational for years, offering strong foundations for those not familiar with IP network management.

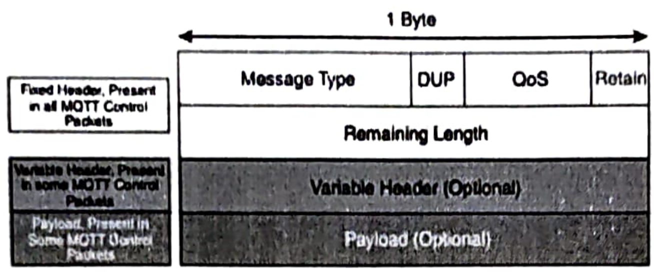
	■ Manageable and highly secure: Communications infrastructure requires appropriate management and security capabilities for proper operations. ■ Stable and resilient: IP has been around for 30 years, and it is clear that IP is a workable solution. IP has a large and well-established knowledge base and, more importantly, it has been used for years in critical infrastructures, such as financial and defense networks. ■ Consumers' market adoption: When developing IoT solutions and products targeting the consumer market, vendors know that consumers' access to applications and devices will occur predominantly over broadband and mobile wireless infrastructure. ■ The innovation factor: The past two decades have largely established the adoption of IP as a factor for increased innovation. IP is the underlying protocol for applications ranging from file transfer and e-mail to the World Wide Web, e-commerce, social networking, mobility, and more.	
1 (c)	<u>Authentication and Encryption on Constrained Nodes</u> **ACE** Much like the RoLL working group, the Authentication and Authorization for Constrained Environments (ACE) working group is tasked with evaluating the applicability of existing authentication and authorization protocols and documenting their suitability for certain constrained-environment use cases. Once the candidate solutions are validated, the ACE working group will focus its work on CoAP with the Datagram Transport Layer Security (DTLS) protocol. The ACE working group may investigate other security protocols later, with a particular focus on adapting whatever solution is chosen to HTTP and TLS.The ACE working group expects to produce a standardized solution for authentication and authorization that enables authorized access (Get, Put, Post, Delete) to resources identified by a URI and hosted on a resource server in constrained environments. An unconstrained authorization server performs mediation of the access. Aligned with the initial focus, access to resources at a resource server by a client device occurs using CoAP and is protected by DTLS.	**3M**
	DICE New generations of constrained nodes implementing an IP stack over constrained access networks are expected to run an optimized IP protocol stack. For example, when implementing UDP at the transport layer, the IETF Constrained Application Protocol (CoAP) should be used at the application layer. In constrained environments secured by DTLS, CoAP can be used to control resources on a device. The DTLS in Constrained Environments (DICE) working group focuses on implementing the DTLS transport layer security protocol in these environments. The first task of the DICE working group is to define an optimized DTLS profile for constrained nodes. In addition, the DICE working group is considering the applicability of the DTLS record layer to secure multicast messages and investigating how the DTLS handshake in constrained environments can get optimized.	**3M**

	(PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out). **AREF (9):** Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins. **Reset Button** Just like the original Nintendo, the Arduino has a reset button (10). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. **Power LED Indicator** Just beneath and to the right of the word "UNO" on your circuit board, there's a tiny LED next to the word 'ON' (11). **TX RX LEDs** TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. **Main IC** The black thing with all the metal legs is an IC, or Integrated Circuit (13). Think of it as the brains of our Arduino. The main IC on the Arduino is slightly different from board type to board type. **Voltage Regulator** The voltage regulator (14) is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it's for.	1M 1M 1M
2 (a)	The Information and Communication Technology (ICT) architecture of a smart city has 4 layers: sensing, communication, data, and service. **Layer 1: Sensing** The sensing layer has a varied set of IoT nodes that are spread across an urban area. These nodes collect data about various activities in the physical environment. An IoT node is a package that comprises sensors, microchips, power supply, and network elements. IoT nodes are categorized into 2 different categories based on their operating conditions: ➢ Constrained node: These nodes operate in a low-power environment. They have low processing power and a low data-transfer rate. ➢ Unconstrained node: These nodes have no operational constraints in terms of power consumption, processing rate, and data-transfer rate **Layer 2: Communications**	2M 2M

SCADA server and converts it to a TCP/IP port using a raw socket connection.

In Scenario C, the SCADA server supports native raw socket capability. Unlike in Scenarios A and B, where a router or IP/serial redirector software has to map the SCADA server's serial ports to IP ports, in Scenario C the SCADA server has full IP support for raw socket connections.

2 (b) MQTT framework and message format in detail.



MQTT Message Format

3M

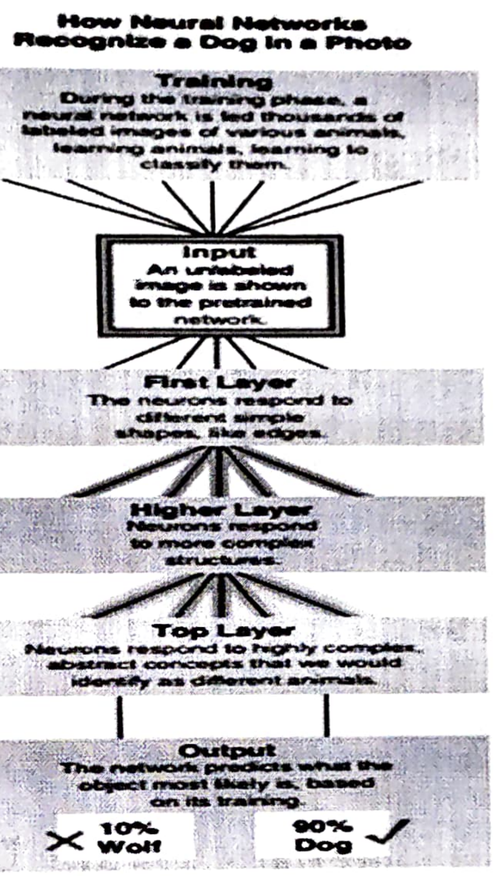
Overview of the MQTT message format is shown in the Figure above. Compared to the CoAP message format, you can see that MQTT contains a smaller header of 2 bytes compared to 4 bytes for CoAP. The first MQTT field in the header is Message Type, which identifies the kind of MQTT packet within a message. Fourteen different types of control packets are specified in MQTT version 3.1.1. Each of them has a unique value that is coded into the Message Type field. Note that values 0 and 15 are reserved. MQTT message types are summarized in below Table.

MQTT Message Types

Message Type	Value	Flow	Description
CONNECT	1	Client to server	Request to connect
CONNACK	2	Server to client	Connect acknowledgement
PUBLISH	3	Client to server Server to client	Publish message
PUBACK	4	Client to server Server to client	Publish acknowledgement
PUBREC	5	Client to server Server to client	Publish received
PUBREL	6	Client to server Server to client	Publish release
PUBCOMP	7	Client to server Server to client	Publish complete
SUBSCRIBE	8	Client to server	Subscribe request
SUBACK	9	Server to client	Subscribe acknowledgement
UNSUBSCRIBE	10	Client to server	Unsubscribe request

3M

	Cloud-based/server processing: videos or snapshots are streamed to the cloud or powerful on-premise server. On-board processing: the system recognizes vehicles locally and sends the parking events and images when required. This solution brings high operating costs since the operator has to train the model for a particular setting. Putting all computer vision problems aside, one of the biggest real-life challenges for camera based solutions is to obtain reasonable quality and clarity pictures at all times and weather conditions. So camera-based solutions can work well in large open space lots like those in supermarkets or airports, well lit at evening time and preferably not much snow. Overhead radars/lidars can detect the presence of a vehicle using radio signals and laser light reflections. The system provides accurate results within 7 metres but at a greater distance and sharper reflection angles its accuracy decreases, so, mains powered sensor fixed on a lamp post can reliably cover only 4-5 parking spots. Ground sensors are considered to be a universal method to monitor the parking occupancy. Battery-powered wireless sensors are installed on each parking space and are not affected by line of sight interference. The proximity to the detected object lets ground sensors provide accurate results at a reasonable maintenance cost. Currently, ground sensors are considered the most flexible and efficient way to address parking problems.	**2M**
2 (c)	Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.	**2M**
	"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards. <u>Features of Arduino Uno Board</u> The features of Arduino Uno ATmega328 includes the following:	**2M**
	➢ The operating voltage is 5V ➢ The recommended input voltage will range from 7v to 12V ➢ The input voltage ranges from 6v to 20V ➢ Digital input/output pins are 14	**2M**

Q.NO.	POINTS	MARKS
	➢ Analog i/p pins are 6 ➢ DC Current for each input/output pin is 40 mA ➢ DC Current for 3.3V Pin is 50 mA ➢ Flash Memory is 32 KB ➢ SRAM is 2 KB ➢ EEPROM is 1 KB ➢ CLK Speed is 16 MHz	
	PART-B	
3 (a)	<u>Neural Network in Machine Learning</u>  Fig. Neural Network Example	3M
	Neural networks are ML methods that mimic the way the human brain works. When you look at a human figure, multiple zones of your brain are activated to recognize colors, movements, facial expressions, and so on. Your brain combines these elements to conclude that the shape you are seeing is human. Neural networks mimic the same logic. The information goes through different algorithms (called units), each of which is in charge of processing an aspect of the information. The resulting value of one unit computation can be used directly or fed into another unit for further processing to occur. In this case, the neural network is said to have several	3M

	layers. For example, a neural network processing human image recognition may have two units in a first layer that determines whether the image has straight lines and sharp angles—because vehicles commonly have straight lines and sharp angles, and human figures do not. If the image passes the first layer successfully (because there are no or only a small percentage of sharp angles and straight lines), a second layer may look for different features (presence of face, arms, and so on), and then a third layer might compare the image to images of various animals and conclude that the shape is a human (or not). The great efficiency of neural networks is that each unit processes a simple test, and therefore computation is quite fast. This model is demonstrated in the Figure above	
3 (b)	In the world of IoT, the creation of massive amounts of data from sensors is common and one of the biggest challenges—not only from a transport perspective but also from a data management standpoint. A great example of the deluge of data that can be generated by IoT is found in the commercial aviation industry and the sensors that are deployed throughout an aircraft. Modern jet engines are fitted with thousands of sensors that generate a whopping 10GB of data per second. For example, modern jet engines, similar to the one shown in Figure below, may be equipped with around 5000 sensors. Therefore, a twin engine commercial aircraft with these engines operating on average 8 hours a day will generate over 500 TB of data daily, and this is just the data from the engines! Aircraft today have thousands of other sensors connected to the airframe and other systems. In fact, a single wing of a modern jumbo jet is equipped with 10,000 sensors The potential for a petabyte (PB) of data per day per commercial airplane is not far-fetched—and this is just for one airplane. Across the world, there are approximately 100,000 commercial flights per day. The amount of IoT data coming just from the commercial airline business is overwhelming.	2M
	<u>Structured Versus Unstructured Data</u> Structured data and unstructured data are important classifications as they typically require different toolsets from a data analytics perspective. Structured data means that the data follows a model or schema that defines how the data is represented or organized, meaning it fits well with a traditional relational database management system (RDBMS). In many cases you will find structured data in a simple tabular form—for example, a spreadsheet where data occupies a specific cell and can be explicitly defined and referenced.	1M
	<u>Data in Motion Versus Data at Rest</u> As in most networks, data in IoT networks is either in transit ("data in motion") or being held or stored ("data at rest"). Examples of data in motion include traditional client/server exchanges, such as web browsing and file transfers, and email. Data saved to a hard drive, storage array, or USB drive is data at rest.	1M

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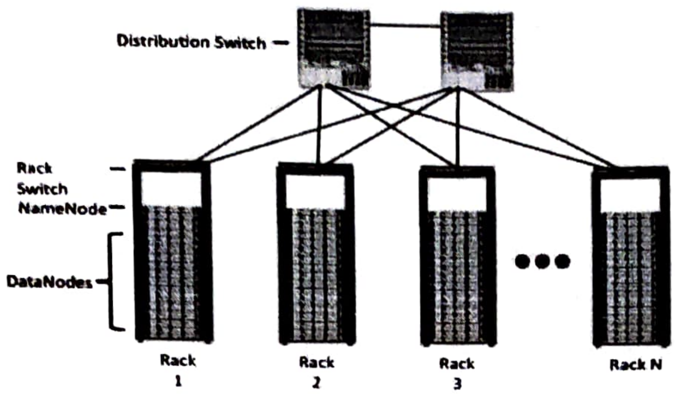

Fig. Distributed Hadoop Cluster

For HDFS, this capability is handled by specialized nodes in the cluster, including Name Nodes and Data Nodes

NameNodes: These are a critical piece in data adds, moves, deletes, and reads on HDFS. They coordinate where the data is stored, and maintain a map of where each block of data is stored and where it is replicated. All interaction with HDFS is coordinated through the primary (active) NameNode, with a secondary (standby) NameNode notified of the changes in the event of a failure of the primary. The NameNode takes write requests from clients and distributes those files across the available nodes in configurable block sizes, usually 64 MB or 128 MB blocks. The NameNode is also responsible for instructing the DataNodes where replication should occur.

DataNodes: These are the servers where the data is stored at the direction of the NameNode. It is common to have many DataNodes in a Hadoop cluster to store the data. Data blocks are distributed across several nodes and often are replicated three, four, or more times across nodes for redundancy. Once data is written to one of the DataNodes, the DataNode selects two (or more) additional nodes, based on replication policies, to ensure data redundancy across the cluster. Disk redundancy techniques such as Redundant Array of Independent Disks (RAID) are generally not used for HDFS because the NameNodes and DataNodes coordinate block-level redundancy with this replication technique.

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<u>LoRaWAN standardization and Alliances</u>

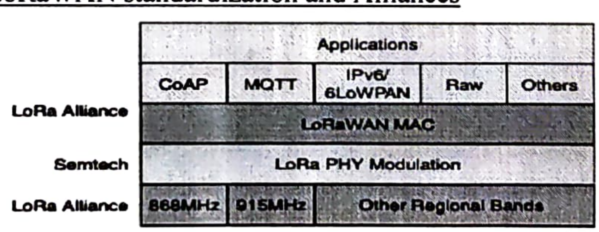

Fig. LoRaWAN Layer

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Much like the MPP and NoSQL systems discussed earlier, Hadoop relies on a scale-out architecture that leverages local processing, memory, and storage to distribute tasks and provide a scalable storage system for data. Both MapReduce and HDFS take advantage of this distributed architecture to store and process massive amounts of data and are thus able to leverage resources from all nodes in the cluster. For HDFS, this capability is handled by specialized nodes in the cluster, including NameNodes and DataNodes

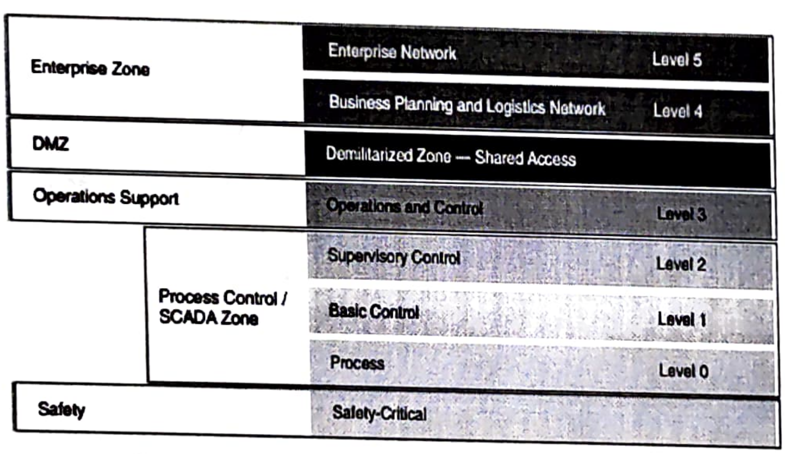
- NameNodes: These are a critical piece in data adds, moves, deletes, and reads on HDFS. **1M**

- DataNodes: These are the servers where the data is stored at the direction of the NameNode.

4(b) <u>IT and OT security practices and systems vary in real time.</u>

- <u>The Purdue Model for Control Hierarchy</u>

Regardless of where a security threat arises, it must be consistently and unequivocally treated. IT information is typically used to make business decisions, such as those in process optimization, whereas OT information is instead characteristically leveraged to make physical decisions, such as closing a valve, increasing pressure, and so on.



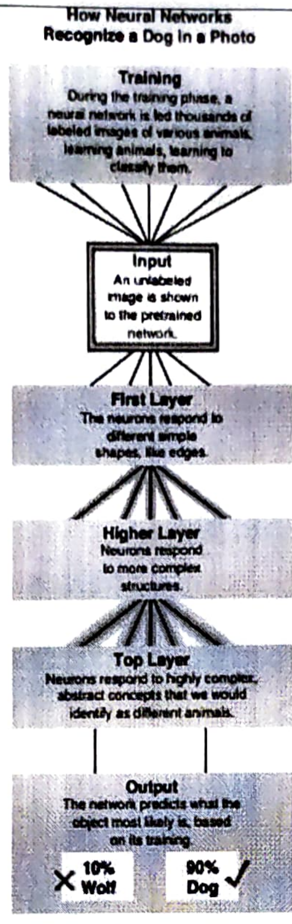
2M

The Logical Framework Based on the Purdue Model for Control Hierarchy

This model identifies levels of operations and defines each level.

Enterprise zone

- Level 5: Enterprise network: Corporate-level applications such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), document management, and services such as Internet access and VPN entry from the outside world exist at this level. **1M**

	 *Neural Network Example*		3M

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE - 560109
II SESSIONAL TEST QUESTION PAPER 2020 – 21 EVEN SEMESTER

SET - B

USN										

Degree : B.E
Branch : Computer Science and Engineering
Course Title : IoT Technology
Duration : 90 Minutes

Semester : VIII
Course Code : 15 / 17CS81
Date : 28.06.2021
Max Marks : 30

Note: Answer ONE full question from each part.

Q No.	Question	Marks	CO mapping	K-Level
	PART-A			
1(a)	**Identify** application protocols for IoT	6	CO3	Applying (K3)
(b)	**Choose** and explain the key advantages of internet protocol.	6	CO3	Applying (K3)
(c)	**Discuss** need for optimization necessary for IP	6	CO3	Applying (K3)
	OR			
2(a)	**Make use of** tunneling legacy concept for SCADA over IP networks ad SCADA protocol translation with a neat diagram.	6	CO3	Applying (K3)
(b)	**Identify** MQTT framework and message format in detail.	6	CO3	Applying (K3)
(c)	**Develop** an explanation for 6LOWPAN protocol header comparison and fragmentation with a neat diagram.	6	CO3	Applying (K3)
	PART-B			
3(a)	**Identify** LoRaWAN standard and alliance MAC layer and security	6	CO2	Applying (K3)
(b)	**Apply** neural network concept in machine learning with a detailed example	6	CO4	Applying (K3)
	OR			
4(a)	**Identify** and explanation for 802.15.4 physical layer, MAC layer and security.	6	CO2	Applying (K3)
(b)	**Identify** the different types of data analysis result.	6	CO4	Applying (K3)

Course in charge

Module Coordinator

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II SESSIONAL TEST 2020 – 21 EVEN SEMESTER

SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VIII**
Branch	:	**Computer Science and Engineering**	**Course Code**	:	**15/17CS81**
Course Title	:	**IoT Technology**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1(a)	**There are 2 broad classification of IoT Application protocol** 1. **The Transport Layer:** IP-based networks use either TCP or UDP. However, the constrained nature of IoT networks requires a closer look at the use of these traditional transport mechanisms. 2. **IoT Application Transport Methods:** There are various types of IoT application data and the ways this data can be carried across a network. 1. **The Transport Layer** This Transport Layer reviews the selection of a protocol for the transport layer as supported by the TCP/IP architecture in the context of IoT networks. With the TCP/IP protocol, two main protocols are specified for the transport layer: ■ Transmission Control Protocol (TCP): This connection-oriented protocol requires a session to get established between the source and destination before exchanging data. You can view it as an equivalent to a traditional telephone conversation, in which two phones must be connected and the communication link established before the parties can talk. ■ User Datagram Protocol (UDP): With this connectionless protocol, data can be quickly sent between source and destination—but with no guarantee of delivery. This is analogous to the traditional mail delivery system, in which a letter is mailed to a destination. Confirmation of the reception of this letter does not happen until another letter is sent in response.	3M
	2. **IoT Application Transport Methods** The following categories of IoT application protocols and their transport methods are explored in the following sections: ■ Application layer protocol not present: In this case, the data payload is directly transported on top of the lower layers. No application layer protocol is used.	3M

	■ Supervisory control and data acquisition (SCADA): SCADA is one of the most common industrial protocols in the world, but it was developed long before the days of IP, and it has been adapted for IP networks. ■ Generic web-based protocols: Generic protocols, such as Ethernet, Wi-Fi, and 4G/LTE, are found on many consumer- and enterprise-class IoT devices that communicate over non-constrained networks. ■ IoT application layer protocols: IoT application layer protocols are devised to run on constrained nodes with a small compute footprint and are well adapted to the network bandwidth constraints on cellular or satellite links or constrained 6LoWPAN networks. Message Queuing Telemetry Transport (MQTT) and Constrained Application Protocol (CoAP), covered later in this chapter, are two well-known examples of IoT application layer protocols	
1 (b)	<u>The key advantages of internet protocol.</u> ■ Open and standards-based: Operational technologies have often been delivered as turnkey features by vendors who may have optimized the communications through closed and proprietary networking solutions. ■ Versatile: A large spectrum of access technologies is available to offer connectivity of "things" in the last mile. Additional protocols and technologies are also used to transport IoT data through backhaul links and in the data center. ■ Ubiquitous: All recent operating system releases, from general-purpose computers and servers to lightweight embedded systems (TinyOS, Contiki, and so on), have an integrated dual (IPv4 and IPv6) IP stack that gets enhanced over time. ■ Scalable: As the common protocol of the Internet, IP has been massively deployed and tested for robust scalability. Millions of private and public IP infrastructure nodes have been operational for years, offering strong foundations for those not familiar with IP network management. ■ Manageable and highly secure: Communications infrastructure requires appropriate management and security capabilities for proper operations. ■ Stable and resilient: IP has been around for 30 years, and it is clear that IP is a workable solution. IP has a large and well-established knowledge base and, more importantly, it has been used for years in critical infrastructures, such as financial and defense networks. ■ Consumers' market adoption: When developing IoT solutions and products targeting the consumer market, vendors know that consumers' access to applications and devices will occur predominantly over broadband and mobile wireless infrastructure. ■ The innovation factor: The past two decades have largely established the adoption of IP as a factor for increased innovation. IP is the underlying protocol for applications ranging from file transfer and e-mail to the World Wide Web, e-commerce, social networking, mobility, and more.	**List – 3M** + **Explain – 3M**

1 (c)

1 (c) **Need for optimization**

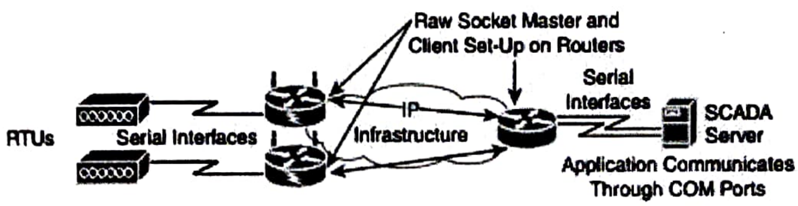
The following sections take a detailed look at why optimization is necessary for IP. Both the nodes and the network itself can often be constrained in IoT solutions.

1) **Constrained Nodes**
2) **Constrained Networks.**

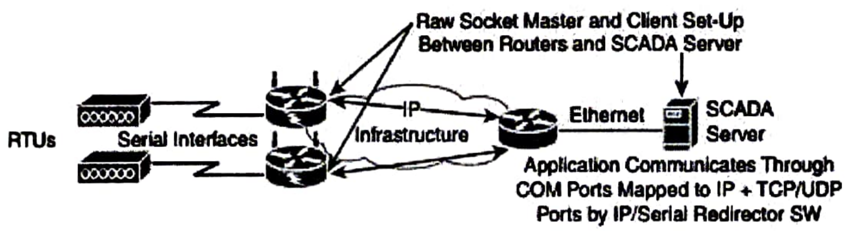
IP Versions. (Explain each with an example)

6M

2(a)

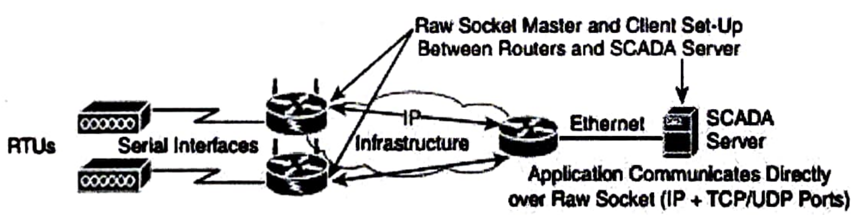


Scenario A: Raw Socket between Routers – no change on SCADA server



Scenario B: Raw Socket between Router and SCADA Server – no SCADA application change on server but IP/Serial Redirector software and Ethernet Interface to be added

3M



Scenario C: Raw Socket between Router and SCADA Server – SCADA application knows how to directly communicate over a Raw Socket and Ethernet Interface

In all the scenarios in Figure above, notice that routers connect via serial interfaces to the remote terminal units (RTUs), which are often associated with SCADA networks. An RTU is a multipurpose device used to monitor and control various systems, applications, and devices managing automation. From the master/slave perspective, the RTUs are the slaves. Opposite the RTUs in each Figure scenario is a SCADA server, or master, that varies its connection type. In reality, other legacy industrial application servers could be shown here as well.

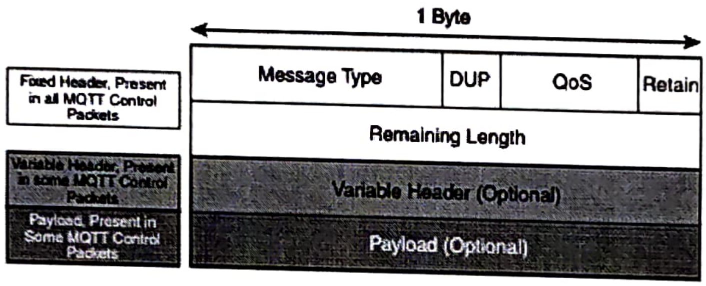
3M

In Scenario A, both the SCADA server and the RTUs have a direct serial connection to their respective routers. The routers terminate the serial connections at both ends of the link and use raw socket encapsulation to transport the serial payload over the IP network.

Scenario B has a small change on the SCADA server side. A piece of software is installed on the SCADA server that maps the serial COM ports to IP ports. This software is commonly referred to as an IP/serial redirector. The IP/serial redirector in essence terminates the serial connection of the SCADA server and converts it to a TCP/IP port using a raw socket connection.

In Scenario C, the SCADA server supports native raw socket capability. Unlike in Scenarios A and B, where a router or IP/serial redirector software has to map the SCADA server's serial ports to IP ports, in Scenario C the SCADA server has full IP support for raw socket connections.

2 (b) MQTT framework and message format in detail.



3M

MQTT Message Format

Overview of the MQTT message format is shown in the Figure above. Compared to the CoAP message format, you can see that MQTT contains a smaller header of 2 bytes compared to 4 bytes for CoAP. The first MQTT field in the header is Message Type, which identifies the kind of MQTT packet within a message. Fourteen different types of control packets are specified in MQTT version 3.1.1. Each of them has a unique value that is coded into the Message Type field. Note that values 0 and 15 are reserved. MQTT message types are summarized in below Table.

MQTT Message Types

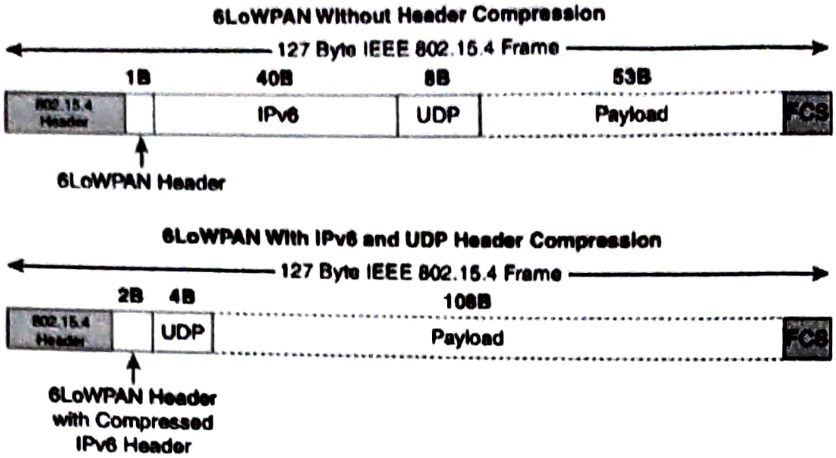
3M

Message Type	Value	Flow	Description
CONNECT	1	Client to server	Request to connect
CONNACK	2	Server to client	Connect acknowledgement
PUBLISH	3	Client to server Server to client	Publish message
PUBACK	4	Client to server Server to client	Publish acknowledgement
PUBREC	5	Client to server Server to client	Publish received
PUBREL	6	Client to server Server to client	Publish release
PUBCOMP	7	Client to server Server to client	Publish complete
SUBSCRIBE	8	Client to server	Subscribe request
SUBACK	9	Server to client	Subscribe acknowledgement
UNSUBSCRIBE	10	Client to server	Unsubscribe request
UNSUBACK	11	Server to client	Unsubscribe acknowledgement
PINGREQ	12	Client to server	Ping request
PINGRESP	13	Server to client	Ping response
DISCONNECT	14	Client to server	Client disconnecting

2 (c) **<u>6LOWPAN protocol header compression</u>**

3M

IPv6 header compression for 6LoWPAN was defined initially in RFC 4944 and subsequently updated by RFC 6282. This capability shrinks the size of IPv6's 40-byte headers and User Datagram Protocol's (UDP's) 8-byte headers down as low as 6 bytes combined in some cases. Note that header compression for 6LoWPAN is only defined for an IPv6 header and not IPv4. The 6LoWPAN protocol does not support IPv4, and, in fact, there is no standardized IPv4 adaptation layer for IEEE 802.15.4.6LoWPAN header compression is stateless, and conceptually it is not too complicated. However, a number of factors affect the amount of compression, such as implementation of RFC 4944 versus RFC 6922, whether UDP is included, and various IPv6 addressing scenarios. It is beyond the scope of this book to cover every use case and how the header fields change for each. However, this chapter provides an example that shows the impact of 6LoWPAN header compression. At a high level, 6LoWPAN works by taking advantage of shared information known by all nodes from their participation in the local network. In addition, it omits some standard header fields by assuming commonly used values. Figure below highlights an example that shows the amount of reduction that is possible with 6LoWPAN header compression.



6LoWPAN Header Compression

Fragmentation

The maximum transmission unit (MTU) for an IPv6 network must be at least 1280 bytes. The term MTU defines the size of the largest protocol data unit that can be passed. For IEEE 802.15.4, 127 bytes is the MTU. You can see that this is a problem because IPv6, with a much larger MTU, is carried inside the 802.15.4 frame with a much smaller one. To remedy this situation, large IPv6 packets must be fragmented across multiple 802.15.4 frames at Layer 2

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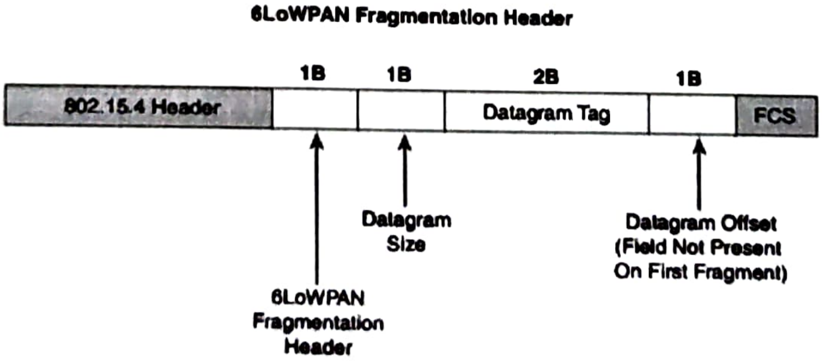
The fragment header utilized by 6LoWPAN is composed of three primary fields: Datagram Size, Datagram Tag, and Datagram Offset. The 1-byte Datagram Size field specifies the total size of the un fragmented payload. Datagram Tag identifies the set of fragments for a payload. Finally, the Datagram Offset field delineates how far into a payload a particular fragment occurs. Figure below provides an overview of a 6LoWPAN fragmentation header.



6LoWPAN Fragmentation Header

3 (a)	<u>LoRaWAN standardization and Alliances</u>	6M

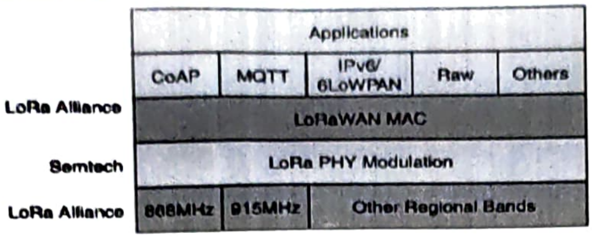


Fig. LoRaWAN Layer

Provide explanation for LoRaWAN standardization and alliances

<u>LoRaWAN MAC Layer Format</u>

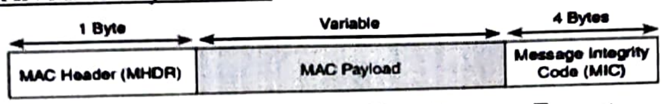


Fig. High-Level LoRaWAN MAC Frame Format

Provide explanation for LoRaWan MAC Layer Format

<u>LoRaWAN Security</u>

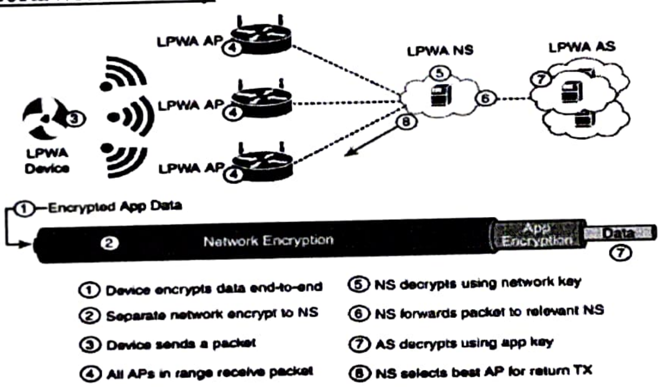
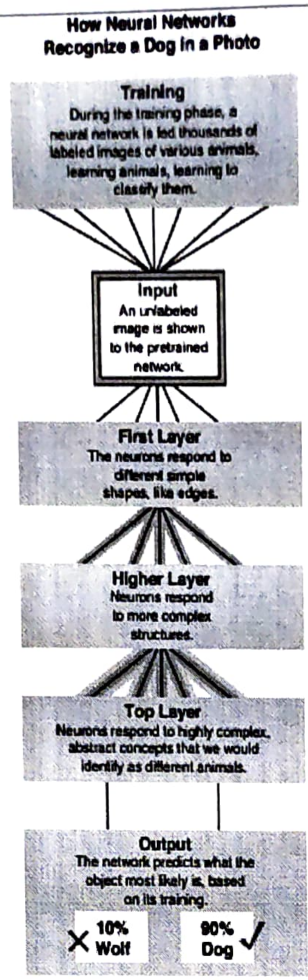


Fig. LoRaWAN Security

Provide explanation for LoRaWan Security

3(b) <u>Neural network concept in machine learning with a detailed example.</u>

Neural networks are ML methods that mimic the way the human brain works. When you look at a human figure, multiple zones of your brain are activated to recognize colors, movements, facial expressions, and so on. Your brain combines these elements to conclude that the shape you are seeing is human. Neural networks mimic the same logic. The information goes through different algorithms (called units), each of which is in charge of processing an aspect of the information. The resulting value of one unit computation can be used directly or fed into another unit for further processing to occur. In this case, the neural network is said to have several layers. The great efficiency of neural networks is that each unit processes a simple test, and therefore computation is quite fast. This model is demonstrated in Figure below. 6M



Neural Network Example

4 (a)	<u>LoRaWAN standardization and Alliances</u>	6M

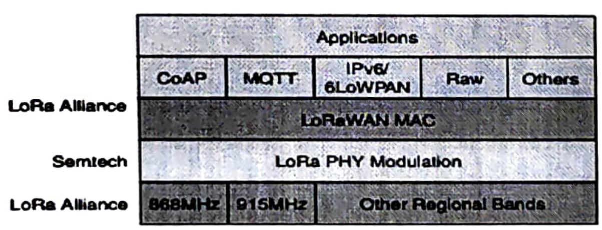


Fig. LoRaWAN Layer

Provide explanation for LoRaWAN standardization and alliances

<u>LoRaWAN MAC Layer Format</u>

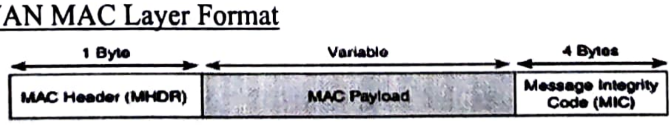


Fig. High-Level LoRaWAN MAC Frame Format

Provide explanation for LoRaWan MAC Layer Format

<u>LoRaWAN Security</u>

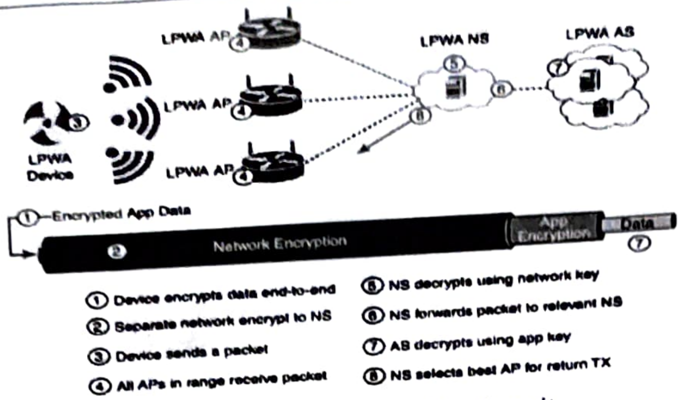


Fig. LoRaWAN Security

	Provide explanation for LoRaWan Security	
4(b)	Mentioning and explanation of types of data analysis result	6M

Course in charge

Module Coordinator

HOD

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III SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

USN | | | | | | | | | |

SET-A

Degree	:	B.E	Semester:	VIII
Branch	:	Computer Science and Engineering	Course Code:	15 / 17CS81
Course Title	:	IoT Technology	Date:	18.06.2021
Duration	:	90 Minutes	Max Marks:	30

Note: Answer ONE full question from each part.

Q No.	Questions	Marks	CO Mapping	K-Level
	PART-A			
1(a)	**Develop** an explanation Raspberry Pi learning board.	6	CO5	Applying (K3)
(b)	**Build** a python program on Raspberry Pi to blink an LED.	6	CO5	Applying (K3)
(c)	**Identify** the different pins / parts of Arduino Uno Board.	6	CO5	Applying (K3)
	OR			
2(a)	**Develop** the explanation the different layers of IoT Smart City layered architecture.	6	CO5	Applying (K3)
(b)	**Identify** Smart parking architecture with advantages and disadvantages.	6	CO5	Applying (K3)
(c)	**Construct** a brief note on Arduino UNO.	6	CO5	Applying (K3)
	PART-B			
3(a)	**Identify** neural network in machine learning with a detailed example.	6	CO4	Applying (K3)
(b)	**Develop** an explanation of data and analytics for IoT.	6	CO4	Applying (K3)
	OR			
4(a)	**Identify** the elements of Hadoop with a neat diagram.	6	CO4	Applying (K3)
(b)	**Develop** an explanation in detail how IT and OT security practices and systems vary in real time.	6	CO4	Applying (K3)

Course in-charge

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III SESSIONAL TEST 2020 – 21 EVEN SEMESTER

SET - A

SCHEME AND SOLUTION

Degree	: **B.E**	**Semester**	: **VIII**
Branch	: **Computer Science and Engineering**	**Course Code**	: **15 / 17CS81**
Course Title	: **IoT Technology**	**Max Marks**	: **30**

Q.NO.	POINTS	MARKS
1(a)	Raspberry Pi is a small single board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer. Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications. Raspberry Pi is slower than laptop or desktop but is still a computer which can provide all the expected features or abilities, at a low power consumption. Raspberry Pi Foundation officially provides Debian based Raspbian OS. Also, they provide NOOBS OS for Raspberry Pi. We can install several Third-Party versions of OS like Ubuntu, Archlinux, RISC OS, Windows 10 IOT Core, etc. Raspbian OS is official Operating System available for free to use. This OS is efficiently optimized to use with Raspberry Pi. Raspbian have GUI which includes tools for Browsing, Python programming, office, games, etc. Raspberry Pi is more than computer as it provides access to the on-chip hardware i.e. GPIOs for developing an application. By accessing GPIO, we can connect devices like LED, motors, sensors, etc and can control them too. It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit).The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB.	3M
	<u>Hardware Components of Raspberry Pi are:</u> **HDMI (High-Definition Multimedia Interface):** It is used for transmitting uncompressed video or digital audio data to the Computer Monitor, Digital TV, etc. Generally, this HDMI port helps to connect Raspberry Pi to the Digital television. **CSI Camera Interface:** CSI (Camera Serial Interface) interface provides a connection in between Broadcom Processor and Pi camera. This interface provides electrical connections between two devices. **DSI Display Interface:** DSI (Display Serial Interface) Display Interface is used for connecting LCD to the Raspberry Pi using 15-pin ribbon cable. DSI	3M

1 (b)	provides fast High-resolution display interface specifically used for sending video data directly from GPU to the LCD display.
	Composite Video and Audio Output: The composite Video and Audio output port carries video along with audio signal to the Audio/Video systems.
	Power LED: It is a RED colored LED which is used for Power indication. This LED will turn ON when Power is connected to the Raspberry Pi. It is connected to 5V directly and will start blinking whenever the supply voltage drops below 4.63V.
	ACT PWR: ACT PWR is Green LED which shows the SD card activity.
	
	After creating the created we need to write the Python script to blink the LED. Before we start writing the software we first need to install the Raspberry Pi GPIO Python module. This is a library that allows us to access the GPIO port directly from Python.
	
	To install the Python library open a terminal and execute the following
	
	$ sudo apt-get install python-rpi.gpio python3-rpi.gpio
	
	With the library installed now open your favorite Python IDE (I recommend Thonny Python IDE more information about using it here).
	
	Our script needs to do the following:
	
	• Initialize the GPIO ports
	• Turn the LED on and off in 1 second intervals
	
	To initialize the GPIO ports on the Raspberry Pi we need to first import the Python library, the initialize the library and setup pin 8 as an output pin.
	
	import RPi.GPIO as GPIO # Import Raspberry Pi GPIO library
	from time import sleep # Import the sleep function from the time module
	GPIO.setwarnings(False) # Ignore warning for now
	GPIO.setmode(GPIO.BOARD) # Use physical pin numbering
	GPIO.setup(8, GPIO.OUT, initial=GPIO.LOW) # Set pin 8 to be an output pin and set initial value to low (off)
	
	Next we need to turn the LED on and off in 1 second intervals by setting the output pin to either high (on) or low (off). We do this inside a infinite loop so our program keep executing until we manually stop it.
	
	while True: # Run forever
	  GPIO.output(8, GPIO.HIGH) # Turn on
	  sleep(1) # Sleep for 1 second
	  GPIO.output(8, GPIO.LOW) # Turn off
	  sleep(1)
		2M
		
		2M
		
		2M

1 (c)	Combining the initialization and the blink code should give you the following full Python program:
	
	import RPi.GPIO as GPIO # Import Raspberry Pi GPIO library from time.
	import sleep # Import the sleep function from the time module
	GPIO.setwarnings(False) # Ignore warning for now
	
	GPIO.setmode(GPIO.BOARD) # Use physical pin numbering
	GPIO.setup(8, GPIO.OUT, initial=GPIO.LOW) # Set pin 8 to be an output pin and set initial value to low (off)
	
	while True: # Run forever
	GPIO.output(8, GPIO.HIGH) # Turn on
	sleep(1) # Sleep for 1 second
	GPIO.output(8, GPIO.LOW) # Turn off
	sleep(1) # Sleep for 1 second
	
	With our program finished, save it as blinking_led.py and run it either inside your IDE or in the console with:
	
	$ python blinking_led.py
	
	Power (USB / Barrel Jack): The USB connection is also how you will load code onto your Arduino board.
	
	Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)
	The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.
	
	GND (3): Short for 'Ground'. There are several GND pins on the Arduino, any of which can be used to ground your circuit.
	
	5V (4) & 3.3V (5): As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.
	
	Analog (6): The area of pins under the 'Analog In' label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
	
	Digital (7): Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).
	
	PWM (8): You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation
		1M
		
		1M
		
		1M

	(PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out). **AREF (9):** Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins. **Reset Button** Just like the original Nintendo, the Arduino has a reset button (10). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. **Power LED Indicator** Just beneath and to the right of the word "UNO" on your circuit board, there's a tiny LED next to the word 'ON' (11). **TX RX LEDs** TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. **Main IC** The black thing with all the metal legs is an IC, or Integrated Circuit (13). Think of it as the brains of our Arduino. The main IC on the Arduino is slightly different from board type to board type. **Voltage Regulator** The voltage regulator (14) is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it's for.	**1M** **1M** **1M**
2 (a)	The Information and Communication Technology (ICT) architecture of a smart city has 4 layers: sensing, communication, data, and service. **Layer 1: Sensing** The sensing layer has a varied set of IoT nodes that are spread across an urban area. These nodes collect data about various activities in the physical environment. An IoT node is a package that comprises sensors, microchips, power supply, and network elements. IoT nodes are categorized into 2 different categories based on their operating conditions: ➢ Constrained node: These nodes operate in a low-power environment. They have low processing power and a low data-transfer rate. ➢ Unconstrained node: These nodes have no operational constraints in terms of power consumption, processing rate, and data-transfer rate **Layer 2: Communications**	**2M** **2M**

	Every smart city system has a billion IoT nodes that are spread across the city. These IoT nodes should be addressed individually. This is made possible with IPv6, which provides a128-bit address field. However, the overheads that are introduced by IPv6 (in addressing the IoT nodes) are not compatible with constrained devices, and therefore 6LoWPAN (Low Power personal Area Network) was adopted. For seamless translation from IPv6 to 6LoWPAN and vice versa, a bridge router is attached to the 6LoWPAN network. An IPv6 packet that is intended for a node in 6LoWPAN gets converted into 6LoWPAN with the help of a bridge router and vice versa. **Layer 3: Data** This is the intelligence layer of smart-city architecture. A mega smart city can work effectively and efficiently only if the data about the city is organized systematically. **Layer 4: Service** This layer acts as a cross-department operation center. Various city boards such as, water-supply board, power-supply board, pollution-control board, transport department etc.. share information by using web portals/mobile applications that are built on this layer. This layer will not just serve government departments by sharing information but also the general public that has access to a subset of all the data. By using this data the public can build services to enhance the operations of the city.	**1M** **1M**
2 (b)	The most conventional technical definition is that smart parking system is a system that collects and disseminates real-time parking space availability data. Of course such systems may incorporate different business logic and value added services that sometimes may have technical implications but we will start with getting the tech basics right. The today's choice of technological tools to collect real-time parking availability data boils down to three broad categories of systems: (1) Cameras, (2) Overhead radars/Lidars and (3) Ground sensors. Each of them has its own advantages and disadvantages and the choice of a particular smart car parking system depends on specific project requirements. Cameras seem to be the most rational approach since it allows monitoring many parking spaces at once. Cameras show good results in test environments where computer vision models are trained for particular settings and vehicle types. However, real-world parking has a much greater variety of viewing angles, lighting conditions, and many other challenges. **Camera-based systems can be classified into two types:**	**4M**

	Cloud-based/server processing: videos or snapshots are streamed to the cloud or powerful on-premise server. On-board processing: the system recognizes vehicles locally and sends the parking events and images when required. This solution brings high operating costs since the operator has to train the model for a particular setting. Putting all computer vision problems aside, one of the biggest real-life challenges for camera based solutions is to obtain reasonable quality and clarity pictures at all times and weather conditions. So camera-based solutions can work well in large open space lots like those in supermarkets or airports, well lit at evening time and preferably not much snow. Overhead radars/lidars can detect the presence of a vehicle using radio signals and laser light reflections. The system provides accurate results within 7 metres but at a greater distance and sharper reflection angles its accuracy decreases, so, mains powered sensor fixed on a lamp post can reliably cover only 4-5 parking spots. Ground sensors are considered to be a universal method to monitor the parking occupancy. Battery-powered wireless sensors are installed on each parking space and are not affected by line of sight interference. The proximity to the detected object lets ground sensors provide accurate results at a reasonable maintenance cost. Currently, ground sensors are considered the most flexible and efficient way to address parking problems.	**2M**
2 (c)	Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards. <u>Features of Arduino Uno Board</u> The features of Arduino Uno ATmega328 includes the following: ➢ The operating voltage is 5V ➢ The recommended input voltage will range from 7v to 12V ➢ The input voltage ranges from 6v to 20V ➢ Digital input/output pins are 14	**2M** **2M** **2M**

- ➤ Analog i/p pins are 6
- ➤ DC Current for each input/output pin is 40 mA
- ➤ DC Current for 3.3V Pin is 50 mA
- ➤ Flash Memory is 32 KB
- ➤ SRAM is 2 KB
- ➤ EEPROM is 1 KB
- ➤ CLK Speed is 16 MHz

Q.NO.	POINTS	MARKS

PART-B

3 (a) Neural Network in Machine Learning

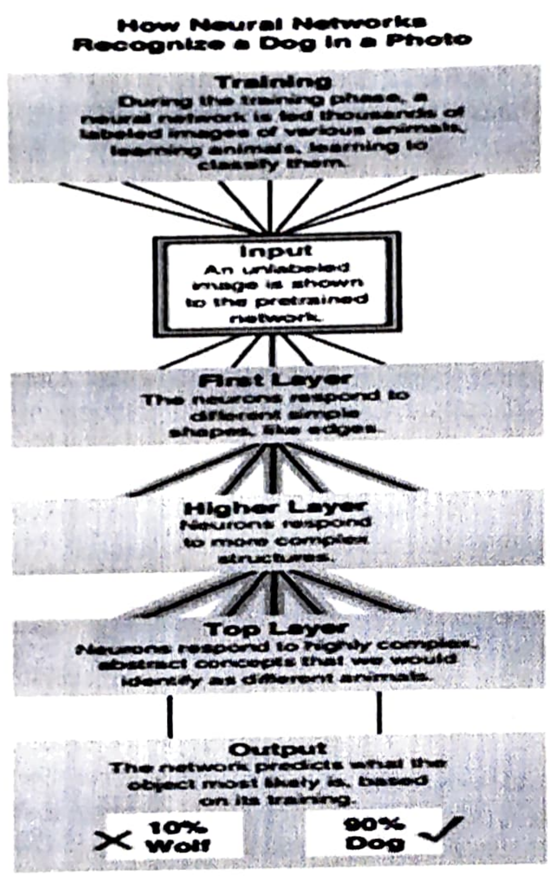


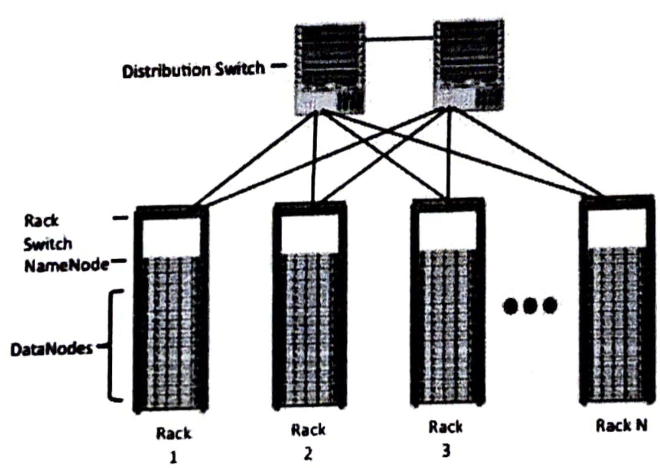
Fig. Neural Network Example

3M

Neural networks are ML methods that mimic the way the human brain works. When you look at a human figure, multiple zones of your brain are activated to recognize colors, movements, facial expressions, and so on. Your brain combines these elements to conclude that the shape you are seeing is human. Neural networks mimic the same logic. The information goes through different algorithms (called units), each of which is in charge of processing an aspect of the information. The resulting value of one unit computation can be used directly or fed into another unit for further processing to occur. In this case, the neural network is said to have several

3M

	layers. For example, a neural network processing human image recognition may have two units in a first layer that determines whether the image has straight lines and sharp angles—because vehicles commonly have straight lines and sharp angles, and human figures do not. If the image passes the first layer successfully (because there are no or only a small percentage of sharp angles and straight lines), a second layer may look for different features (presence of face, arms, and so on), and then a third layer might compare the image to images of various animals and conclude that the shape is a human (or not). The great efficiency of neural networks is that each unit processes a simple test, and therefore computation is quite fast. This model is demonstrated in the Figure above	
3 (b)	In the world of IoT, the creation of massive amounts of data from sensors is common and one of the biggest challenges—not only from a transport perspective but also from a data management standpoint. A great example of the deluge of data that can be generated by IoT is found in the commercial aviation industry and the sensors that are deployed throughout an aircraft. Modern jet engines are fitted with thousands of sensors that generate a whopping 10GB of data per second. For example, modern jet engines, similar to the one shown in Figure below, may be equipped with around 5000 sensors. Therefore, a twin engine commercial aircraft with these engines operating on average 8 hours a day will generate over 500 TB of data daily, and this is just the data from the engines! Aircraft today have thousands of other sensors connected to the airframe and other systems. In fact, a single wing of a modern jumbo jet is equipped with 10,000 sensors The potential for a petabyte (PB) of data per day per commercial airplane is not far-fetched—and this is just for one airplane. Across the world, there are approximately 100,000 commercial flights per day. The amount of IoT data coming just from the commercial airline business is overwhelming.	2M
	<u>Structured Versus Unstructured Data</u> Structured data and unstructured data are important classifications as they typically require different toolsets from a data analytics perspective. Structured data means that the data follows a model or schema that defines how the data is represented or organized, meaning it fits well with a traditional relational database management system (RDBMS). In many cases you will find structured data in a simple tabular form—for example, a spreadsheet where data occupies a specific cell and can be explicitly defined and referenced.	1M
	<u>Data in Motion Versus Data at Rest</u> As in most networks, data in IoT networks is either in transit ("data in motion") or being held or stored ("data at rest"). Examples of data in motion include traditional client/server exchanges, such as web browsing and file transfers, and email. Data saved to a hard drive, storage array, or USB drive is data at rest.	1M

	<u>IoT Data Analytics Overview</u> The true importance of IoT data from smart objects is realized only when the analysis of the data leads to actionable business intelligence and insights.	**1M**
	There are four types of data analysis results: ➢ Descriptive: Descriptive data analysis tells you what is happening, either now or in the past. ➢ Diagnostic: When you are interested in the "why," diagnostic data analysis can provide the answer. ➢ Predictive: Predictive analysis aims to foretell problems or issues before they occur. ➢ Prescriptive: Prescriptive analysis goes a step beyond predictive and recommends solutions for upcoming problems.	**1M**
4 (a)	Hadoop is the most recent entrant into the data management market, but it is arguably the most popular choice as a data repository and processing engine. Hadoop was originally developed as a result of projects at Google and Yahoo!, and the original intent for Hadoop was to index millions of websites and quickly return search results for open source search engines. Initially, the project had two key elements:	**2M**
	Hadoop Distributed File System (HDFS): A system for storing data across multiple nodes. **MapReduce:** A distributed processing engine that splits a large task into smaller ones that can be run in parallel. Both of these elements are still present in current Hadoop distributions and provide the foundation for other projects.	**2M**
	 *Distributed Hadoop Cluster*	**1M**

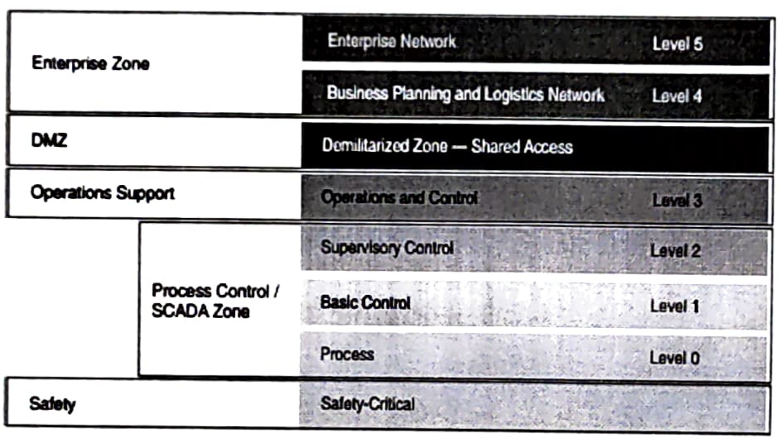
Much like the MPP and NoSQL systems discussed earlier, Hadoop relies on a scale-out architecture that leverages local processing, memory, and storage to distribute tasks and provide a scalable storage system for data. Both MapReduce and HDFS take advantage of this distributed architecture to store and process massive amounts of data and are thus able to leverage resources from all nodes in the cluster. For HDFS, this capability is handled by specialized nodes in the cluster, including NameNodes and DataNodes

- NameNodes: These are a critical piece in data adds, moves, deletes, and reads on HDFS. **1M**
- DataNodes: These are the servers where the data is stored at the direction of the NameNode.

4(b) <u>IT and OT security practices and systems vary in real time.</u>

- <u>The Purdue Model for Control Hierarchy</u>

Regardless of where a security threat arises, it must be consistently and unequivocally treated. IT information is typically used to make business decisions, such as those in process optimization, whereas OT information is instead characteristically leveraged to make physical decisions, such as closing a valve, increasing pressure, and so on.



The Logical Framework Based on the Purdue Model for Control Hierarchy **2M**

This model identifies levels of operations and defines each level.

Enterprise zone

- Level 5: Enterprise network: Corporate-level applications such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), document management, and services such as Internet access and VPN entry from the outside world exist at this level. **1M**

	➢ Level 4: Business planning and logistics network: The IT services exist at this level and may include scheduling systems, material flow applications, optimization and planning systems, and local IT services such as phone, email, printing, and security monitoring. **Industrial demilitarized zone** ➢ DMZ: The DMZ provides a buffer zone where services and data can be shared between the operational and enterprise zones. **Operational zone** ➢ Level 3: Operations and control: This level includes the functions involved in managing the workflows to produce the desired end products and for monitoring and controlling the entire operational system. ➢ Level 2: Supervisory control: This level includes zone control rooms, controller status, control system network/application administration, and other controlrelated applications, such as human-machine interface (HMI) and historian. ➢ Level 1: Basic control: At this level, controllers and IEDs, dedicated HMIs, and other applications may talk to each other to run part or all of the control function. ➢ Level 0: Process: This is where devices such as sensors and actuators and machines such as drives, motors, and robots communicate with controllers or IEDs. **Safety zone** ➢ Safety-critical: This level includes devices, sensors, and other equipment used to manage the safety functions of the control system	1M 1M 1M

Course in-charge **Module Coordinator** **Head of the Department**

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III SESSIONAL TEST QUESTION PAPER 2020 – 21 ODD SEMESTER

USN | | | | | | | | | | |

SET-B

Degree	:	B.E	Semester:	VIII
Branch	:	Computer Science and Engineering	Course Code:	15 / 17CS81
Course Title	:	IoT Technology	Date:	19.07.2021
Duration	:	90 Minutes	Max Marks:	30

Note: Answer ONE full question from each part.

Q No.	Questions	Marks	CO mapping	K-Level
	PART-A			
1(a)	Discuss Street Lighting Architecture with advantages and disadvantages	6	CO5	Applying (K3)
(b)	Develop a code and explain with circuit diagram to blink an LED on Arduino UNO board.	6	CO5	Applying (K3)
(c)	Discuss the communications of Arduino Uno Board.	6	CO5	Applying (K3)
	OR			
2(a)	Identify the different layers of IoT Smart City layered architecture.	6	CO5	Applying (K3)
(b)	Discuss Raspberry Pi learning board.	6	CO5	Applying (K3)
(c)	Discuss Arduino UNO with its pins.	6	CO5	Applying (K3)
	PART-B			
3(a)	Discuss Flexible net flow architecture	6	CO4	Applying (K3)
(b)	Discuss how IT and OT security practices and systems vary in real time.	6	CO4	Applying (K3)
	OR			
4(a)	Identify the elements of Hadoop with a neat diagram.	6	CO4	Applying (K3)
(b)	Discuss data and analytics for IoT	6	CO4	Applying (K3)

Course in charge   Module Coordinator   HOD

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III SESSIONAL TEST 2020 – 21 EVEN SEMESTER

SCHEME AND SOLUTION

Degree	:	**B.E**	**Semester**	:	**VIII**
Branch	:	**Computer Science and Engineering**	**Course Code**	:	**15 / 17CS81**
Course Title	:	**IoT Technology**	**Max Marks**	:	**30**

Q.NO.	POINTS	MARKS
1(a)	**Connected Street Lighting Solution** Cities commonly look for solutions to help reduce lighting expenses and at the same time improve operating efficiencies while minimizing upfront investment. The installation of a smart street lighting solution can provide significant energy savings and can also be leveraged to provide additional services. In this regard, light-emitting diode (LED) technology leads the transition from traditional street lighting to smart street lighting:- • LEDs require less energy to produce more light than legacy lights, and they have a much longer life span and a longer maintenance cycle. • A leading lighting company estimates that a complete switch to LED technology can reduce individual light bills by up to 70%.5 • LEDs are well suited to smart solution use cases. For example, LED color or light intensity can be adapted to site requirements (for example, warmer color and lower intensity in city centers, sun-like clarity on highways, time- and weather-adaptive intensity and color). Mentioning of advantages and disadvantages	6M

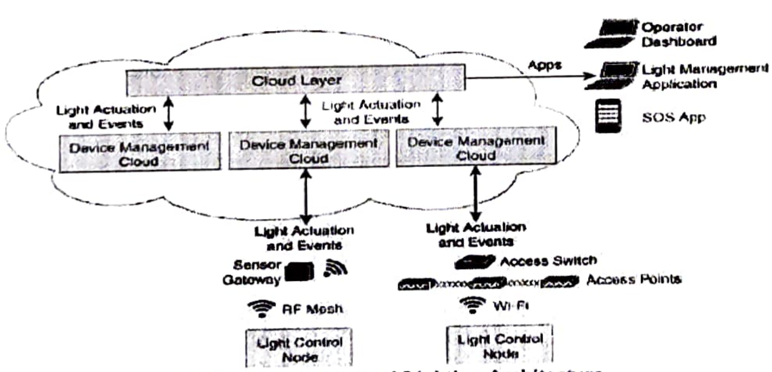


Figure 12-7 *Connected Lighting Architecture*

9.

1 (b)	Write the Python script to blink the LED. Before we start writing the software we first need to install the Raspberry Pi GPIO Python module. This is a library that allows us to access the GPIO port directly from Python.
	
	To install the Python library open a terminal and execute the following
	
	$ sudo apt-get install python-rpi.gpio python3-rpi.gpio
	
	With the library installed now open your favorite Python IDE (I recommend Thonny Python IDE more information about using it here).
	
	Our script needs to do the following:
	
	• Initialize the GPIO ports
	• Turn the LED on and off in 1 second intervals
	
	To initialize the GPIO ports on the Raspberry Pi we need to first import the Python library, the initialize the library and setup pin 8 as an output pin.
	
	import RPi.GPIO as GPIO # Import Raspberry Pi GPIO library
	from time import sleep # Import the sleep function from the time module
	GPIO.setwarnings(False) # Ignore warning for now
	GPIO.setmode(GPIO.BOARD) # Use physical pin numbering
	GPIO.setup(8, GPIO.OUT, initial=GPIO.LOW) # Set pin 8 to be an output pin and set initial value to low (off)
	
	Next we need to turn the LED on and off in 1 second intervals by setting the output pin to either high (on) or low (off). We do this inside a infinite loop so our program keep executing until we manually stop it.
	
	while True: # Run forever
	    GPIO.output(8, GPIO.HIGH) # Turn on
	    sleep(1) # Sleep for 1 second
	    GPIO.output(8, GPIO.LOW) # Turn off
	    sleep(1)
	
	Combining the initialization and the blink code should give you the following full Python program:
	
	import RPi.GPIO as GPIO # Import Raspberry Pi GPIO library from time.
	import sleep # Import the sleep function from the time module
	GPIO.setwarnings(False) # Ignore warning for now
	
	GPIO.setmode(GPIO.BOARD) # Use physical pin numbering
	GPIO.setup(8, GPIO.OUT, initial=GPIO.LOW) # Set pin 8 to be an output pin and set initial value to low (off)
		6M

```
while True: # Run forever
 GPIO.output(8, GPIO.HIGH) # Turn on
 sleep(1) # Sleep for 1 second
 GPIO.output(8, GPIO.LOW) # Turn off
 sleep(1) # Sleep for 1 second
```

With our program finished, save it as blinking_led.py and run it either inside your IDE or in the console with:

```
$ python blinking_led.py
```

1 (c) **Serial (UART) communications**

- **Serial communication on Arduino pins Tx/Rx uses TTL logic levels which operates at either 5V/3.3V depending the type of the board used.**
- **Tx/Rx pins should not be connected to any source which operates more than 5V which can damage the Arduino board.**
- **Serial communication is basically used for communication between Arduino board and a computer or some other compatible devices.** 6M

SPI communications

- **Serial peripheral Interface (SPI) is a synchronous data protocol used by large microcontrollers for communicating with one or more peripheral devices for a shorter distance and also used for communication between two devices.**
- **With SPI there will be always one master device which is a microcontroller like Arduino which controls the functionalities of other peripheral devices.**
- **Devices have three lines in common which are as follows:-**
  - ✓ **MISO (Master in Slave Out)- Slave line for sending data to the master.**
  - ✓ **MOSI (Master Out Slave In)- Master sending data to peripherals**
  - ✓ **SCK (Serial clock) - clock pulses which synchronize data transmission generated by the master And one of the specific line for every device is**
  - ✓ **SS (slave select) - pin on each device that the master can use to enable and disable specific devices.**

I^2C communications

- **Inter-Integrated circuit or I^2C (I squared C) is one of the best protocol used when a workload of one Arduino (Master Writer) is shared with another Arduino (Slave receiver).**
- **The I^2C protocol uses two lines to send and receive data which are a serial clock pin (SCL) which writes data at regular**

	intervals and a serial data pin (SDA) over which data sent between devices. ▪ **When the clock signal changes from LOW to HIGH the information, the address corresponds to a specific device and a command is transferred from board to the I^2C device over the SDA line.** ▪ **This information is sent bit by bit which is executed by the called device, executes and transmits the data back.** Explanation of different types of communication	
2 (a)	The Information and Communication Technology (ICT) architecture of a smart city has 4 layers: sensing, communication, data, and service. **Layer 1: Sensing** The sensing layer has a varied set of IoT nodes that are spread across an urban area. These nodes collect data about various activities in the physical environment. An IoT node is a package that comprises sensors, microchips, power supply, and network elements. IoT nodes are categorized into 2 different categories based on their operating conditions: ➢ Constrained node: These nodes operate in a low-power environment. They have low processing power and a low data-transfer rate. ➢ Unconstrained node: These nodes have no operational constraints in terms of power consumption, processing rate, and data-transfer rate **Layer 2: Communications** Every smart city system has a billion IoT nodes that are spread across the city. These IoT nodes should be addressed individually. This is made possible with IPv6, which provides a128-bit address field. However, the overheads that are introduced by IPv6 (in addressing the IoT nodes) are not compatible with constrained devices, and therefore 6LoWPAN (Low Power personal Area Network) was adopted. For seamless translation from IPv6 to 6LoWPAN and vice versa, a bridge router is attached to the 6LoWPAN network. An IPv6 packet that is intended for a node in 6LoWPAN gets converted into 6LoWPAN with the help of a bridge router and vice versa. **Layer 3: Data** This is the intelligence layer of smart-city architecture. A mega smart city can work effectively and efficiently only if the data about the city is organized systematically. **Layer 4: Service** This layer acts as a cross-department operation center. Various city boards such as, water-supply board, power-supply board, pollution-control board, transport department etc.. share information by using web portals/mobile	**6M**

	applications that are built on this layer. This layer will not just serve government departments by sharing information but also the general public that has access to a subset of all the data. By using this data the public can build services to enhance the operations of the city.	
2 (b)	Raspberry Pi is a small single board computer. By connecting peripherals like Keyboard, mouse, display to the Raspberry Pi, it will act as a mini personal computer. Raspberry Pi is popularly used for real time Image/Video Processing, IoT based applications and Robotics applications. Raspberry Pi is slower than laptop or desktop but is still a computer which can provide all the expected features or abilities, at a low power consumption. Raspberry Pi Foundation officially provides Debian based Raspbian OS. Also, they provide NOOBS OS for Raspberry Pi. We can install several Third-Party versions of OS like Ubuntu, Archlinux, RISC OS, Windows 10 IOT Core, etc. Raspbian OS is official Operating System available for free to use. This OS is efficiently optimized to use with Raspberry Pi. Raspbian have GUI which includes tools for Browsing, Python programming, office, games, etc. Raspberry Pi is more than computer as it provides access to the on-chip hardware i.e. GPIOs for developing an application. By accessing GPIO, we can connect devices like LED, motors, sensors, etc and can control them too. It has ARM based Broadcom Processor SoC along with on-chip GPU (Graphics Processing Unit).The CPU speed of Raspberry Pi varies from 700 MHz to 1.2 GHz. Also, it has on-board SDRAM that ranges from 256 MB to 1 GB. <u>Hardware Components of Raspberry Pi are:</u> **HDMI (High-Definition Multimedia Interface):** It is used for transmitting uncompressed video or digital audio data to the Computer Monitor, Digital TV, etc. Generally, this HDMI port helps to connect Raspberry Pi to the Digital television. **CSI Camera Interface:** CSI (Camera Serial Interface) interface provides a connection in between Broadcom Processor and Pi camera. This interface provides electrical connections between two devices. **DSI Display Interface:** DSI (Display Serial Interface) Display Interface is used for connecting LCD to the Raspberry Pi using 15-pin ribbon cable. DSI provides fast High-resolution display interface specifically used for sending video data directly from GPU to the LCD display. **Composite Video and Audio Output:** The composite Video and Audio output port carries video along with audio signal to the Audio/Video systems. **Power LED:** It is a RED colored LED which is used for Power indication. This LED will turn ON when Power is connected to the Raspberry Pi. It is connected to 5V directly and will start blinking whenever the supply voltage drops below 4.63V. **ACT PWR:** ACT PWR is Green LED which shows the SD card activity.	**6M**

<table>
<tr><td>2 (c)</td><td>

Arduino/Genuino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worring too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

<u>Features of Arduino Uno Board</u>
The features of Arduino Uno ATmega328 includes the following:

- The operating voltage is 5V
- The recommended input voltage will range from 7v to 12V
- The input voltage ranges from 6v to 20V
- Digital input/output pins are 14
- Analog i/p pins are 6
- DC Current for each input/output pin is 40 mA
- DC Current for 3.3V Pin is 50 mA
- Flash Memory is 32 KB
- SRAM is 2 KB
- EEPROM is 1 KB
- CLK Speed is 16 MHz

</td><td>6M</td></tr>
<tr><td colspan="3">PART-B</td></tr>
<tr><td>3 (a)</td><td>

- FNF is a flow technology developed by Cisco Systems that is widely deployed all over the world.
- Key advantages of FNF are as follows:
  - Flexibility, scalability, and aggregation of flow data
  - Ability to monitor a wide range of packet information and produce new information about network behavior
  - Enhanced network anomaly and security detection
  - User-configurable flow information for performing customized traffic identification and ability to focus and monitor specific network behavior
  - Convergence of multiple accounting technologies into one accounting mechanism
- **Flexible NetFlow in Multiservice IoT Networks**

</td><td>6M</td></tr>
</table>

- In the context of multiservice IoT networks, it is recommended that FNF be configured on the routers that aggregate connections from the last mile's routers.
- This gives a global view of all services flowing between the core network in the cloud and the IoT last-mile network.
- FNF can also be configured on the last-mile gateway or fog nodes to provide more granular visibility.

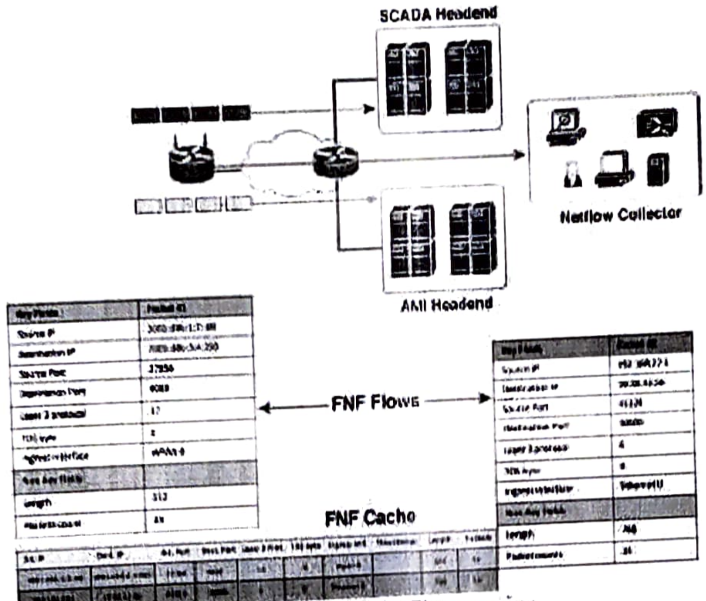


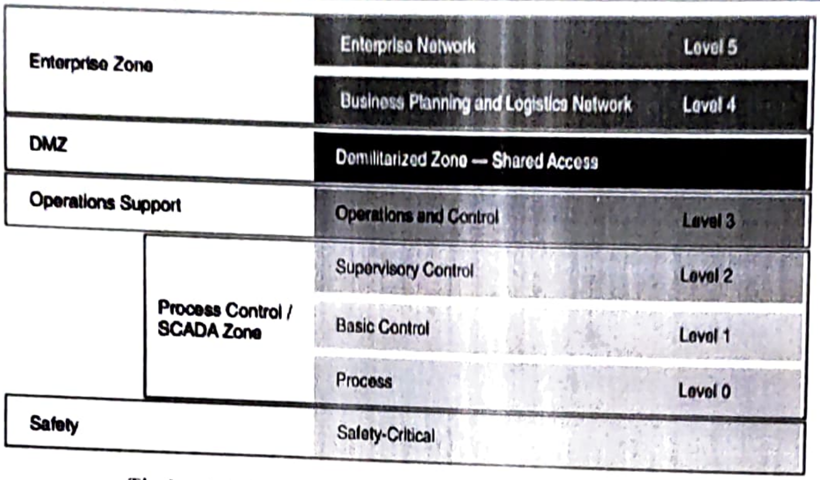
Figure 7-17 *Flexible NetFlow overview*

IT and OT security practices and systems vary in real time.

3 (b)

- The Purdue Model for Control Hierarchy

Regardless of where a security threat arises, it must be consistently and unequivocally treated. IT information is typically used to make business decisions, such as those in process optimization, whereas OT information is instead characteristically leveraged to make physical decisions, such as closing a valve, increasing pressure, and so on.



The Logical Framework Based on the Purdue Model for Control Hierarchy

This model identifies levels of operations and defines each level.

6M

Enterprise zone

- Level 5: Enterprise network: Corporate-level applications such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), document management, and services such as Internet access and VPN entry from the outside world exist at this level.

- Level 4: Business planning and logistics network: The IT services exist at this level and may include scheduling systems, material flow applications, optimization and planning systems, and local IT services such as phone, email, printing, and security monitoring.

Industrial demilitarized zone

- DMZ: The DMZ provides a buffer zone where services and data can be shared between the operational and enterprise zones.

Operational zone

- Level 3: Operations and control: This level includes the functions involved in managing the workflows to produce the desired end products and for monitoring and controlling the entire operational system.

- Level 2: Supervisory control: This level includes zone control rooms, controller status, control system network/application administration, and other controlrelated applications, such as human-machine interface (HMI) and historian.

- Level 1: Basic control: At this level, controllers and IEDs, dedicated HMIs, and other applications may talk to each other to run part or all of the control function.

- Level 0: Process: This is where devices such as sensors and actuators and machines such as drives, motors, and robots communicate with controllers or IEDs.

Safety zone

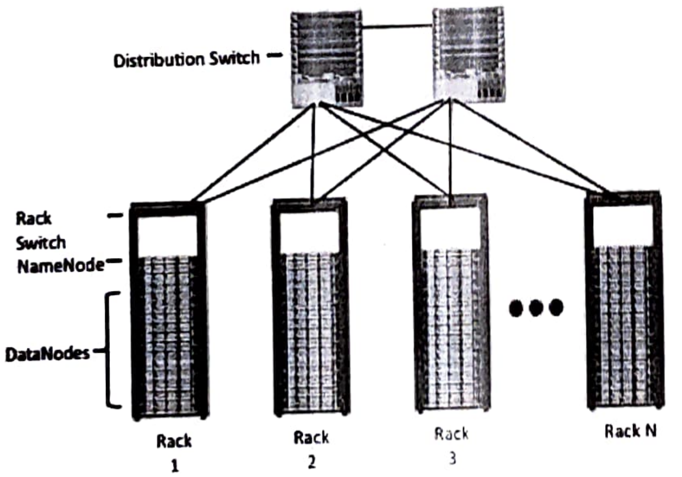
Safety-critical: This level includes devices, sensors, and other equipment used to manage the safety functions of the control system

4 (a)

Hadoop is the most recent entrant into the data management market, but it is arguably the most popular choice as a data repository and processing engine. Hadoop was originally developed as a result of projects at Google and Yahoo!, and the original intent for Hadoop was to index millions of websites and quickly return search results for open source search engines. Initially, the project had two key elements:

Hadoop Distributed File System (HDFS): A system for storing data across multiple nodes.

MapReduce: A distributed processing engine that splits a large task into smaller ones that can be run in parallel. Both of these elements are still present in current Hadoop distributions and provide the foundation for other projects.



Distributed Hadoop Cluster

Much like the MPP and NoSQL systems discussed earlier, Hadoop relies on a scale-out architecture that leverages local processing, memory, and storage to distribute tasks and provide a scalable storage system for data. Both MapReduce and HDFS take advantage of this distributed architecture to store and process massive amounts of data and are thus able to leverage resources from all nodes in the cluster. For HDFS, this capability is handled by specialized nodes in the cluster, including NameNodes and DataNodes

6M

4(b)	➢ NameNodes: These are a critical piece in data adds, moves, deletes, and reads on HDFS. ➢ DataNodes: These are the servers where the data is stored at the direction of the NameNode. There are four types of data analysis results: ➢ Descriptive: Descriptive data analysis tells you what is happening, either now or in the past. ➢ Diagnostic: When you are interested in the "why," diagnostic data analysis can provide the answer. ➢ Predictive: Predictive analysis aims to foretell problems or issues before they occur. ➢ Prescriptive: Prescriptive analysis goes a step beyond predictive and recommends solutions for upcoming problems	**6M**

Course in charge **Module Coordinator** **HOD**

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K.S. INSTITUTE OF TECHNOLOGY, BANGALORE

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

YEAR / SEMESTER	IV/8
COURSE TITLE	INTERNET OF THINGS
COURSE CODE	17CS81
ACADEMIC YEAR	2020-2021
INTERNALS	I

Sl. NO.	USN	NAME	1a	b	C	2a	b	C	3a	b	4a	b	TOTAL	Assignment	Total	CO'S	
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1	1KS17CS052	PARTH.P.SHAH				6	6	6	6	6			30	10	40	18	12
2	1KS17CS053	PAVANI.M	6	6	6				6	6			30	10	40	18	12
3	1KS17CS055	POOJA.R				6	6	6	6	6			30	10	40	18	12
4	1KS17CS056	PRASHANTH.K				6	6	6			6	6	30	10	40	18	12
5	1KS17CS057	PRAVEEN				5	6	5	6	6			28	10	38	16	12
6	1KS17CS058	PRAVEEN.A				6	5	5	6	6			28	10	38	16	12
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8	1KS17CS060	RAJASHREE SHIVAKUMAR				6	6	6	6	6			30	10	40	18	12
9	1KS17CS061	RAKSHITH.R				6	6	5	6	6			29	10	39	17	12
10	1KS17CS062	ROHITH.K				6	5	6	4	5			26	10	36	17	9
11	1KS17CS063	ROHITH.R				2	4	4	6	6			22	10	32	10	12
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15	1KS17CS067	S.MONIKA				6	6	6			5	5	28	10	38	18	10
16	1KS17CS069	SAI KUMAR.L.S	6	5	5				5	6			27	10	37	16	11
17	1KS17CS070	SAI SNEHA.S.V				6	6	6			6	6	30	10	40	18	12
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21	1KS17CS075	SHASHANK SHET.K				6	6	6	6	6			30	10	40	18	12
22	1KS17CS076	SHREYAS.R				6	6	6	6	6			30	10	40	18	12
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34	1KS17CS089	SWATI PAI				6	6	6	6	6			30	10	40	18	12

Sl. NO.	USN	NAME	1a	b	C	2a	b	C	3a	b	4a	b	TOTAL	Assignment	Total	CO'S	
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37	1KS17CS092	TEJAS.C.S				6	6	6	6	6			30	10	40	18	12
38	1KS17CS093	THARUN.K	5	5	5						5	6	26	10	36	15	11
39	1KS17CS094	VARSHINI.N.PRAKASH				6	6	6			6		24	10	34	18	6
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41	1KS17CS096	VARUN ATTIGANAL VENKATESH				6	6	6	6	6			30	10	40	18	12
42	1KS17CS097	VARUN.R.REDDY	5	5	5			5	5				25	10	35	20	5
43	1KS17CS098	VIKRAM SHIVAPPA CHATTARAKI				6	6	5			5	6	28	10	38	17	11
44	1KS17CS099	VINAY RAMARAO BIRADAR				5	6	6	5	6			28	10	38	17	11
45	1KS17CS100	VISHAL.M.S				6	6	6	6	6			30	10	40	18	12
46	1KS17CS101	VYBHAVI.J				6	6	6	6	6			30	10	40	18	12
47	1KS16CS110	VARNA.M				6	6	6	6	6			30	10	40	18	12
49	1KS15CS128	SHARADHA.A				6	6	6	6	6			30	10	20	18	12
50	1KS15CS125	ADARSH SHRESTHA											0	0	0	0	0
51	1KS17CS401	BHARATHI.R	4	6	6				6	6			28	10	19	16	12

COURSE INCHARGE

HOD

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

YEAR / SEMESTER	IV/8
COURSE TITLE	INTERNET OF THINGS
COURSE CODE	17CS81
ACADEMIC YEAR	2020-2021
INTERNALS	II

Sl. NO.	USN	NAME	1a	b	C	2a	b	c	3a	b	4a	b	TOTAL	Assignment	Total	CO'S		
			CO3	CO3	CO3	CO3	CO3	CO3	CO2	CO4	CO2	CO4				CO2	CO3	CO4
			6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	30 M			6 M	18 M	6 M
1	1KS17CS052	PARTH.P.SHAH	6	6	6				5	6			29	10	39	5	18	6
2	1KS17CS053	PAVANI.M	6	6	6				5	6			29	10	39	5	18	6
3	1KS17CS055	POOJA.R				6	6	6	6	6			30	10	40	6	18	6
4	1KS17CS056	PRASHANTH.K	6	5	6				5	6			28	10	38	5	17	6
5	1KS17CS057	PRAVEEN	6	5	5				5	6			27	10	37	5	16	6
6	1KS17CS058	PRAVEEN.A				6	6	6	6	5			29	10	39	6	18	5
7	1KS17CS059	PRAVEEN.S				5			5				10	10	20	5	5	0
8	1KS17CS060	RAJASHREE SHIVAKUMAR				6	0	6	6	6			24	10	34	6	12	6
9	1KS17CS061	RAKSHITH.R				6	6	5	6	6			29	10	39	6	17	6
10	1KS17CS062	ROHITH.K				6	6	5	5	6			28	10	38	5	17	6
11	1KS17CS063	ROHITH.R				6	6	5	5	5			27	10	37	5	17	5
12	1KS17CS064	ROOPASHREE.N				6	6	6			6	6	30	10	40	6	18	6
13	1KS17CS065	ROSHINI.R				6	6	6			6	6	30	10	40	6	18	6
14	1KS17CS066	RUCHITHA.G.K	6	6	6				6	6			30	10	40	6	18	6
15	1KS17CS067	S.MONIKA	6	6	6						6		24	10	34	6	18	0
16	1KS17CS069	SAI KUMAR.L.S	6	5	5				6	6			28	10	38	6	16	6
17	1KS17CS070	SAI SNEHA.S.V				6	6	6			6	6	30	10	40	6	18	6
18	1KS17CS071	SAKSHI KUMARI				6	6	6	6	6			30	10	40	6	18	6
19	1KS17CS072	SANDESH NAIKAL				6	6	6	6	6			30	10	40	6	18	6

Sl. NO.	USN	NAME	1a CO3 6 M	b CO3 6 M	C CO3 6 M	2a CO3 6 M	b CO3 6 M	c CO3 6 M	3a CO2 6 M	b CO4 6 M	4a CO2 6 M	b CO4 6 M	TOTAL 30 M	Assignment	Total	CO'S CO2 6 M	CO3 18 M	CO4 6 M
20	1KS17CS074	SHARANYA.H	6	6	5				0	6			23	10	33	0	17	6
21	1KS17CS075	SHASHANK SHET.K	6	6	6				6	6			30	10	40	6	18	6
22	1KS17CS076	SHREYAS.R	6	6	6				6	5			29	10	39	6	18	5
23	1KS17CS077	SHRI HARSHA KULKARNI				6	6	5	5	6			28	10	38	5	17	6
24	1KS17CS078	SINDHU.H.S	6	6	5						5	6	28	10	38	5	17	6
25	1KS17CS079	SINDHU.M	6	6	5						5	5	27	10	37	5	17	5
26	1KS17CS081	SPOORTHI.R	6	6	6				6	6			30	10	40	6	18	6
27	1KS17CS082	SPOORTHI.V				6	6	6	6	6			30	10	40	6	18	6
28	1KS17CS083	SRIKALA.K.M				6	6	6	6	6			30	10	40	6	18	6
29	1KS17CS084	SRUSHTI.A	6	6	6						6	6	30	10	40	6	18	6
30	1KS17CS085	SUJANA.G.N	6	6	6				6	6			30	10	40	6	18	6
31	1KS17CS086	SUPREETHA.R.KASHYAP	6	6	6				6	6			30	10	40	6	18	6
32	1KS17CS087	SUPRIYA.K	6	6	6				6	6			30	10	40	6	18	6
33	1KS17CS088	SURAKSHITHA.M	6	5	6						6	6	29	10	39	6	17	6
34	1KS17CS089	SWATI PAI				6	6	6	6	6			30	10	40	6	18	6
35	1KS17CS090	T.K.DHANUSHREE				6	6	6	5	6			29	10	39	5	18	6
36	1KS17CS091	TALUPULA SIVA SAI CHAITHANYA				6	6	6	5	5			28	10	38	5	18	5
37	1KS17CS092	TEJAS.C.S				6	6	6	6	6			30	10	40	6	18	6
38	1KS17CS093	THARUN.K				6	5	6	5	6			28	10	38	5	17	6
39	1KS17CS094	VARSHINI.N.PRAKASH				6	5	6	6	6			29	10	39	6	17	6
40	1KS17CS095	VARSHITHA.S	6	6	6						6	6	30	10	40	6	18	6
41	1KS17CS096	VARUN ATTIGANAL VENKATESH	6	6	6				6	5			29	10	39	6	18	5
42	1KS17CS097	VARUN.R.REDDY				6	6	6			0	6	24	10	34	0	18	6
43	1KS17CS098	VIKRAM SHIVAPPA CHATTARAKI	6	6	0				6	6			24	10	34	6	12	6
44	1KS17CS099	VINAY RAMARAO BIRADAR				6	6	5	6	5			28	10	38	6	17	5
45	1KS17CS100	VISHAL.M.S	6	6	6				6	6			30	10	40	6	18	6
46	1KS17CS101	VYBHAVI.J	6	6	6				6	6			30	10	40	6	18	6
47	1KS16CS110	VARNA.M				6	6	6	6	6			30	10	40	6	18	6
49	1KS15CS128	SHARADHA.A	6	6	6				6	6			15	5	20			
50	1KS15CS125	ADARSH SHRESTHA											0	0	0			
51	1KS17CS401	BHARATHI.R				6	6	6	6	6			15	5	20			

COURSE INCHARGE

HOD

Head of the Departme...
Dept. of Computer Science ...

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

YEAR / SEMESTER	IV/8
COURSE TITLE	INTERNET OF THINGS
COURSE CODE	17CS81
ACADEMIC YEAR	2020-2021
INTERNALS	III

Sl. NO.	USN	NAME	1a	b	C	2a	b	c	3a	b	4a	b	TOTAL	Assignment	Total	CO'S	
			C05	C05	C05	C05	C05	C05	CO4	CO4	C04	CO4				CO5	CO4
			6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	30 M			18 M	12 M
1	1KS17CS052	PARTH.P.SHAH				6	6	6			6	6	30	10	40	18	12
2	1KS17CS053	PAVANI.M				6	6	6			6	6	30	10	40	18	12
3	1KS17CS055	POOJA.R				6	6	6			6	6	30	10	40	18	12
4	1KS17CS056	PRASHANTH.K				5	5	5			5	5	25	10	35	15	10
5	1KS17CS057	PRAVEEN				5	6	6			5	6	28	10	38	17	11
6	1KS17CS058	PRAVEEN.A				6	6	6			6	6	30	10	40	18	12
7	1KS17CS059	PRAVEEN.S				5	6	6			6	6	29	10	39	17	12
8	1KS17CS060	RAJASHREE SHIVAKUMAR				6	6	6			6	6	30	10	40	18	12
9	1KS17CS061	RAKSHITH.R				6	6	6			6	6	30	10	40	18	12
10	1KS17CS062	ROHITH.K				6	5	6			5	6	28	10	38	17	11
11	1KS17CS063	ROHITH.R				6	6	6			6	6	30	10	40	18	12
12	1KS17CS064	ROOPASHREE.N				6	6	6			6	6	30	10	40	18	12
13	1KS17CS065	ROSHINI.R				6	5	6			6	6	29	10	39	17	12
14	1KS17CS066	RUCHITHA.G.K				6	6	6			6	6	30	10	40	18	12
15	1KS17CS067	S.MONIKA				6	6	5			6	6	29	10	39	17	12
16	1KS17CS069	SAI KUMAR.L.S				6	6	6			6	6	30	10	40	18	12

Sl. NO.	USN	NAME	1a	b	C	2a	b	c	3a	b	4a	b	TOTAL	Assignment	Total	CO'S	
			C05	C05	C05	C05	C05	C05	CO4	CO4	C04	CO4				CO5	CO4
			6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	30 M			18 M	12 M
17	1KS17CS070	SAI SNEHA.S.V				6	6	6			6	6	30	10	40	18	12
18	1KS17CS071	SAKSHI KUMARI				6	6	6			6	6	30	10	40	18	12
19	1KS17CS072	SANDESH NAIKAL				6	6	6			6	6	30	10	40	18	12
20	1KS17CS074	SHARANYA.H				6	6	0			6	6	24	10	34	12	12
21	1KS17CS075	SHASHANK SHET.K				6	6	6			6	6	30	10	40	18	12
22	1KS17CS076	SHREYAS.R				6	6	6			6	6	30	10	40	18	12
23	1KS17CS077	SHRI HARSHA KULKARNI				6	6	6			6	6	30	10	40	18	12
24	1KS17CS078	SINDHU.H.S				6	6	6			6	6	30	10	40	18	12
25	1KS17CS079	SINDHU.M				6	6	6			6	6	30	10	40	18	12
26	1KS17CS081	SPOORTHI.R				6	6	6			6	6	30	10	40	18	12
27	1KS17CS082	SPOORTHI.V				6	6	6			6	6	30	10	40	18	12
28	1KS17CS083	SRIKALA.K.M				6	6	6			6	6	30	10	40	18	12
29	1KS17CS084	SRUSHTI.A				6	6	6			6	6	30	10	40	18	12
30	1KS17CS085	SUJANA.G.N				6	6	6			6	6	30	10	40	18	12
31	1KS17CS086	SUPREETHA.R.KASHYAP				6	6	5			6	6	29	10	39	17	12
32	1KS17CS087	SUPRIYA.K				6	6	6			6	6	30	10	40	18	12
33	1KS17CS088	SURAKSHITHA.M				6	6	6			6	6	30	10	40	18	12
34	1KS17CS089	SWATI PAI				6	6	6			6	6	30	10	40	18	12
35	1KS17CS090	T.K.DHANUSHREE				6	6	6			6	6	30	10	40	18	12
36	1KS17CS091	TALUPULA SIVA SAI CHAITHANYA				6	6	6			6	6	30	10	40	18	12
37	1KS17CS092	TEJAS.C.S				6	6	6			6	6	30	10	40	18	12
38	1KS17CS093	THARUN.K				6	6	5			6	6	29	10	39	17	12
39	1KS17CS094	VARSHINI.N.PRAKASH				6	6	6			6	6	30	10	40	18	12
40	1KS17CS095	VARSHITHA.S				6	6	5			6	6	29	10	39	17	12
41	1KS17CS096	VARUN ATTIGANAL VENKATESH				6	6	6			6	6	30	10	40	18	12
42	1KS17CS097	VARUN.R.REDDY				6	5	6			5	6	28	10	38	17	11
43	1KS17CS098	VIKRAM SHIVAPPA CHATTARAKI				6	5	6			5	6	28	10	38	17	11
44	1KS17CS099	VINAY RAMARAO BIRADAR				6	5	5			5	6	27	10	37	16	11

Sl. NO.	USN	NAME	1a	b	C	2a	b	c	3a	b	4a	b	TOTAL	Assignment	Total	CO'S	
			C05	C05	C05	C05	C05	C05	CO4	CO4	C04	CO4				CO5	CO4
			6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	6 M	30 M			18 M	12 M
45	1KS17CS100	VISHAL.M.S				6	6	6			6	6	30	10	40	18	12
46	1KS17CS101	VYBHAVI.J				6	6	6			6	6	30	10	40	18	12
47	1KS16CS110	VARNA.M				6	6	6			6	6	30	10	40	18	12
49	1KS15CS128	SHARADHA.A				6	6	6			6	6	30	10	40	18	12
50	1KS15CS125	ADARSH SHRESTHA											0	0	0	0	0
51	1KS17CS401	BHARATHI.R				6	5	6			6	6	29	10	39	17	12

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K.S. Institute of Technology
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K.S. INSTITUTE OF TECHNOLOGY,BENGALURU-560 109
DEPARTMENT OF COMPUTER SCIENCE & ENGG.
VIII B SEC IOT(17CS81) FINAL IA MARKS AY - 2020-21

SI.NO.	USN	NAME	IA1	IA2	IA3	IA AVG	ASSIGNMENT AVG	TOTAL MARKS
1	1KS17CS052	PARTH.P.SHAH	30	29	30	30	10	40
2	1KS17CS053	PAVANI.M	30	29	30	30	10	40
3	1KS17CS055	POOJA.R	30	30	30	30	10	40
4	1KS17CS056	PRASHANTH.K	30	28	25	28	10	38
5	1KS17CS057	PRAVEEN	28	27	28	28	10	38
6	1KS17CS058	PRAVEEN.A	28	29	30	29	10	39
7	1KS17CS059	PRAVEEN.S	0	10	29	13	10	23
8	1KS17CS060	RAJASHREE SHIVAKUMAR	30	24	30	28	10	38
9	1KS17CS061	RAKSHITH.R	29	29	30	30	10	40
10	1KS17CS062	ROHITH.K	26	28	28	28	10	38
11	1KS17CS063	ROHITH.R	22	27	30	27	10	37
12	1KS17CS064	ROOPASHREE.N	30	30	30	30	10	40
13	1KS17CS065	ROSHINI.R	30	30	29	30	10	40
14	1KS17CS066	RUCHITHA.G.K	29	30	30	30	10	40
15	1KS17CS067	S.MONIKA	28	24	29	27	10	37
16	1KS17CS069	SAI KUMAR.L.S	27	28	30	29	10	39
17	1KS17CS070	SAI SNEHA.S.V	30	30	30	30	10	40
18	1KS17CS071	SAKSHI KUMARI	30	30	30	30	10	40
19	1KS17CS072	SANDESH NAIKAL	30	30	30	30	10	40
20	1KS17CS074	SHARANYA.H	21	23	24	23	10	33
21	1KS17CS075	SHASHANK SHET.	30	30	30	30	10	40
22	1KS17CS076	SHREYAS.R	30	29	30	30	10	40
23	1KS17CS077	SHRI HARSHA KULKARNI	27	28	30	29	10	39
24	1KS17CS078	SINDHU.H.S	30	28	30	30	10	40
25	1KS17CS079	SINDHU.M	29	27	30	29	10	39
26	1KS17CS081	SPOORTHI.R	30	30	30	30	10	40
27	1KS17CS082	SPOORTHI.V	30	30	30	30	10	40
28	1KS17CS083	SRIKALA.K.M	30	30	30	30	10	40
29	1KS17CS084	SRUSHTI.A	29	30	30	30	10	40
30	1KS17CS085	SUJANA.G.N	29	30	30	30	10	40
31	1KS17CS086	SUPREETHA.R.K ASHYAP	30	30	29	30	10	40
32	1KS17CS087	SUPRIYA.K	30	30	30	30	10	40

33	1KS17CS088	SURAKSHITHA.M	30	29	30	30	10	40
34	1KS17CS089	SWATI PAI	30	30	30	30	10	40
35	1KS17CS090	T.K.DHANUSHREE	30	29	30	30	10	40
36	1KS17CS091	TALUPULA SIVA SAI CHAITHANYA	27	28	30	29	10	39
37	1KS17CS092	TEJAS.C.S	30	30	30	30	10	40
38	1KS17CS093	THARUN.K	26	28	29	28	10	38
39	1KS17CS094	VARSHINI.N.PRA KASH	24	29	30	28	10	38
40	1KS17CS095	VARSHITHA.S	30	30	29	30	10	40
41	1KS17CS096	VARUN ATTIGANAL	30	29	30	30	10	40
42	1KS17CS097	VARUN.R.REDDY	25	24	28	26	10	36
43	1KS17CS098	VIKRAM SHIVAPPA	28	24	28	27	10	37
44	1KS17CS099	VINAY RAMARAO I	28	28	27	28	10	38
45	1KS17CS100	VISHAL.M.S	30	30	30	30	10	40
46	1KS17CS101	VYBHAVI.J	30	30	30	30	10	40
47	1KS16CS110	VARNA.M	30	30	30	30	10	40
48	1KS15CS128	SHARADHA.A	15	15	15	15	5	20
49	1KS17CS401	BHARATHI.R	14	15	15	15	5	20

COURSE INCHARGE

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Visvesvaraya Technological University

K.S. INSTITUTE OF TECHNOLOGY, BANGALORE

Branch : CS Scheme : 2017 Semester : 8

Sl NO.	USN	17CS81	17CS82	17CS834	17CS84	17CSP85	17CSS86	STUDENT SIGNATURE
1	1KS16CS042	40	32	37	47	91	95	Meghana
2	1KS16CS110	40	23	40	48	86	89	[illegible]
3	1KS17CS001	40	33	39	49	95	97	[illegible]
4	1KS17CS002	40	35	39	50	96	96	[illegible]
5	1KS17CS003	40	39	40	47	91	94	[illegible]
6	1KS17CS004	40	39	39	49	95	97	[illegible]
7	1KS17CS005	40	39	39	49	93	94	[illegible]
8	1KS17CS006	40	40	39	49	99	98	[illegible]
9	1KS17CS007	40	38	40	50	93	96	[illegible]
10	1KS17CS008	40	37	39	49	95	97	[illegible]
11	1KS17CS010	40	38	38	49	88	97	[illegible]
12	1KS17CS011	40	35	39	49	89	96	Anushree J
13	1KS17CS013	40	40	39	50	94	93	[illegible]
14	1KS17CS014	40	36	39	50	93	96	[illegible]
15	1KS17CS016	38	40	39	46	97	92	[illegible]
16	1KS17CS017	40	40	40	50	93	95	[illegible]
17	1KS17CS018	40	40	40	49	98	96	Chandana.B.R
18	1KS17CS019	40	40	40	49	99	98	[illegible] NT
19	1KS17CS020	40	36	39	47	90	88	[illegible]
20	1KS17CS021	40	37	40	48	84	95	Veekshitha
21	1KS17CS022	40	39	40	50	88	98	Deepika
22	1KS17CS023	40	40	40	50	89	93	[illegible]
23	1KS17CS024	40	26	38	49	86	93	[illegible]
24	1KS17CS025	40	40	39	48	97	93	[illegible]
25	1KS17CS026	40	34	39	49	86	97	[illegible]
26	1KS17CS027	40	39	39	49	88	93	[illegible]
27	1KS17CS028	40	27	39	48	91	96	[illegible]
28	1KS17CS029	40	35	39	49	92	94	Harshitha V
29	1KS17CS030	40	40	40	49	99	98	[illegible]
30	1KS17CS032	40	40	39	47	93	93	[illegible]
31	1KS17CS033	39	29	38	50	92	94	[illegible]
32	1KS17CS034	40	33	39	47	84	93	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	USN	17CS81	17CS82	17CS834	17CS84	17CSP85	17CSS86	STUDENT SIGNATURE
36	1KS17CS038	40	38	37	49	99	98	Lokesh B N
37	1KS17CS040	40	38	39	49	93	98	
38	1KS17CS041	40	34	39	49	92	97	Meghana V
39	1KS17CS042	40	37	39	50	94	95	
40	1KS17CS043	40	33	39	49	92	97	
41	1KS17CS044	40	37	39	50	84	94	Mounika
42	1KS17CS045	40	29	39	50	84	95	Neha V
43	1KS17CS046	40	36	39	47	92	94	Nidhi
44	1KS17CS047	40	40	39	49	93	97	
45	1KS17CS048	40	33	39	49	89	93	
46	1KS17CS049	40	28	39	49	86	96	
47	1KS17CS050	40	37	39	49	89	93	
48	1KS17CS051	40	40	38	47	93	93	
49	1KS17CS052	40	40	40	48	89	95	
50	1KS17CS053	40	34	40	49	88	91	
51	1KS17CS055	40	40	40	48	95	96	
52	1KS17CS056	38	32	40	47	91	95	
53	1KS17CS057	38	33	40	48	91	92	
54	1KS17CS058	39	29	40	49	95	94	A. Praveen
55	1KS17CS059	23	23	30	47	90	81	
56	1KS17CS060	38	28	40	49	84	96	
57	1KS17CS061	40	24	40	49	85	94	
58	1KS17CS062	38	24	40	49	84	91	
59	1KS17CS063	37	26	40	48	87	89	
60	1KS17CS064	40	40	40	49	96	97	
61	1KS17CS065	40	36	40	49	87	95	
62	1KS17CS066	40	38	40	49	93	95	
63	1KS17CS067	37	30	40	49	89	95	S Monika
64	1KS17CS069	39	36	40	49	83	88	
65	1KS17CS070	40	40	40	49	96	98	
66	1KS17CS071	40	40	40	49	98	97	
67	1KS17CS072	40	36	40	48	83	93	
68	1KS17CS074	33	29	40	49	85	93	
69	1KS17CS075	40	40	40	48	89	95	
70	1KS17CS076	40	35	40	48	97	96	Shreyas R
71	1KS17CS077	39	27	40	49	85	92	
72	1KS17CS078	40	32	40	49	87	91	Sindhu
73	1KS17CS079	39	39	40	49	87	92	
74	1KS17CS081	40	39	40	50	93	97	Spoorthi
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	USN	17CS81	17CS82	17CS834	17CS84	17CSP85	17CSS86	STUDENT SIGNATURE
78	1KS17CS085	40	29	40	49	89	92	
79	1KS17CS086	40	38	40	48	97	98	
80	1KS17CS087	40	29	40	49	89	91	
81	1KS17CS088	40	36	40	49	87	93	
82	1KS17CS089	40	40	40	49	99	98	
83	1KS17CS090	40	37	40	49	89	96	
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87	1KS17CS094	38	22	40	49	89	92	
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91	1KS17CS098	37	30	40	48	90	90	
92	1KS17CS099	38	34	40	48	84	92	
93	1KS17CS100	40	37	40	48	97	97	
94	1KS17CS101	40	40	40	49	97	97	
95	1KS17CS102	40	29	40	48	91	94	
96	1KS18CS401	39	29	32	47	84	92	Kruthika (BT)
--x--	Faculty Signature							----XXXXXXX----

* - values are either optional subjects or the faculty has not yet entered the marks

HOD
Seal and Signature

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

PRINCIPAL
Seal and Signature

PRINCIPAL
K.S. INSTITUTE OF TECHNOLOGY
BENGALURU - 560 109

KS INSTITUTE OF TECHNOLOGY, BENGALURU-560109

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

17CS81 – Internet of Things Technology

EXHAUSTIVE QUESTION BANK - 1

MODULE-1 AND

1. What is IoT? Explain in detail on genesis of IoT.
2. What is IoT? Explain evolutionary phase of the internet?
3. Explain Access Network sublayer with a neat diagram
4. What are the elements of one M2MIOT Architecture? Explain
5. Explain the functionality of IOT network management sublayer.
6. Describe IOT World Forum(IOTWF) standardize architecture. Compare and contrast IT and OT
7. Differences between the Internet of Things and Internet-Controlled devices.
8. How might wireless communications have an effect on the development and implementation of the internet of things (IoT)?
9. What influences will the internet of things (IoT) have on monetary growth?
10. What does IoT and Digitisation mean? Elaborate on this concept.
11. Discuss IoT Challenges. What are security concerns related to IoT?
12. Explain the differences between IOT and M2M communication
13. Explain the use of IOT with respect to the vision reflect use in smart lightning
14. With a neat diagram. Explain the architecture of IoT.
15. Explain an expanded view of the simplified IoT architecture.
16. Explain Core IoT functional stack.
17. Write a short notes on "IOT impact in real world"
18. What is Machine to Machine communication? what are the differences between IoT and M2M communication ?
19. Show that with an example why an IDE is required for developing a device platform for an IOT application
20. Explain a natural demarcation point between IT and OT in the IoT Reference Model framework.
21. Explain application of IoT in home automation systems.

MODULE-2

1. List and explain different types of sensors.
2. Difference between sensors and actuators. Explain with an example.
3. Explain about the generic block diagram of an IoT device
4. Elaborate on small physical objects and small virtual objects.
5. With a neat diagram, explain how actuators and sensors interact with physical world. Classify actuators based on energy types.
6. List out the limitations of the smart objects in WSNs and explain the data aggregation in WSN with a neat diagram
7. What is zigbee ? Explain 802.15.4 physical layer , MAC layer and security.
8. Explain LoRaWAN standard and alliance MAC layer and security
9. What is SANET? Explain some advantages and disadvantages that a wireless based solution offers.
10. Explain IoT access technologies.
11. Illustrate with an example why an IDE is required for developing a device platform for an IoT application?
12. Briefly explain protocol stack utilization IEEE892.15.

K.S.Institute of Technology, Bangalore

Department of Computer Science & Engineering

Subject: Internet ofThings Technology **Subject Code: 17CS81**

QUESTION BANK OF MODULE 3,4 and 5

MODULE 3

1. Discuss the key advantages of the IP suite for the Internet ofThings.
2. Contrast between Adoption and Adaptation of the Internet Protocol.
3. Explain working of IP as the IoT networklayer.
4. Write a note on Business case forIP.
5. Discuss the need foroptimization.
6. Explain in detail the application protocols for IoT (CoAP and MQTT).
7. Discuss the various methods used in IoT application transport (or) briefly explain the following: Application layer protocol not present, SCADA, Generic web-based protocols and IoT application layerprotocols.
8. Explain the necessity of optimization with respect to the followingtopics:-
   i) Constrained Nodes ii) Constrained Networks iii) IP versions
9. Write a note on optimizing IP for IoT. (Note: The following topics needs to be explained in your answer- "From 6LoWPAN to 6Lo", "Header Compression" , "Fragmentation", "Mesh addressing- Mesh-Under Versus Mesh-OverRouting",)
10. Write short notes on: a) 6Lo Working Group b) 6TiSCH c) RPL d) Authentication and Encryption on Constrained Nodes (ACE andDICE),
11. Discuss on Internet Protocol for Smart Objects (IPSO) Alliance, Wi-SUN Alliance, Thread and IPv6 Ready Logo.
12. With a neat diagram explain 6LoWPAN protocol header compression and fragmentation
13. List and explain the key advantages of internet protocol.
14. Explain RPL encryption and authentication on constrained nodes.
15. Explain tunneling legacy SCADA over IP networks and SCADA protocol translation with a neat diagram
16. Describe MQTT framework and message formats in detail
17. Briefly explain the working of TCP andUDP.

MODULE 4

1. Explain data and analytics forIoT.
2. Discuss the Big data analytics tools and technology (explain 3 Vs, MPPs, NoSQL databases, Hadoop and itsecosystem).
3. Compare the following: a) structured andunstructureddata b) Data in motion and data at rest, by providing suitable examples foreach.
4. Discuss on the overview of IoT data analytics (or) Explain types of data analysisresults.
5. Explain the challenges of IoT data analytics.
6. Define Machine Learning and explain the overview of ML (include the brief explanation of supervised v/s unsupervised learning and neuralnetworks).
7. Explain how neural network is used to recognize the image of a dog in thephoto.
8. Compare local learning and remotelearning.
9. Explain the common applications of ML forIoT.
10. Write short notes on "PredictiveAnalytics".
11. Give detailed explanation of the followingtopics:-
    a) Distributed HadoopCluster
    b) Writing a File toHDFS
    c) YARN
    d) ApacheKafka
    e) ApacheSpark
    f) Apache Storm and ApacheFlink
    g) LambdaArchitecture
12. Write short notes on thefollowing:-
    a) Edge StreamingAnalytics.
    b) Distributed AnalyticsSystems
    c) NetworkAnalytics
    d) Flexible NetFlowArchitecture
13. Compare Big Data and EdgeAnalytics.
14. List and explain the key values of edge streaminganalytics.
15. Explain the core functions of EdgeAnalytics.
16. With a case study relate the concept of securingIoT.
17. Explain in detail how IT and OT security practices and systems vary in realtime.
18. Discuss OCTAVE and FAIR formal riskanalysis.
19. Explain the elements of Hadoop with a neat diagram
20. Explain neural network in machine learning with a detailed example
21. Describe the components of FNF
22. Explain Form Risk analysis structures.
23. Explain the purdue model for control hierarchy and OT network characteristics

MODULE 5

1. Explain Rasberry Pi leaning board

   i) Explain the following with respect to Arudino programming

   ii) Structure

   iii) Functions

   iv) Variables

   v) Flow control statements

   vi) Data types vi) Constants
2. Write a python program on Rasberry Pi to blink an LED
3. Explain smart city architecture. (Dec-Jan-2019)
4. Write short notes on :i)IOT challenges ii) Backhaul Technologies
5. Give a brief note on Arduino UNO
6. With a neat diagram, explain Raspberry PI board
7. With a neat diagram, explain wireless temperature monitoring system using Raspberry Pi
8. Explain in detail smart city IOT architecture,
9. With the case study explain smart and connected cities using RaspberryPi

COURSE INCHARGE

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

USN

Eighth Semester B.E. Degree Examination, June/July 2019
Internet of Things Technology

Time: 3 hrs. Max. Marks: 80

Note: ***Answer FIVE full questions, choosing one full question from each module.***

Module-1

1 a. What is IOT? Explain in detail on Genesis of IOT. **(08 Marks)**
b. What does IOT and digitaization mean? Elaborate on this concept. **(04 Marks)**
c. Write a short note on "IOT impact in Real World". **(04 Marks)**

OR

2 a. Discuss IOT challenges. **(08 Marks)**
b. With a neat diagram, explain architecture of IOT. **(04 Marks)**
c. Explain Core IOT functional stack. **(04 Marks)**

Module-2

3 a. List and explain different types of sensors. **(08 Marks)**
b. Elaborate on small physical objects and small virtual objects. **(04 Marks)**
c. Explain "IOT Access Technologies". **(04 Marks)**

OR

4 a. Briefly explain protocol stack utilization IEEE 802.15.4. **(08 Marks)**
b. What is SANET? Explain some advantages and disadvantages that a wireless based solution offers. **(08 Marks)**

Module-3

5 a. Explain working of IP as the IOT network layer. **(08 Marks)**
b. Write note on Business case for IP. **(04 Marks)**
c. Discuss need for optimization. **(04 Marks)**

OR

6 a. Describe application protocols for IOT. **(08 Marks)**
b. Discuss the various methods used in IOT application transport. **(08 Marks)**

Module-4

7 a. What do you mean by data and analytics for IOT? Explain. **(04 Marks)**
b. Discuss Bigdata analyties tools and technology. **(04 Marks)**
c. With a case study relate the concept of securing IOT. **(08 Marks)**

OR

8 a. Explain in detail how IT and OT security practices and systems vary in real time. **(08 Marks)**
b. Discuss OCTAVE and FAIR formal risk analysis. **(08 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-5

9	a.	Give a brief note on Arduino UNO.	(04 Marks)
	b.	With a neat diagram, explain Raspberry P_i board.	(04 Marks)
	c.	With a neat diagram, explain wireless temperature monitoring system using Raspberry P_i.	(08 Marks)

OR

10	a.	Explain in detail smart city IOT architecture.	(08 Marks)
	b.	With the case study explain smart and connected cities using Raspberry P_i.	(08 Marks)

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CBCS SCHEME

USN | | | | | | | | | | |

15CS81

Eighth Semester B.E. Degree Examination, Aug./Sept.2020
Internet of Things and Technology

Time: 3 hrs. Max. Marks: 80

Note: i) For Regular Students: Answer any FIVE full questions irrespective of modules.
ii) For Arrear Students : Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Define IoT and discuss the Genesis of IoT in detail. (04 Marks)
b. List out the difference between IT and OT networks and their various challenges. (06 Marks)
c. List out the most significant challenges and problems that IoT is currently facing. (06 Marks)

2 a. List and explain the defining characteristics of fog computing. (06 Marks)
b. Explain the IoT reference model published by the IoTWF. (10 Marks)

Module-2

3 a. Define sensor and its characteristics. (06 Marks)
b. List out the most useful classification scheme for the pragmatic application of sensors in a IoT network. (10 Marks)

4 a. Briefly describe about communication criteria. (08 Marks)
b. What are the main topologies used for IoT connecting devices? (08 Marks)

Module-3

5 a. What are the key advantages of the IP suite for the IoT? (10 Marks)
b. What are the points to be considered while comparing the transport of DLMS/COSEM over a cellular network versus an LLN deployment? (06 Marks)

6 a. Explain in detail COAP message format. (08 Marks)
b. Explain Message Queuing Telemetry Transport (MQTT). (08 Marks)

Module-4

7 a. What are the ways IoT data is categorized? Explain in detail. (06 Marks)
b. Discuss the following :
(i) Supervised learning
(ii) Unsupervised learning
(iii) Neural Networks. (10 Marks)

8 a. Explain any two Big data analytics tools and technologies. (10 Marks)
b. Explain Lambda Architecture in details. (06 Marks)

Module-5

9 a. What is Arduino? What are the advantages of Arduino? (06 Marks)
b. How to install arduino software for the windows PCs? (10 Marks)

10 a. Distinguish between Raspberry Pi and Arduino. (04 Marks)
b. Develop a python program which monitors a temperature of an engine using DS18B20 sensor and Raspberry Pi. (12 Marks)

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Code No: R163205B

R16

SET - 1

III B. Tech II Semester Supplementary Examinations, November - 2019

INTERNET OF THINGS

(Computer Science and Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B**)
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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PART –A

(14 Marks)

1. a) Differentiate between sensors and actuators. [2M]
   b) Compare and contrast microprocessor and microcontroller. [2M]
   c) What is XBEE radio? [2M]
   d) What kind of IP is used in addressing IoT devices, Give an example? [3M]
   e) What is MQTT? [3M]
   f) What is Nimbits? [2M]

PART –B

(56 Marks)

2. a) What is IoT? Describe in detail about IoT ecosystem. [7M]
   b) How does the functioning of UART, SPI and I2C differ? [7M]

3. a) Explain M2M service layer standardization. [7M]
   b) Describe the design principles for connected devices. [7M]

4. a) Write about the basic operations available in CoAP protocol. [7M]
   b) Describe any two web communication protocols. [7M]

5. a) Give a short note on internet connectivity principles. [7M]
   b) Describe in detail about FTP service. [7M]

6. a) Describe the secure authentication and access control in constrained devices. [7M]
   b) Explain the data acquiring and storage mechanism for IoT. [7M]

7. How to use a service platform while developing IoT applications? Explain with respective to Xively cloud service. [14M]

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K.S.INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF COMPUTER SCIENCE & ENGG
COURSE END SURVEY

Staff Name : Mrs. Beena K
Subject: Internet of Things **Sub Code: 17CS81** **Sem/Sec: 7th B**

Q1	Rate your knowledge gained about Internet of things
Q2	To what extent can you grade the understanding on the concept of Data and Analytics in IOT?
Q3	Grade your perspective with respect to IOT subject
Q4	To what extent you understood Hadoop ?
Q5	Rate your depth knowledge about how to code usuing Raspberry Pi
Q6	Were you able to understand the need for optimization in IOT?
Q7	To what extend you understood IP protocols ?
Q8	Did the subject stimulate the interest in further exploring it?
Q9	Rate your knowldege about Arduino UNO?

SI NO	USN	NAME	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
1	1KS17CS063	ROHITH.R	Excellent	Very Good	Very Good	Excellent	Very Good	Very Good	Very Good	Very Good	Excellent
2	1KS17CS053	PAVANI.M	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
3	1KS17CS061	RAKSHITH.R	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
4	1KS17CS056	PRASHANTH.K	Very Good	Very Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
5	1KS17CS066	RUCHITHA.G.K	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good
6	1KS17CS094	VARSHINI.N.PRAKASH	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
7	1KS17CS059	PRAVEEN.S	Good	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good
8	1KS17CS060	RAJASHREE SHIVAKUMAR	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
9	1KS17CS070	SAI SNEHA.S.V	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
10	1KS17CS062	ROHITH.K	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
11	1KS17CS057	PRAVEEN	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good
12	1KS17CS064	ROOPASHREE.N	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
13	1KS17CS097	VARUN.R.REDDY	Very Good	Very Good	Very Good	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent
14	1KS17CS088	SURAKSHITHA.M	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Satisfactory

15	1KS17CS067	S.MONIKA	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Goo
16	1KS17CS069	SAI KUMAR.L.S	Very Good	Very Good	Very Good	Very Good	Excellent	Very Good	Very Good	Good	Very Good
17	1KS17CS077	SHRI HARSHA KULKARNI	Very Good	Very Good	Excellent	Very Good	Very Good	Excellent	Very Good	Excellent	Excellent
18	1KS17CS071	SAKSHI KUMARI	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
19	1KS17CS082	SPOORTHI.V	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
20	1KS17CS074	SHARANYA.H	Very Good	Good	Good	Very Good	Good	Good	Good	Good	Very Good
21	1KS17CS093	THARUN.K	Good	Good	Very Good	Excellent	Very Good	Very Good	Good	Good	Very Good
22	1KS17CS076	SHREYAS.R	Excellent	Very Good	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Excellent
23	1KS17CS086	SUPREETHA.R.KASH YAP	Very Good	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Excellent	Excellent
24	1KS17CS079	SINDHU.M	Good	Good	Good	Good	Good	Good	Good	Good	Good
25	1KS17CS081	SPOORTHI.R	Good	Good	Good	Good	Good	Good	Very Good	Very Good	Excellent
26	1KS17CS085	SUJANA.G.N	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good
27	1KS17CS089	SWATI PAI	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
28	1KS17CS087	SUPRIYA.K	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
29	1KS17CS058	PRAVEEN.A	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
30	1KS17CS052	PARTH.P.SHAH	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
31	1KS17CS090	T.K.DHANUSHREE	Good	Very Good	Good	Good	Satisfactory	Very Good	Very Good	Very Good	Good
32	1KS17CS091	TALUPULA SIVA SAI CHAITHANYA	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
33	1KS17CS095	VARSHITHA.S	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
34	1KS17CS098	VIKRAM SHIVAPPA CHATTARAKI	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
35	1KS17CS099	VINAY RAMARAO BIRADAR	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
36	1KS17CS100	VISHAL.M.S	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
37	1KS17CS101	VYBHAVI.J	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
38	1KS16CS110	VARNA.M	Good	Very Good	Good	Good	Satisfactory	Very Good	Very Good	Very Good	Good
39	1KS15CS128	SHARADHA.A	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
40	1KS17CS401	BHARATHI.R	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
41	1KS17CS072	SANDESH NAIKAL	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
42	1KS17CS083	SRIKALA.K.M	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
43	1KS17CS065	ROSHINI.R	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

Very Good
Very Good
Excellent

44	1KS17CS055	POOJA.R	Good	Very Good	Good	Good	Satisfactory	Very Good	Very Good	Very Good	Good
45	1KS17CS075	SHASHANK SHET.K	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
46	1KS17CS084	SRUSHTI.A	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
47	1KS17CS096	VARUN ATTIGANAL VENKATESH	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
COUNT(Excellent)			14	14	16	18	17	17	17	17	20
COUNT(Very Good)			22	25	24	24	22	27	25	24	21
COUNT(Good)			11	8	7	5	5	3	5	6	5
COUNT(Satisfactory)			0	0	0	0	3	0	0	0	1
Percentage of student response			100	100	100	100	93.6170213	100	100	100	97.8723404

STAFF SIGNATURE

HOD

K.S.INSTITUTE OF TECHNOLOGY, BANGALORE
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING
INDIRECT ATTAINMENT COURSE END SURVEY

YEAR/SEMESTER	IV/VIII
COURSETITLE	Internet of Things
COURSE CODE	17CS81
ACADEMICYEAR	2020-21

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	
EXCELLENT	14	14	16	18	17	17	17	17	20	99.0543735
VERYGOOD	22	25	24	24	22	27	25	24	21	
GOOD	11	8	7	5	5	3	5	6	5	
SATISFACTORY	0	0	0	0	3	0	0	0	1	
STUDENTS RESPONSE(GOOD &ABOVE)	100	100	100	100	93.6170213	100	100	100	97.8723404	

STAFF SIGNATURE

HOD

Head of the Department
Dept. of Computer Science & Engg.
K.S. Institute of Technology
Bengaluru -560 109

K S INSTITUTE OF TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

YEAR / SEMESTER	IV / VIII
COURSE TITLE	INTERNET OF THINGS AND
COURSE CODE	17CS81
ACADEMIC YEAR	2020-2021

Sl. No	USN	Name of the Student	17CS81														
			IA1		A1		IA2			A2			IA3		A3		SEE
			CO1	CO2	CO1	CO2	CO2	CO3	CO4	CO2	CO3	CO4	CO4	CO5	CO4	CO5	
			18	12	6	4	6	18	6	2	6	2	12	18	4	6	60
1	1KS17CS001	AAFREEN HUSSAIN	12	18	6	4	6	18	6	2	6	2	12	18	4	6	31
2	1KS17CS002	ABHISHEK GOWDA.M.V	12	18	6	4	6	6	6	2	6	2	12	18	4	6	39
3	1KS17CS003	AKSHATHA RAMESH	12	18	6	4	6	6	6	2	6	2	12	18	4	6	26
4	1KS17CS004	AKSHITHA.B.S	12	18	6	4	6	18	6	2	6	2	12	18	4	6	35
5	1KS17CS005	AMOGH.R	12	18	6	4	6	18	6	2	6	2	12	18	4	6	32
6	1KS17CS006	AMOGHA MANJUNATHA.K	12	18	6	4	6	18	6	2	6	2	12	18	4	6	32
7	1KS17CS007	AMRUTHA.V.DESHPANDE	12	18	6	4	6	18	6	2	6	2	12	18	4	6	33
8	1KS17CS008	ANOOP.P.S	12	18	6	4	6	18	6	2	6	2	12	18	4	6	32
9	1KS17CS010	ANUSHA.A.G	12	18	6	4	6	6	6	2	6	2	12	18	4	6	32
10	1KS17CS011	ANUSHREE.J	12	18	6	4	6	18	6	2	6	2	12	18	4	6	26
11	1KS17CS013	ASHISH.K.AMAR	12	18	6	4	6	18	6	2	6	2	12	18	4	6	21
12	1KS17CS014	LAKSHMI PRASANNA.B	12	18	6	4	6	18	6	2	6	2	12	18	4	6	40
13	1KS17CS016	BHAVESH BHANSALI	12	12	6	4	6	18	6	2	6	2	12	18	4	6	25
14	1KS17CS017	CHAITRA	12	18	6	4	6	18	6	2	6	2	12	18	4	6	42
15	1KS17CS018	CHANDANA.B.R	12	18	6	4	6	18	6	2	6	2	12	18	4	6	35
16	1KS17CS019	CHENNA KESHAVA.N.T	12	18	6	4	6	18	6	2	6	2	12	18	4	6	32
17	1KS17CS020	DARSHAN.S	12	18	6	4	6	18	6	2	6	2	12	18	4	6	35
18	1KS17CS021	DEEKSHITHA.R	12	18	6	4	6	6	6	2	6	2	12	18	4	6	28
19	1KS17CS022	DEEPIKA.S.H	12	18	6	4	6	6	6	2	6	2	12	18	4	6	27
20	1KS17CS023	DIVYA YASHASWI	12	18	6	4	6	18	6	2	6	2	12	18	4	6	23
21	1KS17CS024	GANESH.G.B	12	18	6	4	6	18	6	2	6	2	12	18	4	6	29
22	1KS17CS025	GANESH	12	18	6	4	6	18	6	2	6	2	12	18	4	6	42
23	1KS17CS026	GAUTHAM.C.R	12	18	6	4	6	18	6	2	6	2	12	18	4	6	31
24	1KS17CS027	H.PRIYANKA	12	18	6	4	6	18	6	2	6	2	12	18	4	6	33
25	1KS17CS028	HANUMESH.V.T	12	17	6	4	6	18	6	2	6	2	12	18	4	6	25
26	1KS17CS029	HARSHITHA.V	12	16	6	4	6	18	6	2	6	2	12	18	4	6	21
27	1KS17CS030	INDRASENA KALYANAM	12	18	6	4	6	18	6	2	6	2	12	18	4	6	35
28	1KS17CS032	KARAN RAGHUNATH	12	18	6	4	6	18	6	2	6	2	12	18	4	6	46

29	1KS17CS033	KARTHIK.T.C	10	15	6	4	6	18	6	2	6	2	12	18	4	6	42
30	1KS17CS034	KAVITHA.S	12	18	6	4	6	6	6	2	6	2	12	18	4	6	40
31	1KS17CS035	KEERTHI.N	12	18	6	4	6	18	6	2	6	2	12	18	4	6	22
32	1KS17CS036	KRITHIKA JAGANNATH	12	18	6	4	6	18	6	2	6	2	12	18	4	6	36
33	1KS17CS037	LAVANYA.V	12	18	6	4	6	18	6	2	6	2	12	18	4	6	27
34	1KS17CS038	LOKESH.B.M	12	17	6	4	6	18	6	2	6	2	12	18	4	6	25
35	1KS17CS040	MANJUNATH.A	12	16	6	4	6	18	6	2	6	2	12	18	4	6	25
36	1KS17CS041	MEGHANA.C.V	12	18	6	4	6	18	6	2	6	2	12	18	4	6	30
37	1KS17CS042	MEGHANA.G	12	18	6	4	6	18	6	2	6	2	12	18	4	6	46
38	1KS17CS043	MEGHANA.G.R	12	18	6	4	6	18	6	2	6	2	12	18	4	6	41
39	1KS17CS044	MOUNIKA.M.K.L	12	16	6	4	6	18	6	2	6	2	12	18	4	6	31
40	1KS17CS045	NEHA.K	12	18	6	4	6	18	6	2	6	2	12	18	4	6	31
41	1KS17CS046	NIKHIL SUBRAMANYA.K	12	18	6	4	6	18	6	2	6	2	12	18	4	6	40
42	1KS17CS047	NIKITHA KATARI	12	18	6	4	6	18	6	2	6	2	12	18	4	6	34
43	1KS17CS048	NISCHITHA.C	12	18	6	4	6	18	6	2	6	2	12	18	4	6	30
44	1KS17CS049	NITISH KUMAR GUPTA	12	16	6	4	6	6	6	2	6	2	12	18	4	6	35
45	1KS17CS050	NYDILE.G.R	12	18	6	4	6	18	6	2	6	2	12	18	4	6	27
46	1KS17CS051	P.KISHORE	12	18	6	4	6	18	6	2	6	2	12	18	4	6	33
47	1KS17CS052	PARTH.P.SHAH	18	12	6	4	5	18	6	2	6	2	12	18	4	6	36
48	1KS17CS053	PAVANI.M	18	12	6	4	5	18	6	2	6	2	12	18	4	6	44
49	1KS17CS055	POOJA.R	18	12	6	4	6	18	6	2	6	2	12	18	4	6	36
50	1KS17CS056	PRASHANTH.K	18	12	6	4	5	17	6	2	6	2	10	15	4	6	24
51	1KS17CS057	PRAVEEN	16	12	6	4	5	16	6	2	6	2	11	17	4	6	31
52	1KS17CS058	PRAVEEN.A	16	12	6	4	6	18	5	2	6	2	12	18	4	6	27
53	1KS17CS059	PRAVEEN.S	NA	NA	6	4	0	0	0	2	6	2	12	17	4	6	25
54	1KS17CS060	RAJASHREE	18	12	6	4	6	12	6	2	6	2	12	18	4	6	28
55	1KS17CS061	RAKSHITH.R	17	12	6	4	6	17	6	2	6	2	12	18	4	6	26
56	1KS17CS062	ROHITH.K	17	9	6	4	5	17	6	2	6	2	11	17	4	6	36
57	1KS17CS063	ROHITH.R	10	12	6	4	5	17	5	2	6	2	12	18	4	6	34
58	1KS17CS064	ROOPASHREE.N	18	12	6	4	6	18	6	2	6	2	12	18	4	6	32
59	1KS17CS065	ROSHINI.R	18	12	6	4	6	18	6	2	6	2	12	17	4	6	34
60	1KS17CS066	RUCHITHA.G.K	17	12	6	4	6	18	6	2	6	2	12	18	4	6	33
61	1KS17CS067	S.MONIKA	18	10	6	4	6	18	0	2	6	2	12	17	4	6	30
62	1KS17CS069	SAI KUMAR.L.S	16	11	6	4	6	16	6	2	6	2	12	18	4	6	38
63	1KS17CS070	SAI SNEHA.S.V	18	12	6	4	6	18	6	2	6	2	12	18	4	6	33
64	1KS17CS071	SAKSHI KUMARI	18	12	6	4	6	18	6	2	6	2	12	18	4	6	32
65	1KS17CS072	SANDESH NAIKAL	18	12	6	4	6	18	6	2	6	2	12	18	4	6	35
66	1KS17CS074	SHARANYA.H	12	9	6	4	0	17	6	2	6	2	12	12	4	6	6
67	1KS17CS075	SHASHANK SHET.K	18	12	6	4	6	18	6	2	6	2	12	18	4	6	33
68	1KS17CS076	SHREYAS.R	18	12	6	4	6	18	5	2	6	2	12	18	4	6	41
69	1KS17CS077	SHRI HARSHA KULKARNI	16	11	6	4	5	17	6	2	6	2	12	18	4	6	30
70	1KS17CS078	SINDHU.H.S	18	12	6	4	5	17	6	2	6	2	12	18	4	6	40
71	1KS17CS079	SINDHU.M	18	11	6	4	5	17	5	2	6	2	12	18	4	6	33
72	1KS17CS081	SPOORTHI.R	18	12	6	4	6	18	6	2	6	2	12	18	4	6	38

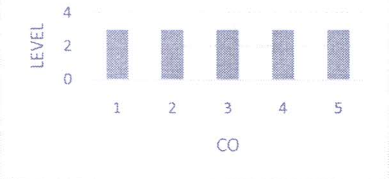
73	1KS17CS082	SPOORTHI.V	18	12	6	4	6	18	6	2	6	2	12	18	4	6	40
74	1KS17CS083	SRIKALA.K.M	18	12	6	4	6	18	6	2	6	2	12	18	4	6	36
75	1KS17CS084	SRUSHTI.A	17	12	6	4	6	18	6	2	6	2	12	18	4	6	21
76	1KS17CS085	SUJANA.G.N	17	12	6	4	6	18	6	2	6	2	12	18	4	6	29
77	1KS17CS086	SUPREETHA.R.KASHYAP	18	12	6	4	6	18	6	2	6	2	12	17	4	6	30
78	1KS17CS087	SUPRIYA.K	18	12	6	4	6	18	6	2	6	2	12	18	4	6	37
79	1KS17CS088	SURAKSHITHA.M	18	12	6	4	6	17	6	2	6	2	12	18	4	6	27
80	1KS17CS089	SWATI PAI	18	12	6	4	6	18	6	2	6	2	12	18	4	6	34
81	1KS17CS090	T.K.DHANUSHREE	18	12	6	4	5	18	6	2	6	2	12	18	4	6	30
82	1KS17CS091	TALUPULA SIVA SAI	15	12	6	4	5	18	5	2	6	2	12	18	4	6	21
83	1KS17CS092	TEJAS.C.S	18	12	6	4	6	18	6	2	6	2	12	18	4	6	35
84	1KS17CS093	THARUN.K	15	11	6	4	5	17	6	2	6	2	12	17	4	6	28
85	1KS17CS094	VARSHINI.N.PRAKASH	18	6	6	4	6	17	6	2	6	2	12	18	4	6	21
86	1KS17CS095	VARSHITHA.S	18	12	6	4	6	18	6	2	6	2	12	17	4	6	32
87	1KS17CS096	VARUN ATTIGANAL	18	12	6	4	6	18	5	2	6	2	12	18	4	6	26
88	1KS17CS097	VARUN.R.REDDY	20	5	6	4	0	18	6	2	6	2	11	17	4	6	32
89	1KS17CS098	VIKRAM SHIVAPPA	17	11	6	4	6	12	6	2	6	2	11	17	4	6	26
90	1KS17CS099	VINAY RAMARAO BIRADA	17	11	6	4	6	17	5	2	6	2	11	16	4	6	21
91	1KS17CS100	VISHAL.M.S	18	12	6	4	6	18	6	2	6	2	12	18	4	6	27
92	1KS17CS101	VYBHAVI.J	18	12	6	4	6	18	6	2	6	2	12	18	4	6	42
93	1KS17CS102	SHRIRAKSHA.S.KANAGO	12	17	6	4	6	18	6	2	6	2	12	18	4	6	45
94	1KS18CS401	KRUTHIKA.B.M	11	16	6	4	6	18	6	2	6	2	12	18	4	6	25
60% of Maximum marks (X)			11	07	04	02	04	11	04	01	04	01	07	11	02	04	36
No. of students above X			91	91	94	94	91	86	92	94	94	94	94	94	94	94	24
Total number of students (Y)			93	93	94	94	94	94	94	94	94	94	94	94	94	94	94
CO Percentage			97.85	97.85	100.00	100.00	96.81	91.49	97.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	25.53
			CO1	CO2	CO1	CO2	CO2	CO3	CO4	CO2	CO3	CO4	CO4	CO5	CO4	CO5	SEE

CO	CIE	SEE	DIRECT ATTAIN MENT	Level	COURS E END SURVE	LEVE L	ATTAIN MENT
CO1	98.92	25.53	62.23	3.00	99.18	3.00	3
CO2	98.66	25.53	62.10	3.00	99.18	3.00	3
CO3	95.74	25.53	60.64	3.00	99.18	3.00	3
CO4	99.47	25.53	62.50	3.00	99.18	3.00	3
CO5	100.00	25.53	62.77	3.00	99.18	3.00	3
AVERAGE							3.00

	IA1	A1	IA2	A2	IA3	A3	AVG
CO1	97.85	100.00					98.92
CO2	97.85	100.00	96.81	100			98.66
CO3			91.49	100			95.74
CO4			97.87	100	100.00	100	99.47
CO5					100.00	100	100.00

CO Attainment Level	Significance	For Direct attainment , 50% of CIE and 50% of SEE marks are conside
Level 3	60% and above students should have scored >= 60% of Total marks	For indirect attainment, Course end survey is considered.
Level 2	55% to 59% of students should have scored >= 60% of Total marks	CO attainment is 90%of direct attainment + 10% of Indirect atttainment.
Level 1	50% to 54% of students should have scored >= 60% of Total marks	PO attainment = CO-PO mapping strength/3 * CO attainment .

CO ATTAINMENT



Co-Po Mapping Table

CO'S	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	2	2	3	2	-	2	3	-	-	1	1	3	3	3
CO2	2	3	3	2	-	3	2	-	-	1	2	2	3	3
CO3	3	3	3	3	-	1	1	-	-	1	-	3	3	3
CO4	3	3	3	3	3	3	2	-	3	1	2	2	3	3
CO5	3	3	3	3	3	1	1	-	-	1	2	2	3	3
AVG	2.6	2.8	3	2.6	3	2	1.8	-	3	1	1.75	2.4	3	3

PO ATTAINMENT TABLE

CO'S	CO Attainment in %	CO RESULT	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3.00	Y	2.00	2.00	3.00	2.00	-	2.00	3.00	-	-	1.00	1.00	3.00	3.00	3.00
CO2	3.00	Y	2.00	3.00	3.00	2.00	-	3.00	2.00	-	-	1.00	2.00	2.00	3.00	3.00
CO3	3.00	Y	3.00	3.00	3.00	3.00	-	1.00	1.00	-	-	1.00	-	3.00	3.00	3.00
CO4	3.00	Y	3.00	3.00	3.00	3.00	3.00	3.00	2.00	-	3.00	1.00	2.00	2.00	3.00	3.00
CO5	3.00	Y	3.00	3.00	3.00	3.00	3.00	1.00	1.00	-	-	1.00	2.00	2.00	3.00	3.00
Average			2.60	2.80	3.00	2.60	3.00	2.00	1.80	-	3.00	1.00	1.75	2.40	3.00	3.00

Course Incharge

HOD

Head of the Department
Dept. of Computer Sc... Engg.
K.S. Institute of Tech...
Bengaluru -560 109

K S INSTITUTE OF TECHNOLOGY BENGALURU
DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Module wise challenging questions
Sub: Internet of Things and Technology(17CS81)

Module 1:

1. Explain the impact of IoT in the real world.
2. Discuss on Connected Roadways.
3. Explain the current challenges being addressed by Connected Roadways.
4. Summarize the concept of Connected Factory.
5. Explain how IoT is making a disruptive impact is in the smart connected buildings space.
6. Illustrate the conversion of building protocols to IP over time.
7. Explain the concept of "Digital Ceiling".
8. Summarize the role of IoT to implement "Smart Creatures".

Module 2:

1. Write short notes on Micro-Electro-Mechanical Systems (MEMS).
2. Explain the physical layer of 1901.2a along with NB-PLC Frequency Bands.
3. Explain the general MAC Frame Format for IEEE 1901.2
4. Discuss on the topology, security and competitive technologies with respect to IEEE1901.2a
5. Explain about the physical layer, MAC layer, topology, security and competitivetechnologies w.r.t IEEE 802.11ah wireless technology or IEEE 802.11 WiFi technology.
6. Discuss on LoRaWAN (should explain overview of LoRaWAN layers, its physical layer,MAC frame format, topology, security and its competitive technologies).
7. Write short notes on NB-IoT and other LTE variations in detail.

Module 3:

1. Discuss the various methods used in IoT application transport (or) briefly explain the following: Application layer protocol not present, SCADA, Generic web-based protocoland IoT application layer protocols.
2. Explain the necessity of optimization with respect to the following topics:-

   i) Constrained Nodes ii) Constrained Networks iii) IP versions

Module 4:

1. Write short notes on "Predictive Analytics".
2. Give detailed explanation of the following topics:
   a) Distributed Hadoop Clusterb) Writing a File to HDFSc) YARNd) Apache Kafka
   e) Apache Sparf) Apache Storm and Apache Flinkg) Lambda Architecture
3. Write short notes on the following:
   a) Edge Streaming Analytics.b) Distributed Analytics Systemsc) Network Analytics
   d) Flexible NetFlow Architecture

Module 5:

1. Write programs to illustrate the following using Arduino Uno:-
   i) Blinking an LED
   ii) Toggle the state of the LED using a switch
   iii) Simulation of traffic lights foe pedestrians
   iv) Creation of dimmable LED using a potentiometer
   v) Interfacing temperature sensor
   vi) Simulation of automatic lights using light sensor
   vii) Measuring the speed of sound using ultrasonic sensor
   viii) Detection of an obstacle using Infrared sensor
   ix) Display the room temperature on an LCD unit by using LM35 and potentiometer andalso demonstrate the beeping of buzzer when the temperature exceeds 320C.
   x) Displaying custom characters on LCD unit
   xi) Displaying digit/number on a 7 segment display
   xii) Interfacing GSM module to create and send messages, receive and display messagesusing LCD display
   xiii) Interfacing GPS to find the global coordinates of a position.
   xiv) Interfacing servo motor to control physical movement of objects.

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Module - 1 : What is IoT ?

- **Goal of IoT:**
  - **Connect the unconnected**

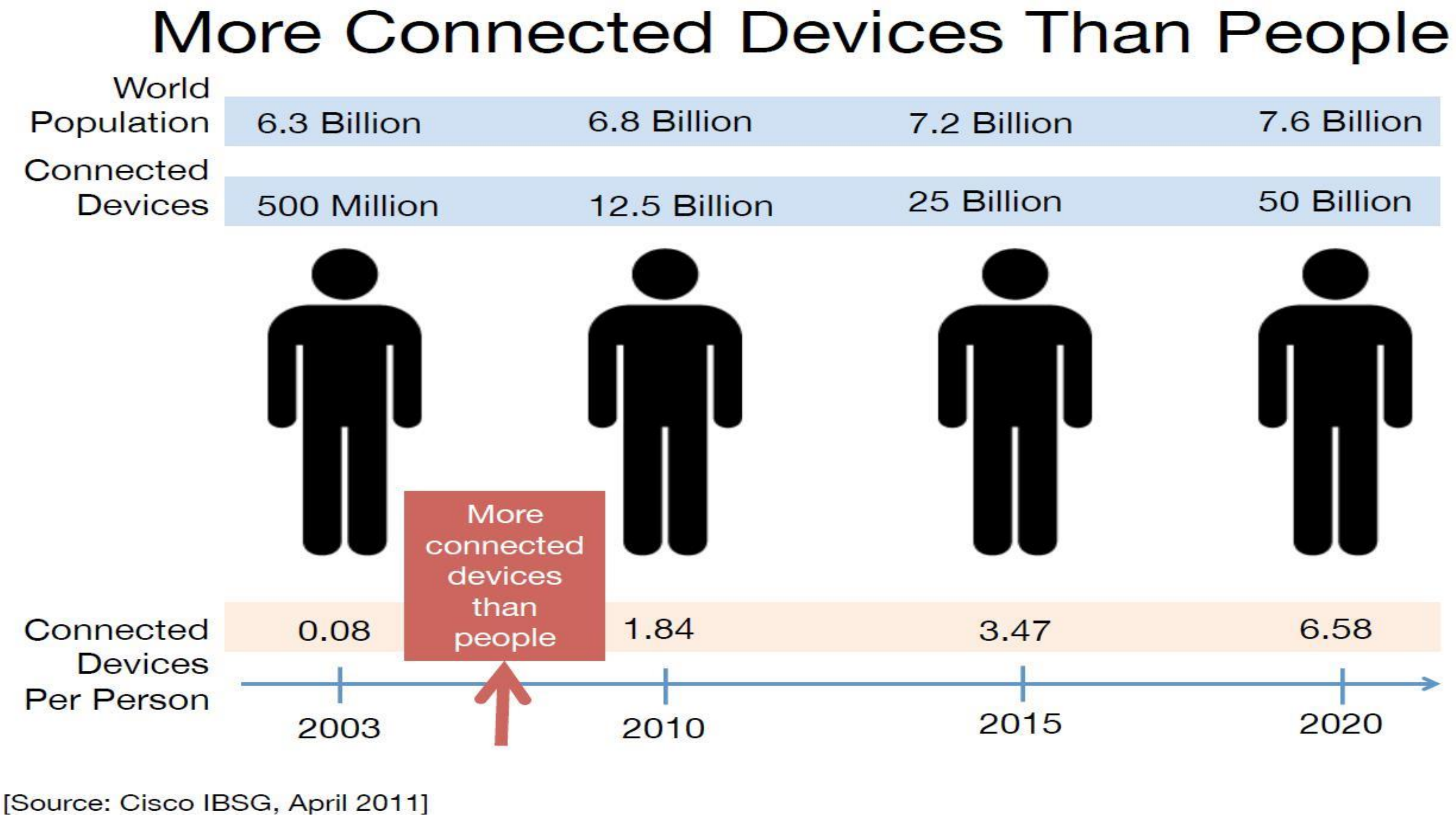
    Objects that are not currently joined to a computer network-Internet, will be connected so that they can communicate and interact with people and other objects.

- **IoT is a technology transition in which the devices will allow us to sense and control the physical world by making objects smarter and connecting them through an intelligent network.**

- **When objects and machines can be sensed and controlled remotely by across a network, a tighter integration between physical world and computers are enabled. This allows enablement of advanced applications.**

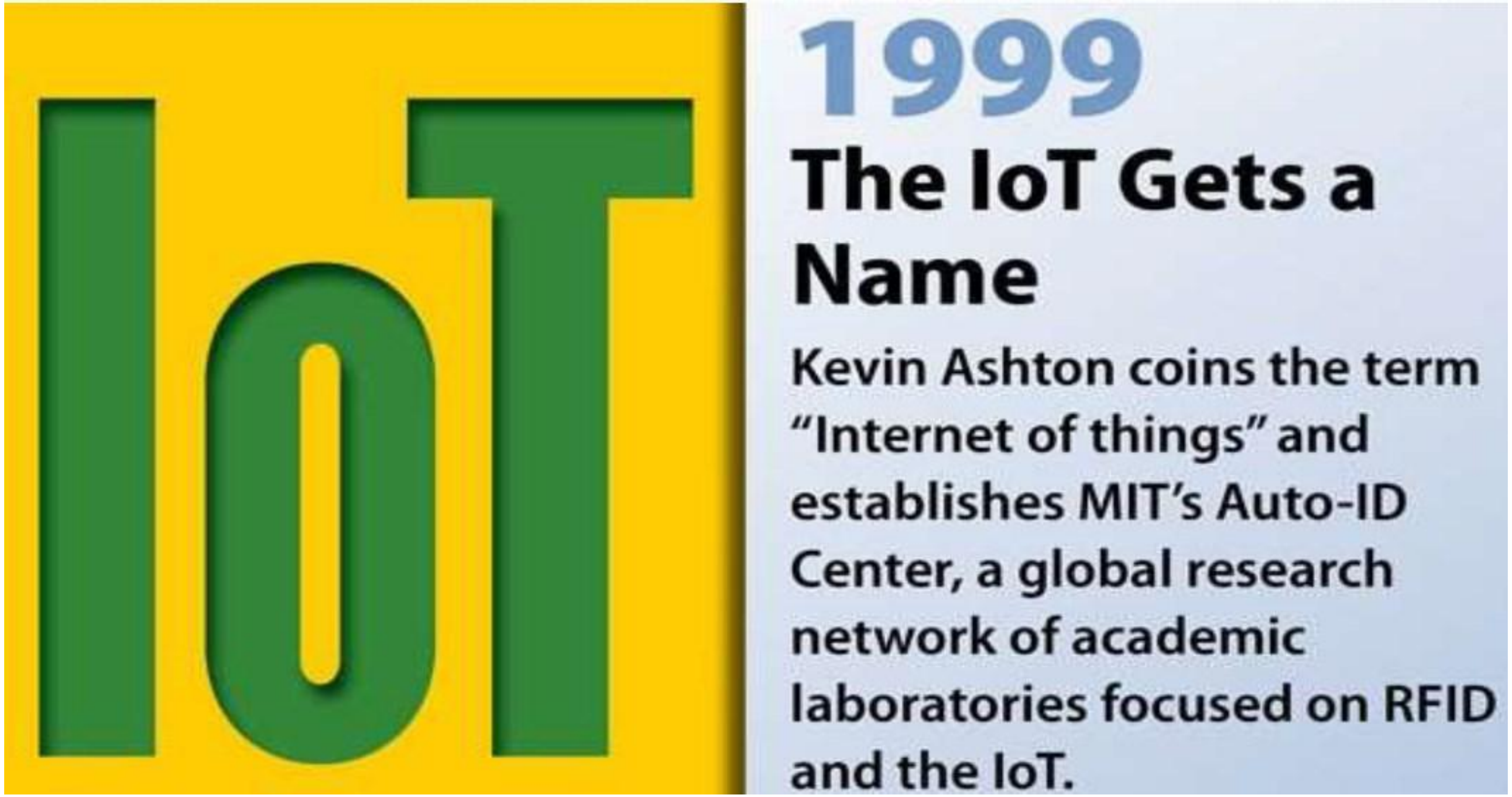
Module - 1 : What is IoT ?

- **Genesis of IoT:**
  - **The age of IoT is started in 2008 and 2009. In these years, more "things" connected to the Internet than people in the world.**



Module - 1 : What is IoT ?

- **History:**

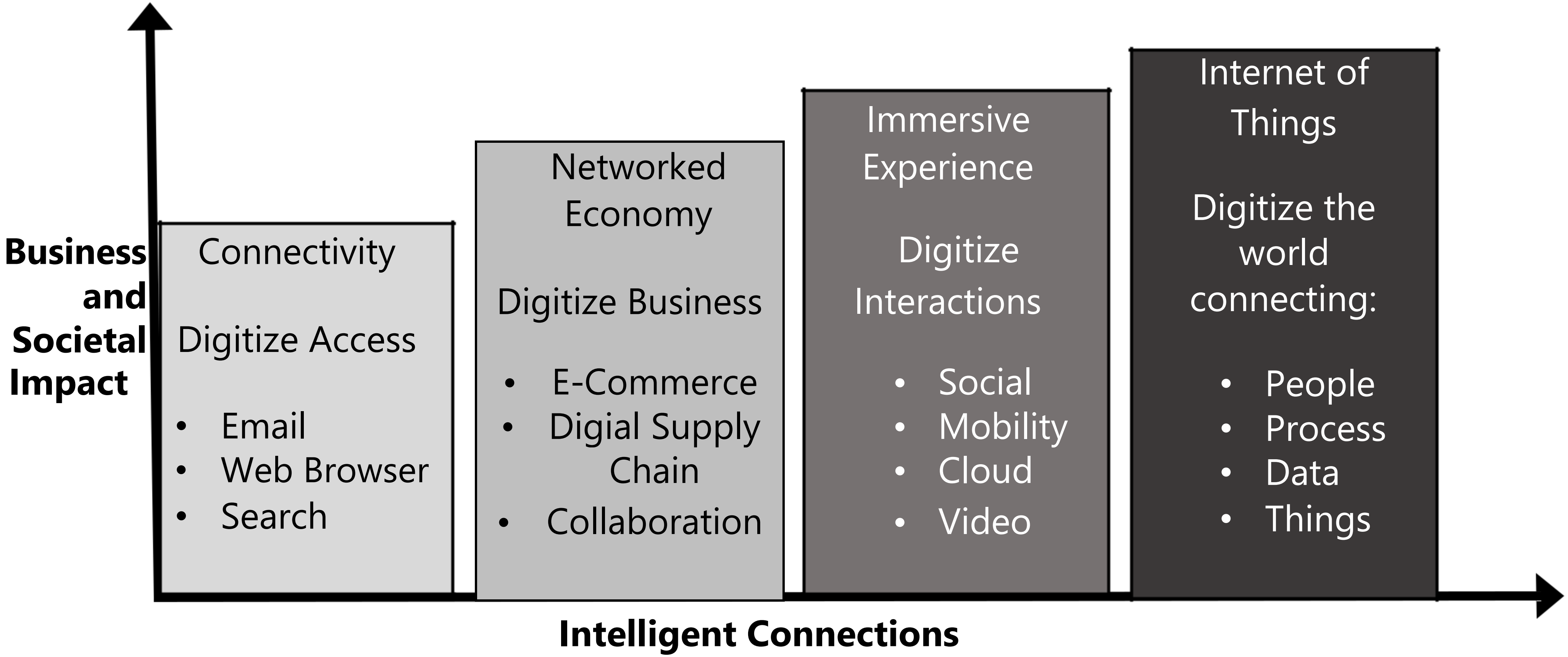


Module - 1 : What is IoT ?

- **Kevin's Explanation:**
- **IoT involves the addition of senses to computers.**
- **In the 20th century, computers were brains without senses.**
- **In the 21st century, computers are sensing things for themselves.**

Module - 1 : What is IoT ?

➢ **Evolutionary Phases of the Internet**



Module - 1 : What is IoT ?

➢ **Evolutionary Phases of the Internet**

Internet Phase	Definition
Connectivity (Digitize Access)	This phase connected people to email, web services and search, so that information is easily accessed.
Networked Economy (Digitize Business)	This phase enabled e-commerce and supply chain enhancements along with collaborative engagement to drive increased efficiency in business.
Immersive Experiences (Digitize Interactions)	This phase extended the Internet Experience to encompass widespread video and social media while always being connected through mobility. More and more applications are moved to Cloud.
Internet of Things (Digitize the World)	This phase is adding connectivity to Objects and machines to the world around us to enable new services and experiences. It is connecting the unconnected.

Module - 1 : What is IoT ?

- **Evolutionary Phases of the Internet**
  - **Each phase of evolutionary phases builds on the previous one.**
  - **With each subsequent phase, more value becomes available for businesses, governments and society in general.**

Internet Phase: first Phase	Connectivity(Digitize Access)
- **Began in the mid 1990s.** - **Email and getting Internet were luxuries for universities and corporations.** - **Dial-up modems and basic connectivity were involved.** - **Saturation occurred when connectivity and speed was not a challenge.** - **The focus now was on leveraging connectivity for efficiency and profit.**	

Module - 1 : What is IoT ?

- **Evolutionary Phases of the Internet**

Internet Phase: Second Phase	Networked Economy (Digitize Business)

- **E-Commerce and digitally connected supply chains become the rage.**
- **Caused one of the major disruptions of the past 100 years..**
- **Vendors and suppliers became closely interlinked with producers.**
- **Online Shopping experienced incredible growth .**
- **The economy become more digitally intertwined as suppliers, vendors and consumers all became more directly connected.**

Module - 1 : What is IoT ?

- **Evolutionary Phases of the Internet**

Internet Phase: Third Phase	Immersive Experiences (Digitize Interactions)

- **Immersive Experiences, is characterized by the emergence of social media, collaborations and widespread mobility on a variety of devices.**
- **Connectivity is now pervasive, using multiple platforms from mobile phones to tablets to laptops and desktop computers.**
- **Pervasive connectivity enables communications and collaboration as well as social media across multiple channels via email, texting,voice and video.**
- **Person to person interactions have become digitized.**

Module - 1 : What is IoT ?

- **Evolutionary Phases of the Internet**

Internet Phase: Forth(last) Phase	Internet of Things (Digitize the World)

- **We are in beginning of the IoT phase.**
- **99% of "things" are still unconnected.**
- **Machines and objects in this phase connect with other machines and objects along with humans.**
- **Business and society are using and experiencing huge increase in data and knowledge.**
- **Increased automation and new process efficiencies, IoT is changing our world to new way.**

Module - 1 : IoT and Digitization

- **IoT and Digitization**
  - **At a high level, IoT focuses on connecting “things” such as objects and machines, to a computer network, such as the Internet.**
  - **Digitization encompasses the connection of “things” with the data they generate and the business insights that result.**

  Example: Wi-Fi devices in Malls detecting customers, displaying offers, based on the spends, mall is segregated, changes to location of product displays and advertising.

  - **Digitization: It is the conversion of information into a digital format.**

Module - 1 : IoT and Digitization

➢ IoT and Digitization

Example:

1. Digital camera- No films used, mobile phones with camera.

Digitization of photography changed experience of capturing images.

2. Video rental industry and transportation , no one purchases video tapes or DVDs.

With digitization , everyone is streaming video content or purchasing the movies as downloadable files.

3.Transportation- Taxi Uber,Ola use digital technologies.

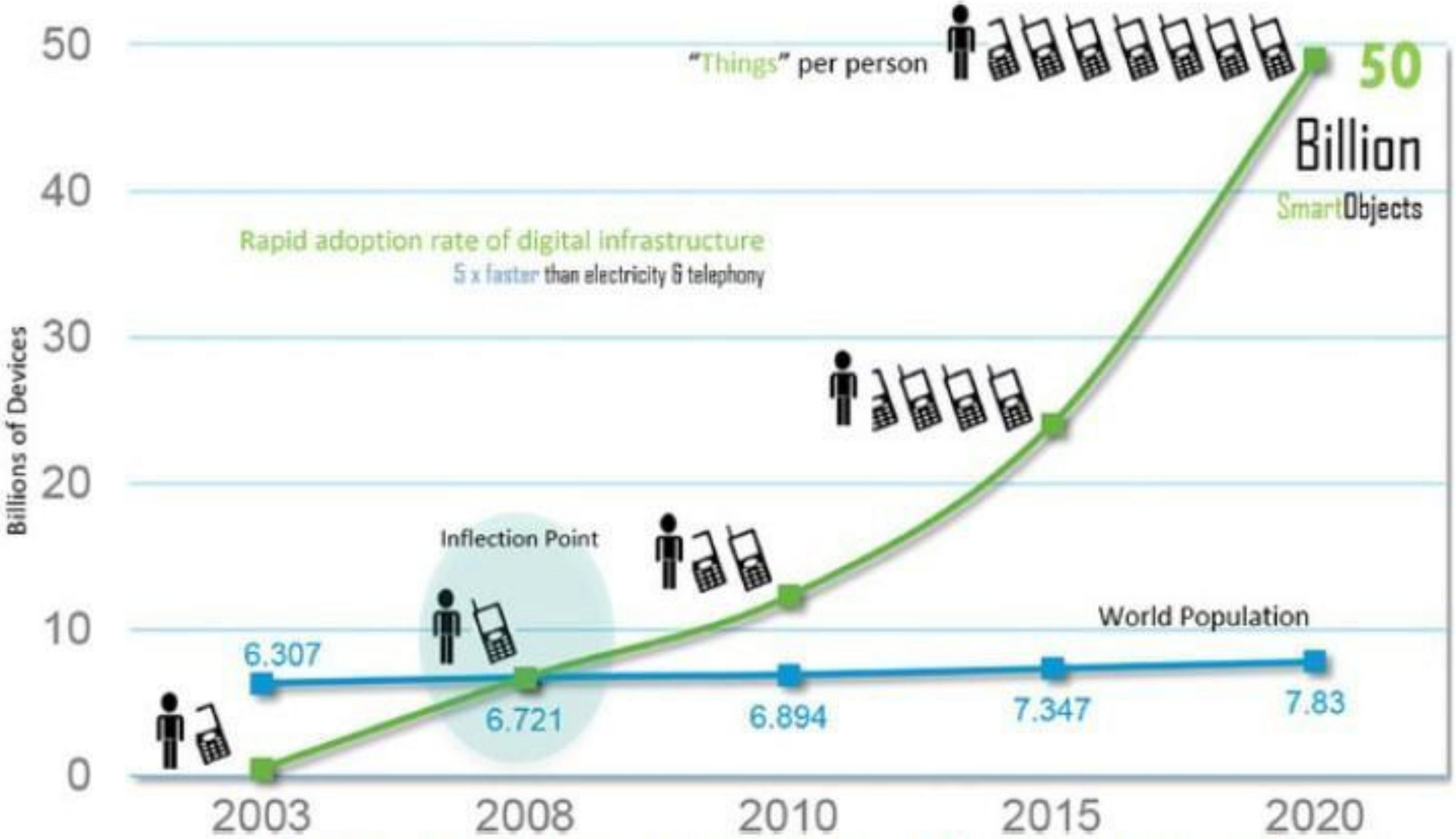
4. Home Automation – Popular product: Nest – sensors determine the climate and connects to other smart objects like smoke alarm, video camera and various third party devices.

Module - 1 : IoT Impact

- **IoT Impact**
  - **About 14 billion or 0.06% of "things" are connected to the internet today.**
  - **Cisco predicts in 2020 , it may go upto 50 billion and says this new connection will lead to $19 trillion in profit and cost savings.**
  - **UK government says 100 billion objects may connected**
  - **Managing and monitoring smart objects using real –time connectivity enables a new level of data-driven decision making.**
  - **This results in optimization of systems and processes and delivers new services that save time for both people and business while improving the overall quality of life.**

Module - 1 : IoT Impact

- **IoT Impact**



The Rapid Growth in the Number of Devices Connected to the Internet

Module - 1 : IoT Impact

- **Connected Roadways- Google's Self Driving Car**
- **Connected Roadways is a term associated with both the drivers and driverless cars fully integrating with the surrounding transportation infrastructure.**
- **Basic sensors reside in cars monitor oil Pressure,tire pressure, temperature and other Operating conditions, provide data around Core car functions.**

Google's Self-Driving Car

Module - 1 : IoT Impact

➢ **Connected Roadways**

Current challenges being addressed by Connected Roadways

Challenge	Supporting Data
Safety	• 5.6 million crashes in 2012, 33,000 fatalities – US department of Transportation • IoT and enablement of connected vehicle technologies significantly reduces the loss of lives each year.
Mobility	• More than a billion cars on road worldwide. • Connected vehicle mobility application will give drivers more informed decisions which may reduce travel time. • Communication between mass transit, emergency response vehicle and traffic management help optimizing the routing of vehicle resulting in reducing in travel delays further.

Module - 1 : IoT Impact

➢ **Connected Roadways**

Current challenges being addressed by Connected Roadways

Challenge	Supporting Data
Environement	• Each year, Transit System will reduce CO_2 emission s by 16.2 million metric tons by reducing private vehicle miles- American Public Transportation Association • Connected Vehicle Environmental Application will give all travels the real time information to make “green transportation” choice.

Module - 1 : IoT Impact

- **Connected Roadways- IoT connected Roadways**
- **Intersection Movement Assist(IMA)**

This App warns the Driver when it is not Safe to enter an Intersection due to high Possibility of collision.

Application of Intersection Movement Assist

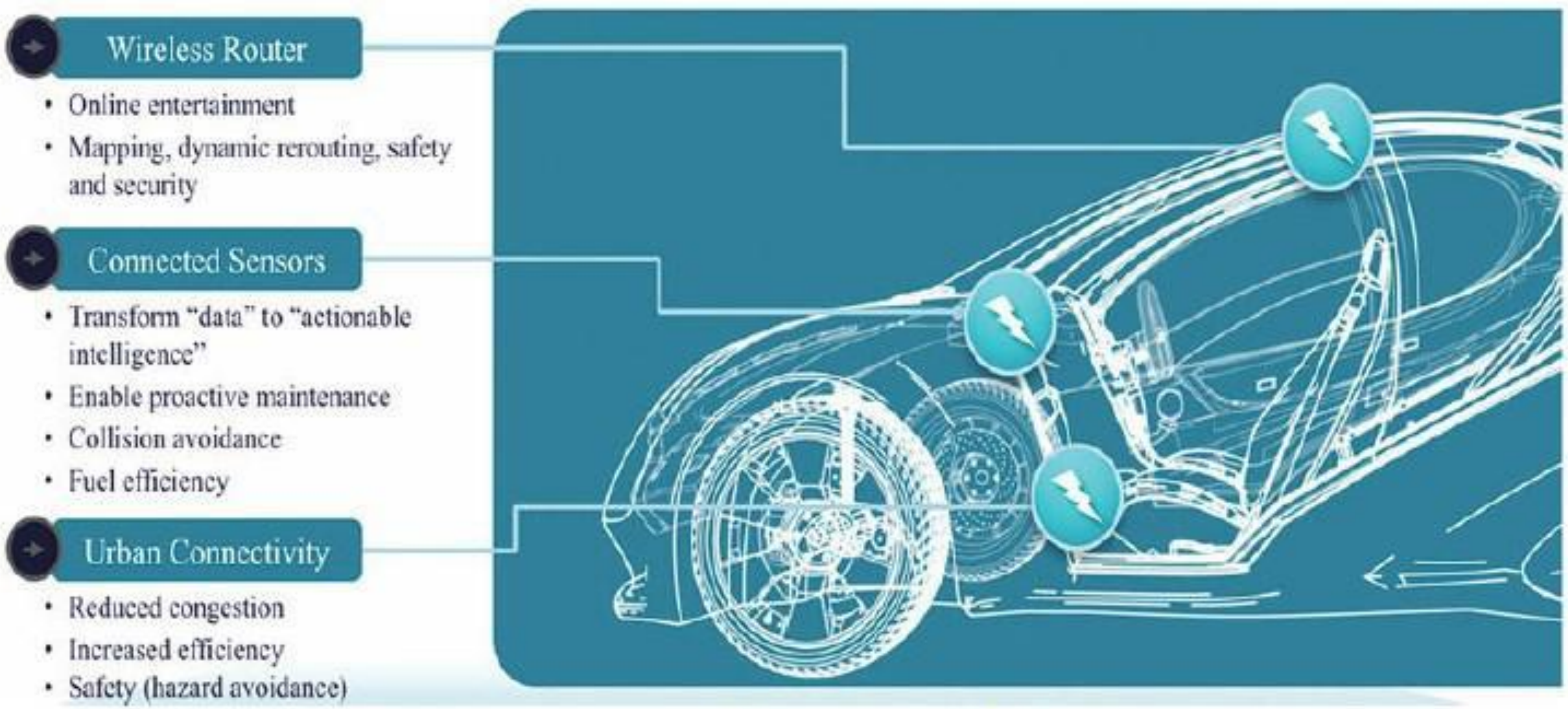
Module - 1 : IoT Impact

➢ **The Connected Car**

With automated vehicle tracking, a vehicle 's location is used for notification of arrival times, theft prevention or high way assistance.

-Cargo Management

-fully connected car will generate >25GB data/hour



The Connected Car

Module - 1 : IoT Impact

- **The Connected Roadways – creates another area where third party uses the data generated by car.**
- **Example- tyre company can collect data related to use and durability of their product in arrange of environments in real time.**
- **GPS/Map – to enable dynamic rerouting to avoid traffic , accidents and other hazards.**
- **Internet based Entertainment can be personalized and customized to optimize road trip.**
- **Data will be used for advertisement**
- **IoT Data Broker –provides Business opportunity**
- **Fiber optic sensing able to record how Many cars are passing , their speed and type.**

Module - 1 : IoT Impact

➢ **The Connected Factory**

The main challenges facing manufacturing in a factory environment today:

- **Accelerating new products and service introduction to meet customer and market opportunities.**
- **Increasing plant productions, quality and uptime while decreasing cost.**
- **Mitigating unplanned downtime**
- **Securing factories from cyber threads**
- **Decreasing high cabling and re-cabling costs**
- **Improving worker productivity and safety.**

Module - 1 : IoT Impact

➢ **The Connected Factory**

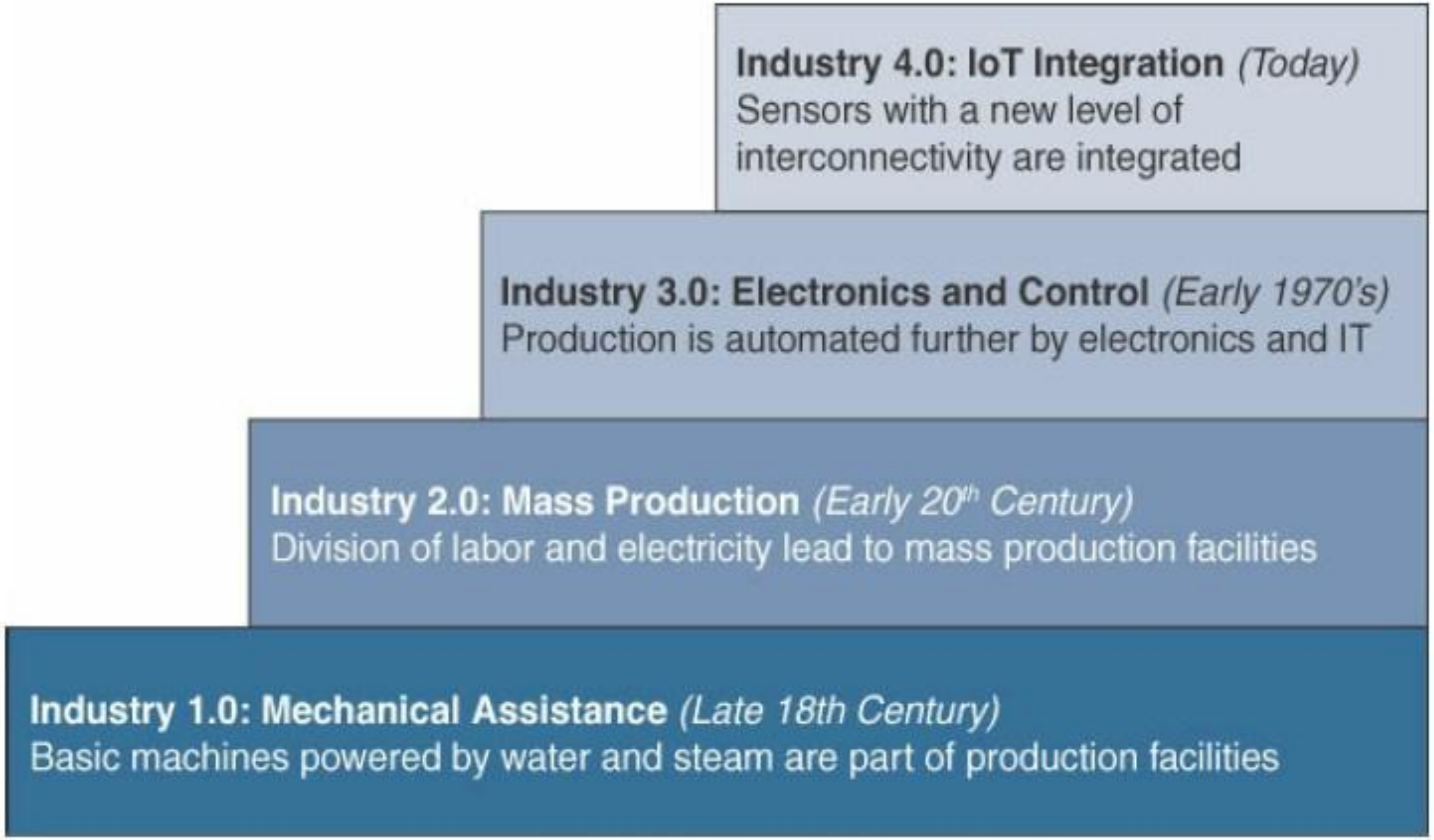
Example- In the ore melting process, control room will be far off from the unit resulting in multiple trips and controlling becomes difficult.

With IoT and Connected factory – "machine to people " connections are implemented to bring sensor data directly to operator on the floor via mobile devices. Time is no longer wasted in moving.

Real time location system (RTLS) attached Wi-fi RFID tag to locate the real time location and status of product.

Module - 1 : IoT Impact

➢ **The Four Industrial Revolution**



The Four Industrial Revolutions

Module - 1 : IoT Impact

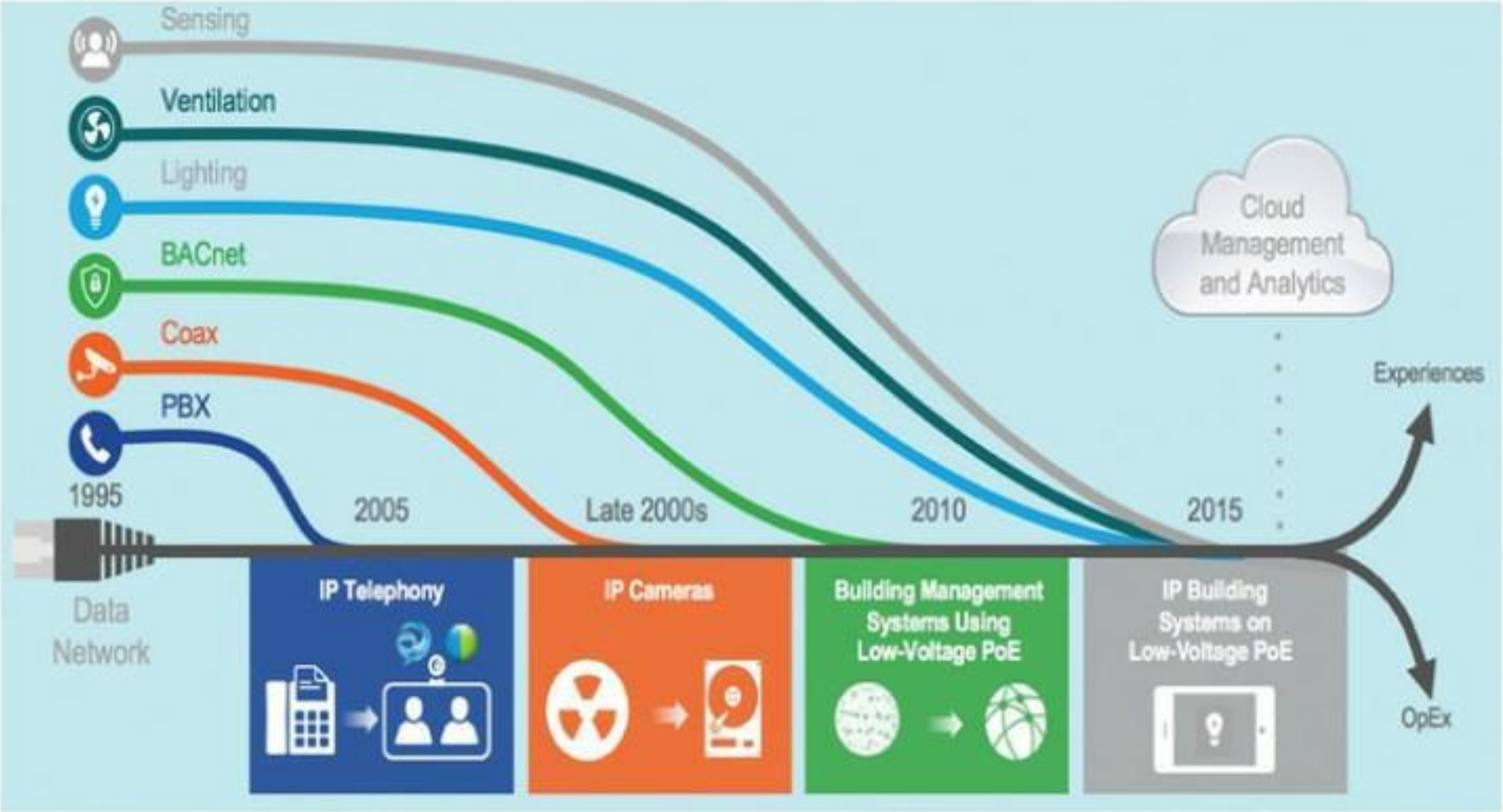
- **Smart Connected Buildings**
- **The function of a building is to provide a work environment that keeps the worker comfortable, efficient and safe.**
- **Physical Security alarm –fire alarm and suppression system to keep worker safe.**
- **Sensors to detect occupancy in the building.**
- **Lights are off automatically when no one is there.**

Module - 1 : IoT Impact

- **Smart Connected Buildings**
- **Sensors are used to control the heating, ventilation and air-conditioning (HVAC) system**
- **Temperature sensors are spread throughout the building and are used to influence the building management system(BMS) control of air flow into the room.**
- **Building Automation System(BAS) provides a single management system for HVAC, lighting, alarm and detection system.**
- **Defacto communication protocol for building automation is known as BACnet (Building Automation and Control Network)**

Module - 1 : IoT Impact

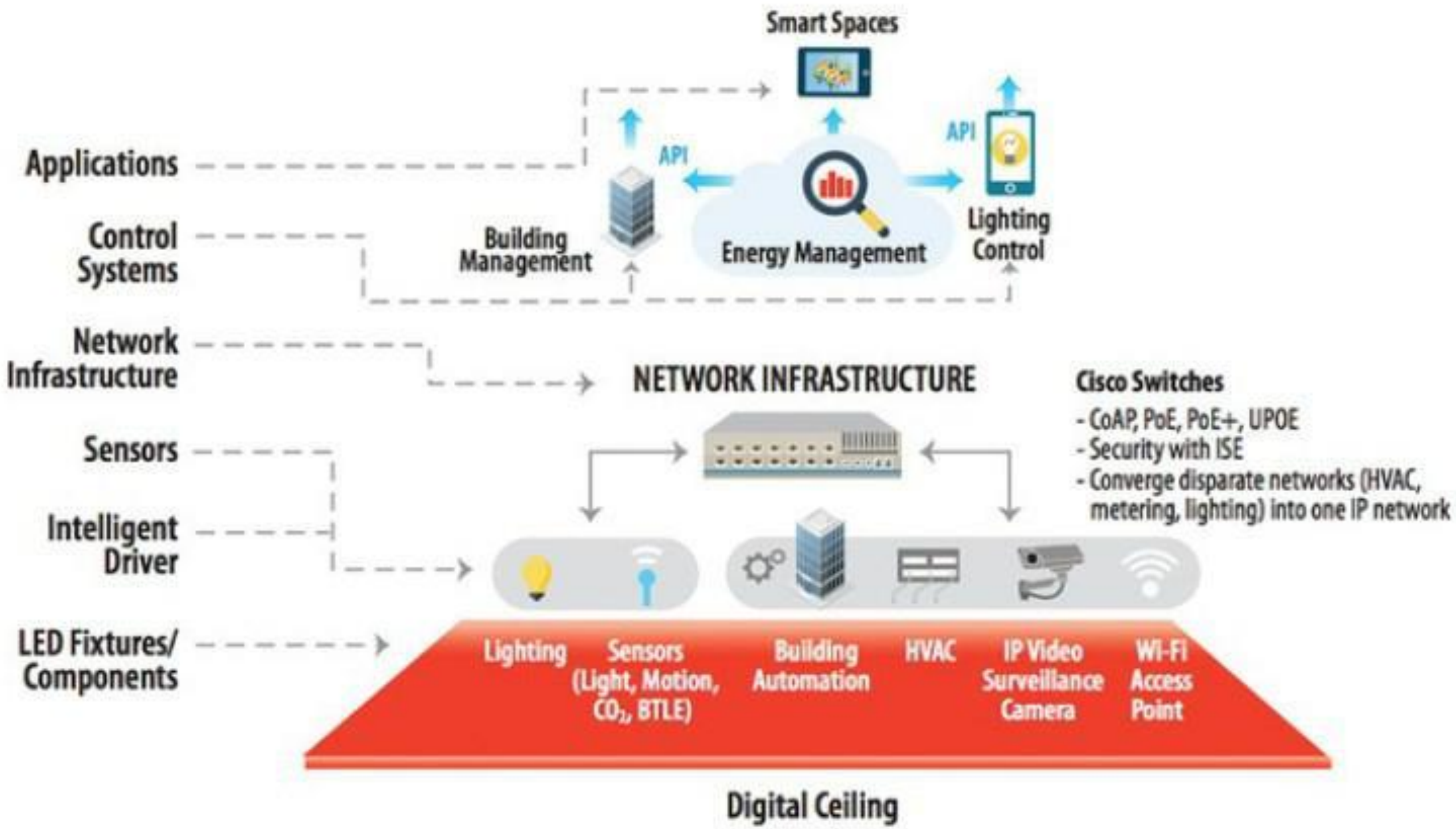
➢ **Smart Connected Buildings- Convergence of Building Technologies to IP**



Convergence of Building Technologies to IP

Module - 1 : IoT Impact

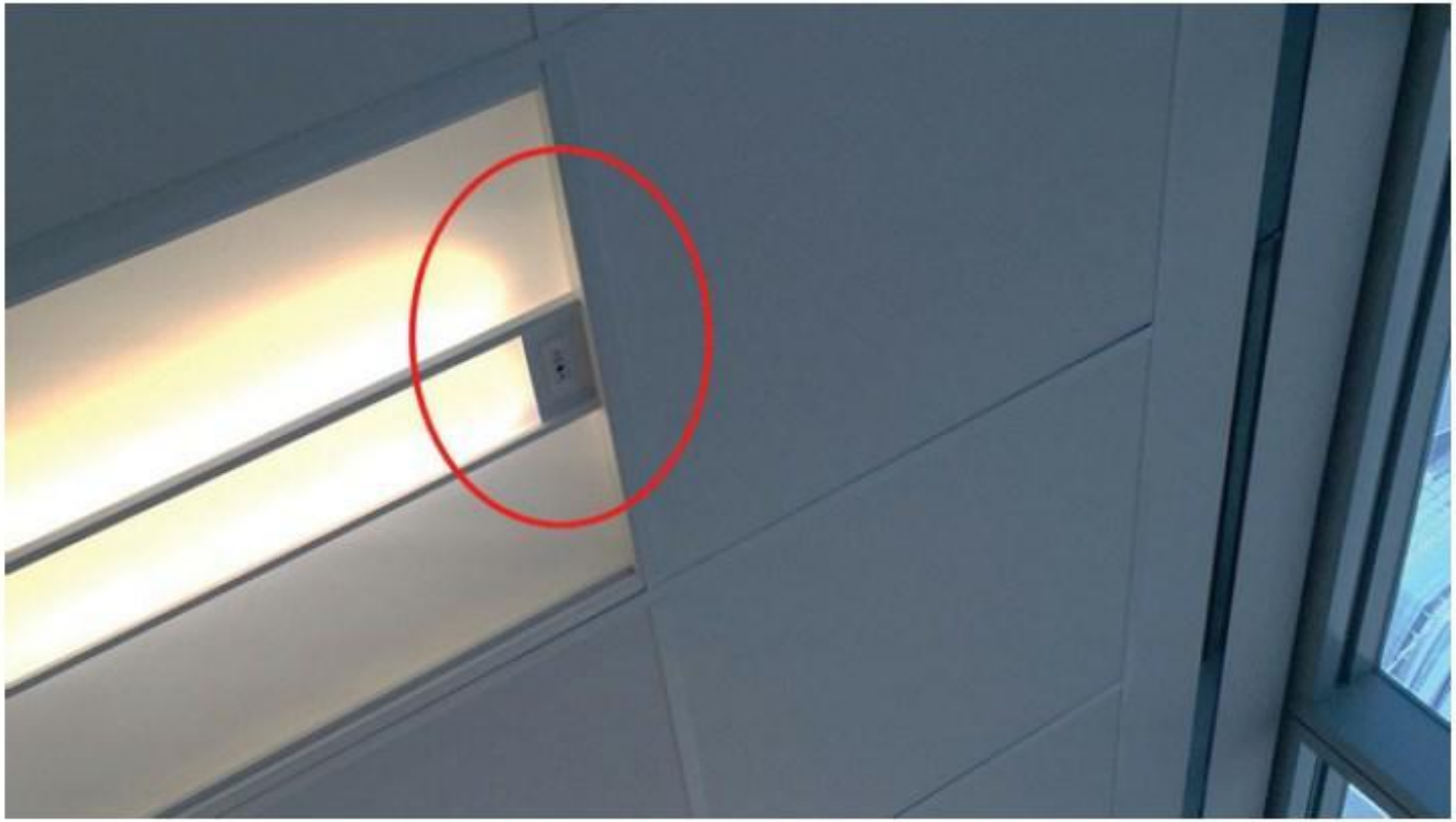
➢**Smart Connected Buildings- A Framework for the Digital Ceiling**



A Framework for the Digital Ceiling

Module - 1 : IoT Impact

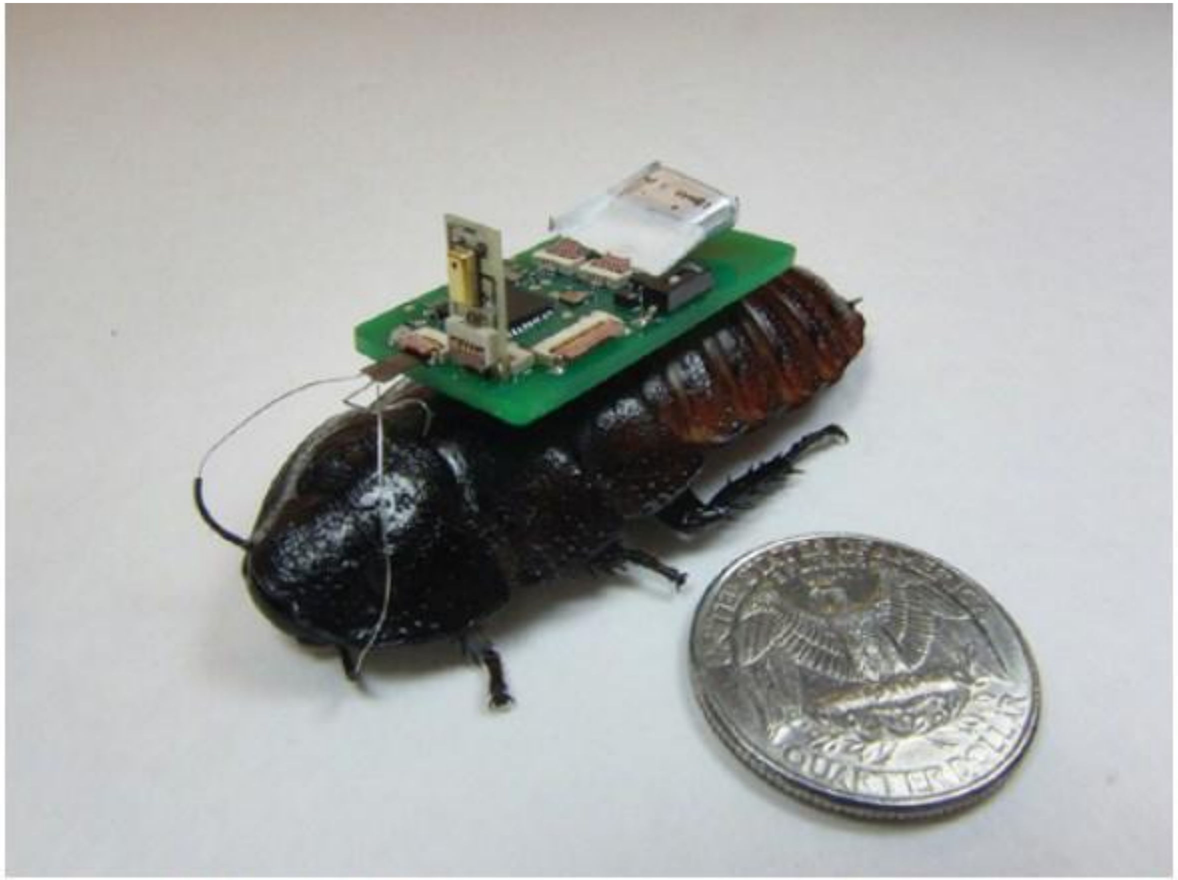
- **Smart Connected Buildings- An LED Ceiling with Occupancy Sensor**



Module - 1 : IoT Impact

- **Smart Creatures-IoT Enabled Roach to find survivors**

- **IoT provides the ability to connect living things to the Internet.**
- **Sensors can be placed on animals and insects.**
- **Connected cow- sensors on cow's ear.**
- **IoT enables roaches to save life in disaster situations.**



IoT-Enabled Roach Can Assist in Finding Survivors After a Disaster (Photo courtesy of Alper Bozkurt, NC State University)

Module - 1 : Convergence of IT and IoT

➢ **Comparing Operational Technology(OT) and Information Technology(IT)**

Criterion	Industrial OT Network	Enterprise IT Network
Operational focus	Keep the business operating 24x7	Manage the computers, data, and employee communication system in a secure way
Priorities	1. Availability 2. Integrity 3. Security	1. Security 2. Integrity 3. Availability
Types of data	Monitoring, control, and supervisory data	Voice, video, transactional, and bulk data
Security	Controlled physical access to devices	Devices and users authenticated to the network

Module - 1 : Convergence of IT and IoT

- **Comparing Operational Technology(OT) and Information Technology(IT)**

Criterion	Industrial OT Network	Enterprise IT Network
Implication of failure	OT network disruption directly impacts business	Can be business impacting, depending on industry, but workarounds may be possible
Network upgrades (software or hardware)	Only during operational maintenance windows	Often requires an outage window when workers are not onsite; impact can be mitigated
Security vulnerability	Low: OT networks are isolated and often use proprietary protocols	High: continual patching of hosts is required, and the network is connected to Internet and requires vigilant protection

Module - 1 : IoT challenges

➢ IoT challenges

Challenge	Description
Scale	• IT networks scale is larger, The scale of OT is several orders of magnitude larger. • Example: Electrical Company has deployed tons of millions meters in service area where they employed tens of thousands of employees for acting as IP Node using IP v6. • i.e the scale of network, the utility is managing has increased by more than 1000 fold.
Security	• With more “things” connected with other “things” and people security is an increasingly complex issue for IoT. Threat surface is greatly expanded and if device gets hacked, its connectivity is a major concern. • A Compromised device can serve as a launching point to attack other devices and systems.
Privacy	• A sensor become more prolific in every day lives, the data what they gather will be specific to individuals and their activities. • Example: Health information , Shopping patterns, transactions at retail establishments. • For Businesses, the data has monetary value. • Organization discusses about who owns the data and how individuals can control whether it is shared and with whom.

Module - 1 : IoT challenges

➢ IoT challenges

Challenge	Description
Big Data and Data Analytics	• IoT and large number of sensors are going to trigger deluge of data that must be handled. • This data will provide critical information and insights if it can be processed in an efficient manner. • Challenge is evaluating massive amounts of data arriving from different sources in various forms and doing so in a timely manner.
Interoperability	• As with nascent technology, various protocols and architectures are jockeying for market share and standardizations within IoT. • Some of these protocols and architectures are based on proprietary elements and others are open. • Recently IoT Standards are helping minimize this problem, but there are often various protocols and implementations available for IoT networks.

Module - 1 : IoT challenges

➢ IoT challenges

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Big Data and Data Analytics	• IoT and large number of sensors are going to trigger deluge of data that must be handled. • This data will provide critical information and insights if it can be processed in an efficient manner. • Challenge is evaluating massive amounts of data arriving from different sources in various forms and doing so in a timely manner.
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Module - 1 Drivers Behind New Network Architecture

- **The key difference between IT and IoT is the Data.**
- **IT systems are mostly concerned with reliable and continuous support of business application such as email, web, database, CRM systems and so on.**
- **IoT is all about the data generated by sensors and how that data is used.**
- **The essence of IoT architectures involve how data is transported, collected, analyzed and acted upon.**

Module - 1 Drivers Behind New Network Architecture

➢ **IoT Architectural Drivers.**

Challenges	Description	IoT Architectural Changes required
Scale	The massive scale of IoT endpoints (sensors) is far beyond that of typical IT networks.	• The IPv4 address space has reached exhaustion and is unable to meet IoT's scalability requirements. • Scale can be met only by IPv6. • IT networks continue to use IPv4 through features like Network Address Translation.
Security	IoT devices, especially those on wireless sensor networks(WSNs) are often physically exposed to the world.	• Security is required at every level of the IoT network. • Every IoT endpoint node on the network must be part of the overall security strategy and must support device level authentication and link encryption. • It must also be easy to deploy with some type of a zero – touch deployment model.

Module - 1 Drivers Behind New Network Architecture

➢ IoT Architectural Drivers.

Challenges	Description	IoT Architectural Changes required
Devices and networks constrained by power, CPU memory and link speed	Due to the massive scale and longer distances, the networks are often constrained, lossy and capable of supporting only minimal data rates (10s of bps to 100s of kbps)	• New-last mile wireless technologies are needed to support constrained IoT devices over long distances. • The network is also constrained, i.e modifications need to be made to the traditional network-layer transport mechanisms.
The massive volume of data generated	The sensors generate the massive amount of data on daily basis, causing network bottlenecks and slow analytics in the cloud.	• Data analytics capabilities need to be distributed throughout the IoT network, from the edge to the cloud. • In traditional IT networks, analytics and applications typically run only in the cloud.

Module - 1 Drivers Behind New Network Architecture

➢ IoT Architectural Drivers.

Challenges	Description	IoT Architectural Changes required
Support for legacy systems	An IoT network often comprises a collection of modern, IP capable end points as well as legacy , non-IP devices that rely on serial or proprietary protocols.	• Digital transformation is a long process that may take many years , and IoT networks need to support translation and / or tunneling mechanisms to support legacy protocols over standards-based protocols, such as Ethernet and IP.
The need for data to be analyzed in real time	Where as Traditional IT networks perform scheduled batch processing of data, IoT data needs to be analyzed and responded to in real – time.	• Analytics software need to be positioned closer to the edge and should support real-time streaming analytics. • Traditional IT analytics software (such as relational database or even Hadoop), are better suited to batch-level analytics hat occur after the fact.

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Scale**
  - **The scale of a typical IT network is on the order of several thousand devices typically printers, mobile wireless devices, laptops, servers and so on.**
  - **The traditional 3 layer campus networking model supports access, distribution and core.**
  - **IoT introduces a model where an average-sized utility, factory , transportation system or city could easily support a network of million of routable IP endpoints.**
  - **Based on scale requirements of this order, IPv6 is the natural foundation for the IoT network layer.**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Security**
  - **It world war 3, it would be for cyberspace. Targeted malicious attacks using vulnerabilities in networked machines such as out break of of the stuxnet worm, which specifically affected Siemens Programming Logic Controller (PLC) systems.**
  - **Protecting Corporate Data from intrusion and theft is the main function of IT department.**
  - **IT departments protect servers, applications and cyber crown jewels of the corporation.**
  - **In IT, first line of defense is perimeter firewall.**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Security**
  - **Placing IP endpoints outside the firewall is critical and visible to anyone.**
  - **IoT endpoints are located in WSN that use unlicensed spectrum and are visible to world through spectrum analyzer and physically accessible and widely distributed in the field.**
  - **Ukrainian Power Grid experienced an unprecedented cyber attack that targeted SCADA(Supervisory control and data acquisition) system, affected 225,000 customers**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

➢ Security

- **For optimum security, IoT systems must:**
  - **Be able to identify and authenticate all entities involved in the IoT service(i.e Gateways, endpoint devices, home networks, roaming networks, service platforms)**
  - **Ensure that all user data shared between the endpoint device and back-end applications is encrypted**
  - **Comply with local data protection legislation so that all data is protected and stored correctly.**
  - **Utilize an IoT connectivity management platform and establish rules-based security policies so immediate action can be taken if anomalous behavior is detected from connected devices.**
  - **Take a holistic, network- level approach to security.**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Constraint devices and Networks**
  - **Most IoT devices are designed for a single job, they are small and inexpensive.**
  - **This results in that they have limited power , CPU and memory.**
  - **They transmit only when there is something important.**
  - **Large amount of this small devices, large and uncontrolled environents where they are deployed, the network that provide tends to be very lossy and support very low data rates where as in IT networks provides multi-giga bit connections speed and endpoints with powerful CPUs.**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Constraint devices and Networks**
  - **For faster network, VLAN may be considered but If too many devices are in VLAN, it affects performance.**
  - **So, IoT needs new bread of connectivity technologies that meet both the scale and constraint limitations.**

Module - 1 Drivers Behind New Network Architecture

The requirements driving specific architectural changes for IoT.

- **Data**
  - **IoT devices generate a mountain of data.**
  - **In IoT, data is like Gold, they enable business to deliver new IoT services that enhance the customer experience, reduce cost and deliver new revenue opportunities.**
  - **IoT generated data is unstructured but insights it provides through analytics will provide new business models.**
  - **Example: A smart city with few 100 thousands smart street lights , all connected through an IoT network. Lights ON/OFF, replacement, operational expense.**

Module – 1 COMPARING IoT Architecture

- **The foundational concept in all these architecture is supporting data, process and the functions that end point devices perform.**

➢ **The OneM2M IoT standardized Architecture:**

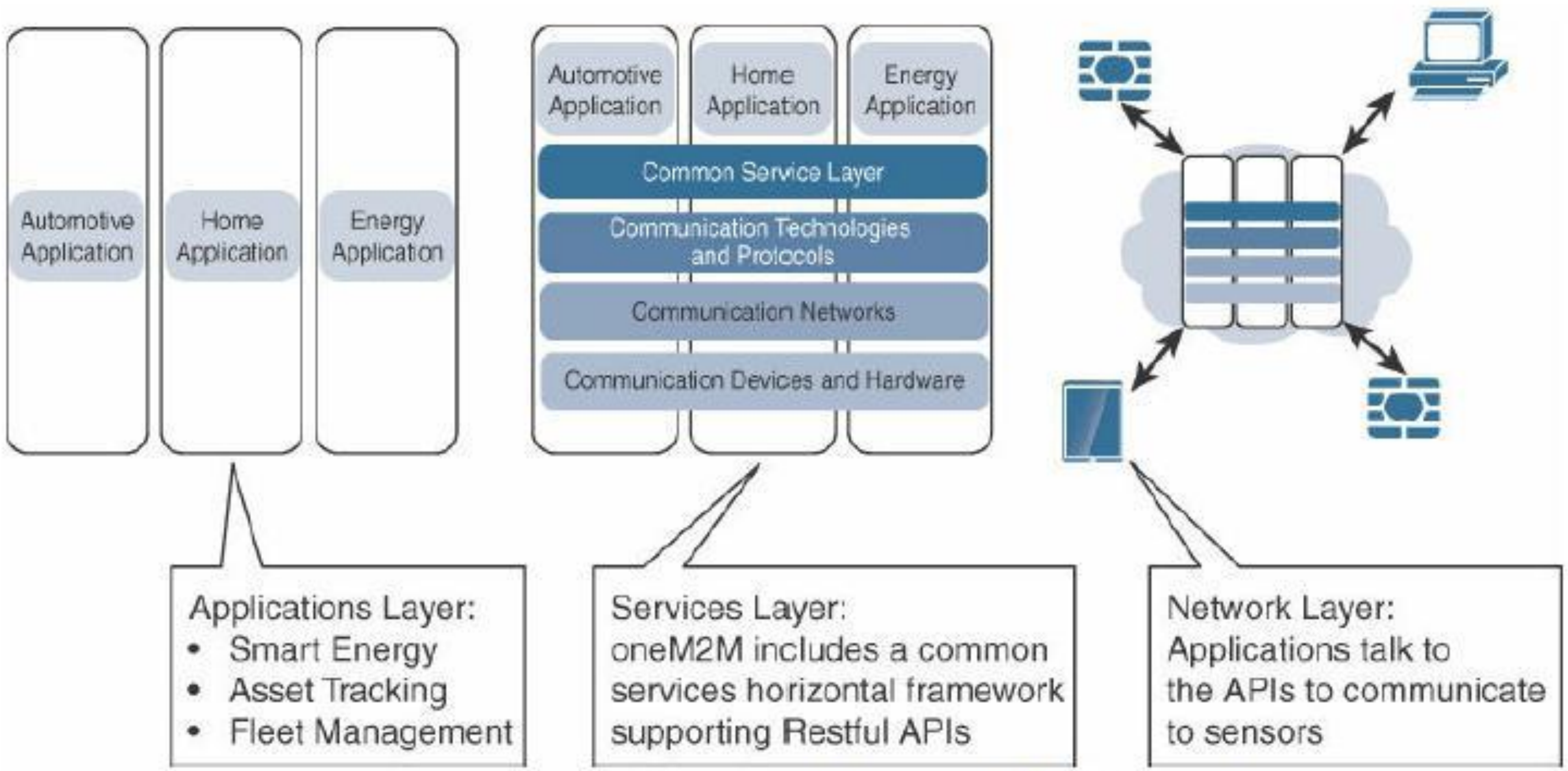
  - **To standardize the rapidly growing field of machine-to-machine (M2M) communications, the European Telecommunications standards Institute (ETSI) created the M2M Technical Committee in 2008.**
  - **The goal of the committee was to create a common architecture that would help accelerate the adoption of M2M application and devices and extended to IoT.**
  - **Similar, in 2012 ETSI and 13 other funding members launched oneM2M as a global initiative to promote efficient M2M communication system and IoT .**

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
  - **The goal of one M2M is to create a common services layer which can be readily embedded in the field devices to allow communication with application servers.**
  - **OneM2M's framework focuses on IoT services, applications and platforms. These include smart metering applications, smart grid, smart city automation, -e-health and connected vehicles.**
  - **One of the greatest challenges in designing an IoT architecture is dealing with the heterogeneity of devices, software and access methods.**

Module – 1 COMPARING IoT Architecture

➢ **The OneM2M IoT standardized Architecture:**



The Main Elements of the oneM2M IoT Architecture

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
- **The OneM2M IoT standardized Architecture divides IoT functions into 3 major domains:**
- **1. Application Layer**
- **2. Service Layer**
- **3. Network Layer**

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
- **1. Application Layer**
  - **oneM2M architecture gives more attention to connectivity between devices and their applications.**
  - **This domain includes the application-layer protocols and attempts to standardize northbound API definitions for interactions with Business intelligent (BI) systems.**
  - **Application tend to be industry specific and have their own sets of data models, thus they are shown as vertical entity**

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
- **2. Service Layer**
  - **Shown as horizontal framework across the vertical industry applications.**
  - **Horizontal modules include the physical network that the IoT application run on, the underlying management protocols and the hardware.**
  - **Example: Backhaul communications via cellular, MPLS networks, VPNs and so on.**
  - **Riding on To is the common service layer.**
  - **This conceptual layer adds APIs and middle ware supporting third party services and applications.**

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
- **3. Network Layer**
  - **This is the communication domain for the IoT devices and endpoints.**
  - **It includes the devices themselves and the communication network that links them.**
  - **Includes Wireless mess technologies such as IEEE 802.15.4 and wireless point to multi point systems such as IEEE 801.1.11ah.**
  - **It also includes wired device connections such as IEEE 1901 power line communications.**

Module – 1 COMPARING IoT Architecture

- **The OneM2M IoT standardized Architecture:**
- **3. Network Layer**
  - **In many cases, the smart (and sometimes not-so-smart) devices communicate with each other.**
  - **In other cases, machine-to-machine communication is not necessary, and the devices simply communicate through a field area network (FAN) to use-case-specific apps in the IoT application domain.**
  - **Therefore, the device domain also includes the gateway device, which provides communications up into the corenetwork and acts as a demarcation point between the device and network domains.**

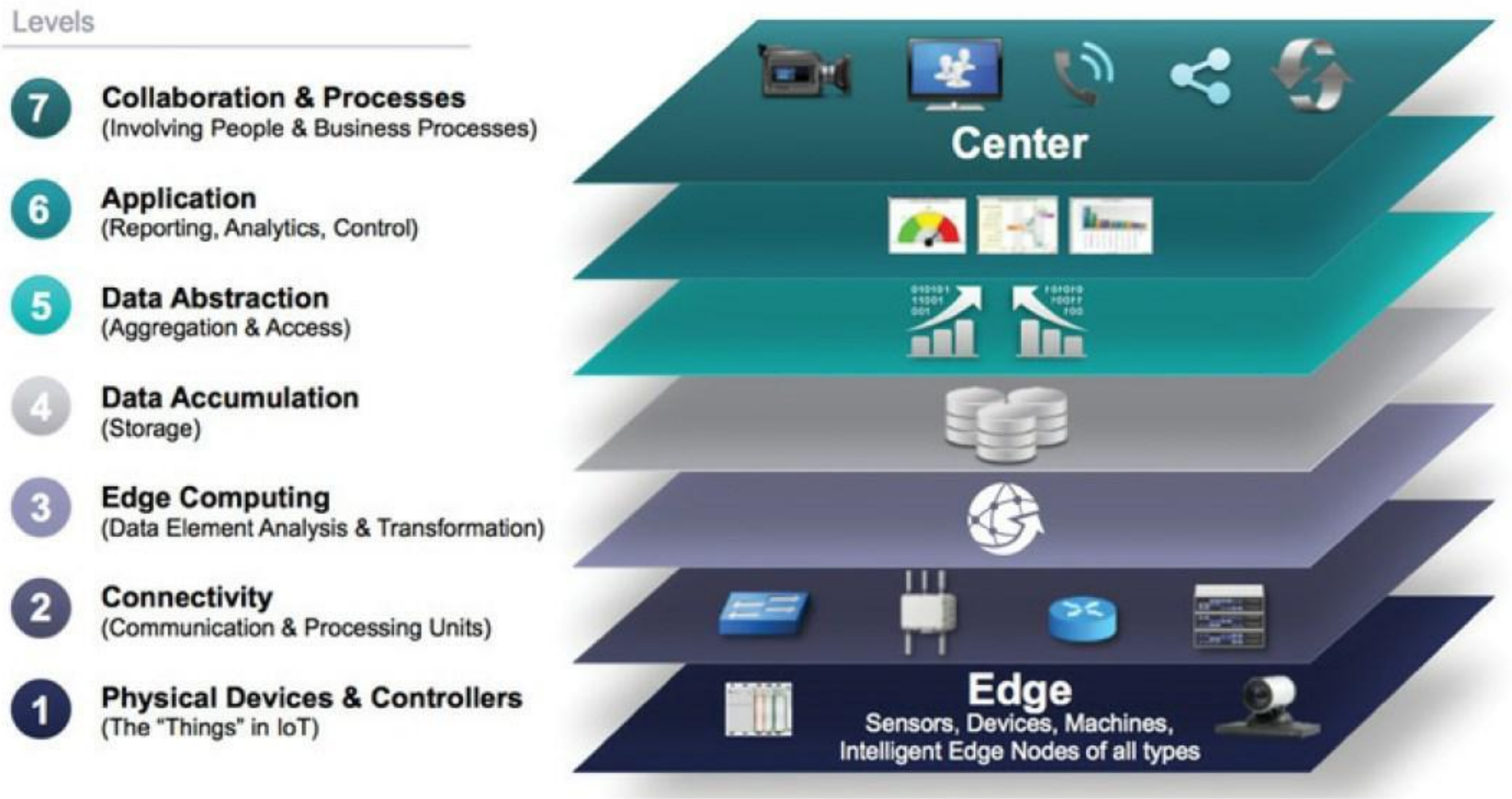
Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **In 2014 the IoTWF architectural committee (led by Cisco, IBM, Rockwell Automation, and others) published a seven-layer IoT architectural reference model.**
- **IoT World Forum Model offers a clean, simplified perspective on IoT and includes edge computing, data storage, and access. It provides a succinct way of visualizing IoT from a technical perspective.**
- **Each of the seven layers is broken down into specific functions, and security encompasses the entire model.**

Module – 1 COMPARING IoT Architecture

➢ **The IoT World Forum (IoTWF) Standardized Architecture**



IoT Reference Model Published by the IoT World Forum

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **The IoT Reference Model defines a set of levels with control flowing from the center (this could be either a cloud service or a dedicated data center), to the edge, which includes sensors, devices, machines and other types of intelligent end nodes.**
- **In general, data travels up the stack, originating from the edge, and goes northbound to the center.**
- **Using this reference model, we are able to achieve the following:**
    - **Decompose the IoT problem into smaller parts**
    - **Identify different technologies at each layer and how they relate to one another**
    - **Define a system in which different parts can be provided by different vendors**
    - **Have a process of defining interfaces that leads to interoperability**
    - **Define a tiered security model that is enforced at the transition points between levels**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Seven layers of the IoT Reference Model**
- **Layer 1: Physical Devices and Controllers Layer**
    - **The first layer of the IoT Reference Model is the physical devices and controllers layer.**
    - **This layer is home to the "things" in the Internet of Things, including the various endpoint devices and sensors that send and receive information.**
    - **The size of these "things" can range from almost microscopic sensors to giant machines in a factory.**
    - **Their primary function is generating data and being capable of being queried and/or controlled over a network.**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

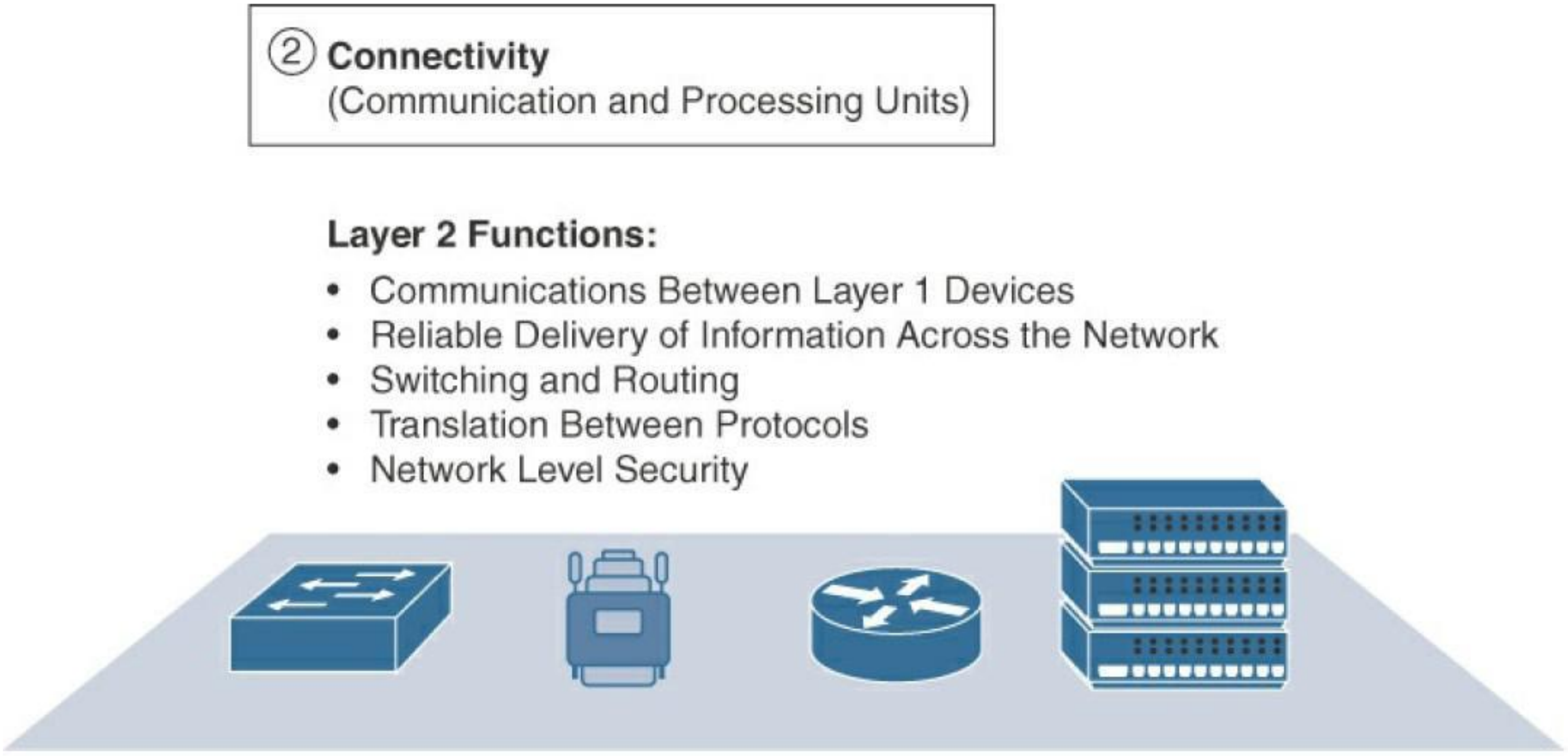
- **Layer 2: Connectivity Layer**
  - **In the second layer of the IoT Reference Model, the focus is on connectivity.**
  - **The most important function of this IoT layer is the reliable and timely transmission of data.**
  - **More specifically, this includes transmissions between Layer 1 devices and the network and between the network and information processing that occurs at Layer 3 (the edge computing layer).**
  - **The connectivity layer encompasses all networking elements of IoT and doesn’t really distinguish between the last-mile network, gateway, and backhaul networks.**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Layer 2:**

Connectivity Layer



IoT Reference Model Connectivity Layer Functions

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

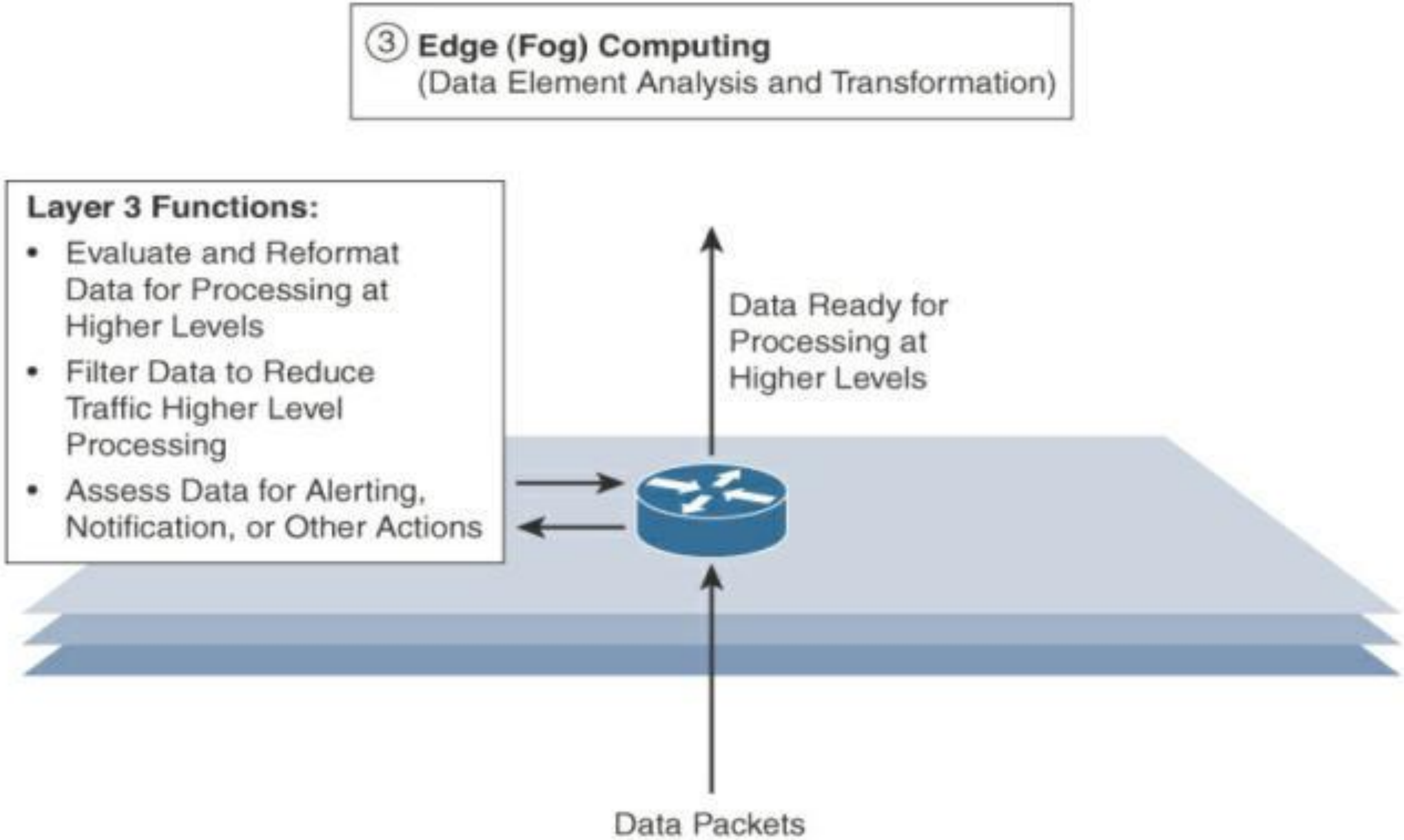
- **Layer 3: Edge Computing Layer**
  - **Edge computing is the role of Layer 3.**
  - **Edge computing is often referred to as the “fog” layer .**
  - **At this layer, the emphasis is on data reduction and converting network data flows into information that is ready for storage and processing by higher layers.**
  - **One of the basic principles of this reference model is that information processing is initiated as early and as close to the edge of the network as possible.**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Layer 3: Edge**

Computing Layer



IoT Reference Model Layer 3 Functions

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Layer 3: Edge Computing Layer**
    - **Another important function that occurs at Layer 3 is the evaluation of data to see if it can be filtered or aggregated before being sent to a higher layer.**
    - **This also allows for data to be reformatted or decoded, making additional processing by other systems easier.**
    - **Thus, a critical function is assessing the data to see if predefined thresholds are crossed and any action or alerts need to be sent**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Upper Layers: Layers 4–7**
  - **The upper layers deal with handling and processing the IoT data generated by the bottom layer.**
  - **For the sake of completeness, Layers 4–7 of the IoT Reference Model are summarized in the following Table.**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- **Upper Layers:**

Layers 4–7

IoT Reference Model Layer	Functions
Layer 4: Data accumulation layer	Captures data and stores it so it is usable by applications when necessary. Converts event-based data to query-based processing.
Layer 5: Data abstraction layer	Reconciles multiple data formats and ensures consistent semantics from various sources. Confirms that the data set is complete and consolidates data into one place or multiple data stores using virtualization.
Layer 6: Applications layer	Interprets data using software applications. Applications may monitor, control, and provide reports based on the analysis of the data.
Layer 7: Collaboration and processes layer	Consumes and shares the application information. Collaborating on and communicating IoT information often requires multiple steps, and it is what makes IoT useful. This layer can change business processes and delivers the benefits of IoT.

Summary of Layers 4–7 of the IoTWF Reference Model

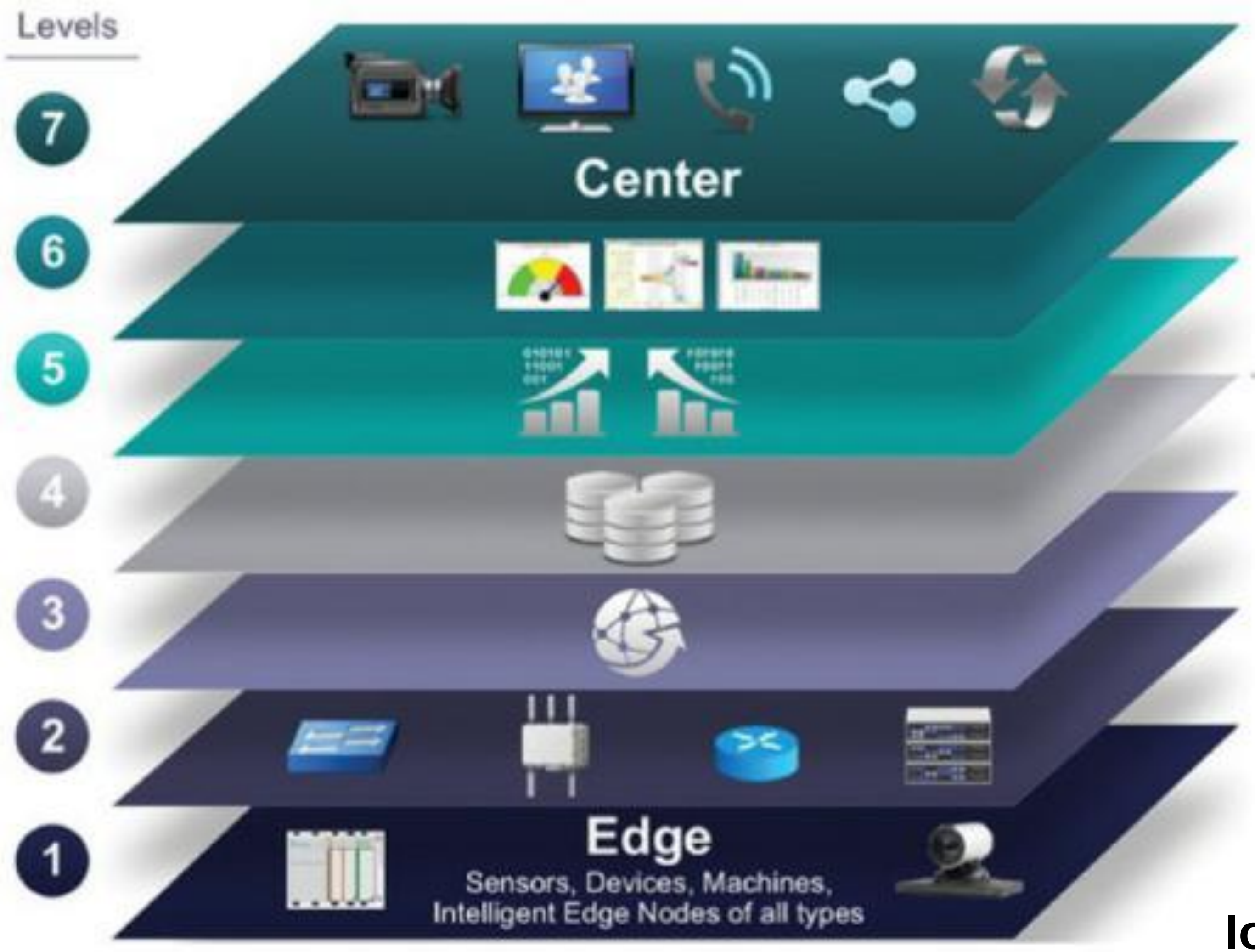
Module – 1 COMPARING IoT Architecture

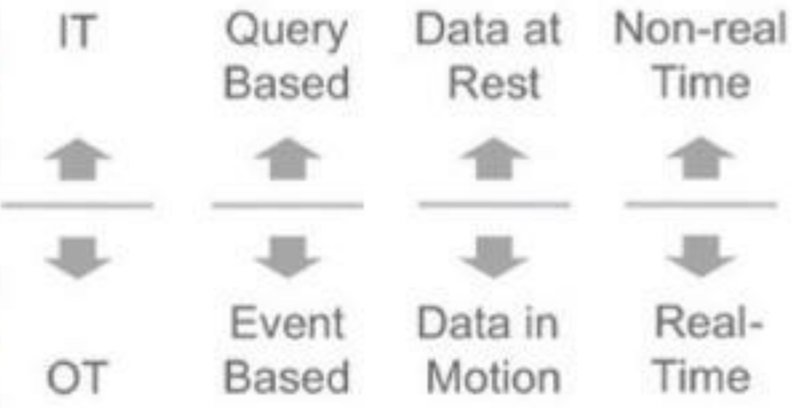
The IoT World Forum (IoTWF) Standardized Architecture:

- **IT and OT Responsibilities in the IoT Reference Model**
  - **An interesting aspect of visualizing an IoT architecture this way is that we can start to organize responsibilities along IT and OT lines.**
  - **Following Figure illustrates a natural demarcation point between IT and OT in the IoT Reference Model framework.**

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:





IoT Reference Model Separation of IT and OT

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- As demonstrated in Figure, IoT systems have to cross several boundaries beyond just the functional layers.
- The bottom of the stack is generally in the domain of OT.
- For an industry like oil and gas, this includes sensors and devices connected to pipelines, oil rigs, refinery machinery, and so on.
- The top of the stack is in the IT area and includes things like the servers, databases, and applications, all of which run on a part of the network controlled by IT.

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- In the past, OT and IT have generally been very independent and had little need to even talk to each other. IoT is changing that paradigm.
- At the bottom, in the OT layers, the devices generate real-time data at their own rate—sometimes vast amounts on a daily basis.
- Not only does this result in a huge amount of data transiting the IoT network, but the sheer volume of data suggests that applications at the top layer will be able to ingest that much data at the rate required.

Module – 1 COMPARING IoT Architecture

The IoT World Forum (IoTWF) Standardized Architecture:

- To meet this requirement, data has to be buffered or stored at certain points within the IoT stack.
- Layering data management in this way throughout the stack helps the top four layers handle data at their own speed.
- As a result, the real-time “data in motion” close to the edge has to be organized and stored so that it becomes “data at rest” for the applications in the IT tiers.
- The IT and OT organizations need to work together for overall data management.

Module – 1 COMPARING IoT Architecture

Additional IoT Reference Models:

IoT Reference Model	Description
Purdue Model for Control Hierarchy	The Purdue Model for Control Hierarchy (see www.cisco.com/c/en/us/td/docs/solutions/Verticals/EttF/EttFDIG/ch2_EttF.pdf) is a common and well-understood model that segments devices and equipment into hierarchical levels and functions. It is used as the basis for ISA-95 for control hierarchy, and in turn for the IEC-62443 (formerly ISA-99) cyber security standard. It has been used as a base for many IoT-related models and standards across industry.

Module – 1 COMPARING IoT Architecture

Additional IoT Reference Models:

IoT Reference Model	Description
Industrial Internet Reference Architecture (IIRA) by Industrial Internet Consortium (IIC)	The IIRA is a standards-based open architecture for Industrial Internet Systems (IISs). To maximize its value, the IIRA has broad industry applicability to drive interoperability, to map applicable technologies, and to guide technology and standard development. The description and representation of the architecture are generic and at a high level of abstraction to support the requisite broad industry applicability. The IIRA distills and abstracts common characteristics, features and patterns from use cases well understood at this time, predominantly those that have been defined in the IIC.

Module – 1 COMPARING IoT Architecture

Additional IoT Reference Models:

IoT Reference Model	Description
Internet of Things–Architecture (IoT-A)	IoT-A created an IoT architectural reference model and defined an initial set of key building blocks that are foundational in fostering the emerging Internet of Things. Using an experimental paradigm, IoT-A combined top-down reasoning about architectural principles and design guidelines with simulation and prototyping in exploring the technical consequences of architectural design choices.

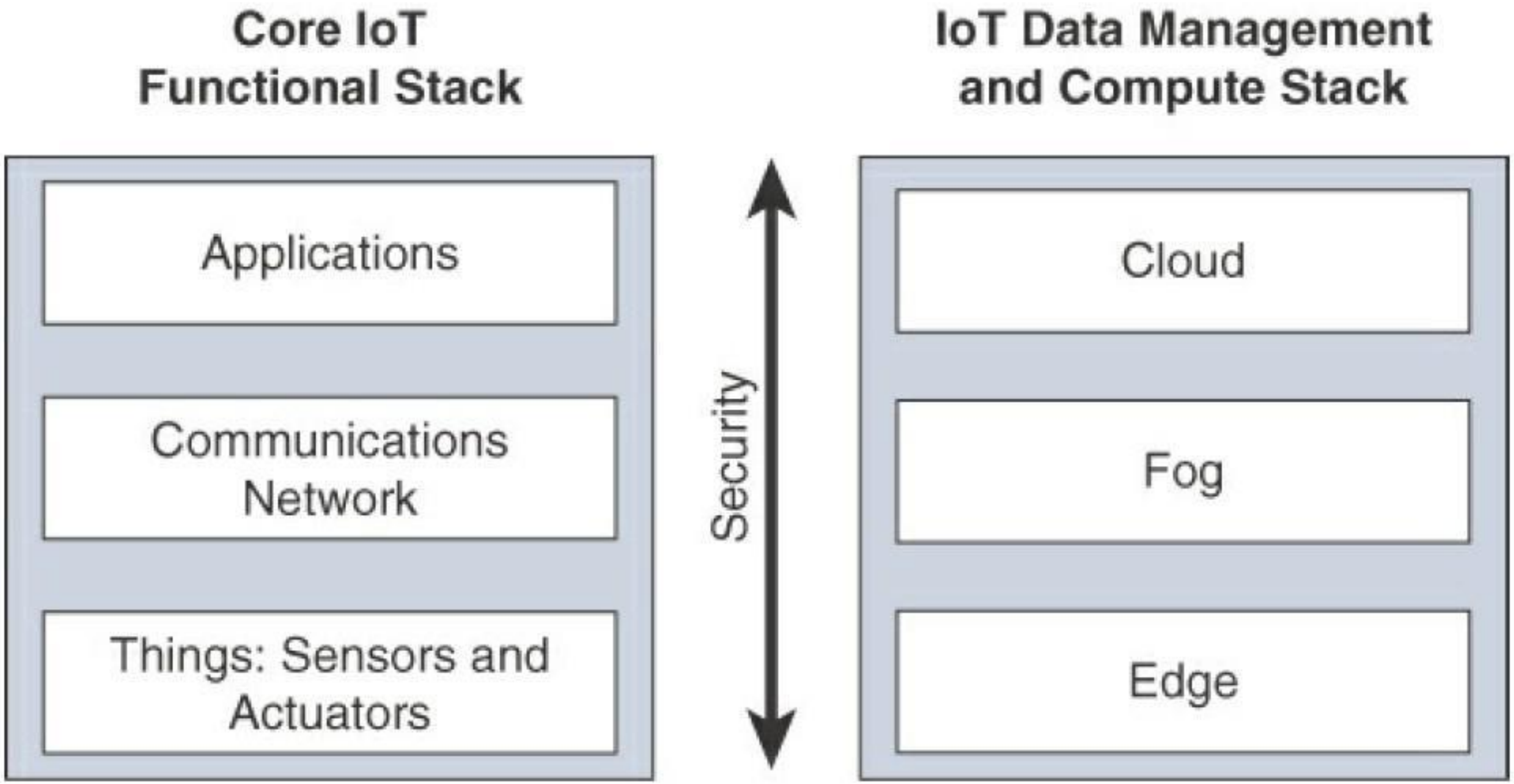
Module – 1 COMPARING IoT Architecture

A Simplified IoT Architecture:

- **All reference models, they each approach IoT from a layered perspective, allowing development of technology and standards somewhat independently at each level or domain.**
- **The commonality between these frameworks is that they all recognize the interconnection of the IoT endpoint devices to a network that transports the data where it is ultimately used by applications, whether at the data center, in the cloud, or at various management points throughout the stack**

Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:



Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **The framework separates the core IoT and data management into parallel and aligned stacks, allowing us to carefully examine the functions of both the network and the applications at each stage of a complex IoT system.**
- **This separation gives us better visibility into the functions of each layer.**
- **The network communications layer of the IoT stack itself involves a significant amount of detail and incorporates a vast array of technologies.**

Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **Consider for a moment the heterogeneity of IoT sensors and the many different ways that exist to connect them to a network.**

- **The network communications layer needs to consolidate these together, offer gateway and backhaul technologies, and ultimately bring the data back to a central location for analysis and processing.**

Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **Many of the last-mile technologies used in IoT are chosen to meet the specific requirements of the endpoints and are unlikely to ever be seen in the IT domain.**

- **However, the network between the gateway and the data center is composed mostly of traditional technologies that experienced IT professionals would quickly recognize.**

- **These include tunneling and VPN technologies, Ipbased quality of service (QoS), conventional Layer 3 routing protocols such as BGP and IP-PIM, and security capabilities such as encryption, access control lists (ACLs), and firewalls.**

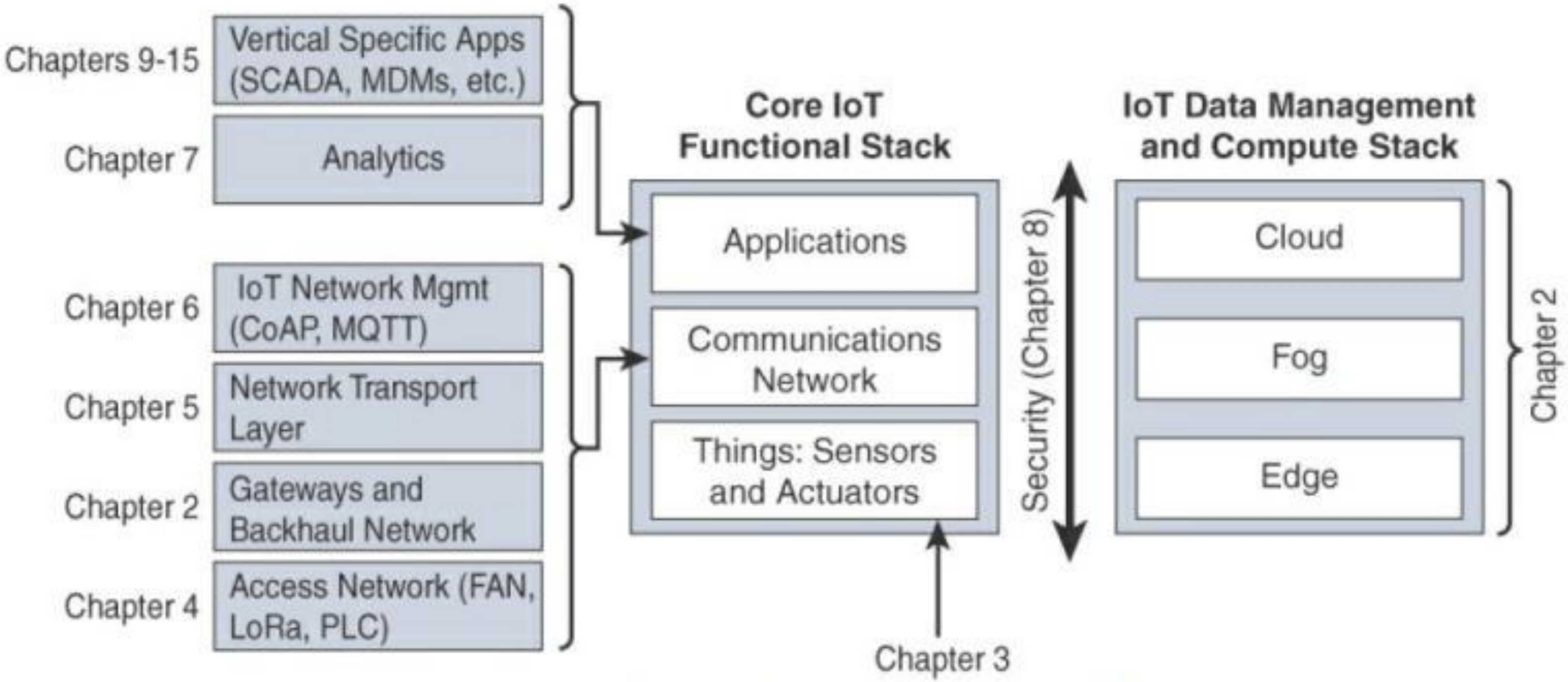
Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **In the model presented, data management is aligned with each of the three layers of the Core IoT Functional Stack.**
- **The three data management layers are the edge layer (data management within the sensors themselves), the fog layer (data management in the gateways and transit network), and the cloud layer (data management in the cloud or central data center).**

Module – 1 Simplified IoT Architecture

A Simplified IoT Architecture:



Expanded View of the Simplified IoT Architecture

Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **The Core IoT Functional Stack can be expanded into sublayers containing greater detail and specific network functions.**
- **For example, the communications layer is broken down into four separate sublayers: the access network, gateways and backhaul, IP transport, and operations and management sublayers.**
- **The applications layer of IoT networks is quite different from the application layer of a typical enterprise network.**

Module – 1 A Simplified IoT Architecture

A Simplified IoT Architecture:

- **IoT often involves a strong big data analytics component.**
- **IoT is not just about the control of IoT devices but, rather, the useful insights gained from the data generated by those devices.**
- **Thus, the applications layer typically has both analytics and industry-specific IoT control system components.**

Module – 1 The Core IoT Functional Stack

- **IoT networks are built around the concept of “things,” or smart objects performing functions and delivering new connected services.**
- **These objects are “smart” because they use a combination of contextual information and configured goals to perform actions.**
- **These actions can be self-contained (that is, the smart object does not rely on external systems for its actions); however, in most cases, the “thing” interacts with an external system to report information that the smart object collects, to exchange with other objects, or to interact with a management platform.**

Module – 1 The Core IoT Functional Stack

- In this case, the management platform can be used to process data collected from the smart object and also guide the behavior of the smart object.
- From an architectural standpoint, several components have to work together for an IoT network to be operational:
  - "Things" layer:
    - At this layer, the physical devices need to fit the constraints of the environment in which they are deployed while still being able to provide the information needed.

Module – 1 The Core IoT Functional Stack

- **Communications network layer:** When smart objects are not self contained, they need to communicate with an external system. In many cases, this communication uses a wireless technology. This layer has four sublayers:

1. **Access network sublayer:**

   - The last mile of the IoT network is the access network.
   - This is typically made up of wireless technologies such as 802.11ah, 802.15.4g, and LoRa.
   - The sensors connected to the access network may also be wired.

Module – 1 The Core IoT Functional Stack

2. Gateways and backhaul network sublayer:

- A common communication system organizes multiple smart objects in a given area around a common gateway.
- The gateway communicates directly with the smart objects.
- The role of the gateway is to forward the collected information through a longer-range medium (called the backhaul) to a headend central station where the information is processed.
- This information exchange is a Layer 7 (application)function, which is the reason this object is called a gateway.
- On IP networks, this gateway also forwards packets from one IP network to another, and it therefore acts as a router.

Module – 1 The Core IoT Functional Stack

3. **Network transport sublayer:**

   - **For communication to be successful, network and transport layer protocols such as IP and UDP must be implemented to support the variety of devices to connect and media to use.**

4. **IoT network management sublayer:**

   - **Additional protocols must be in place to allow the headend applications to exchange data with the sensors.**
   - **Examples include CoAP and MQTT.**

Module – 1 The Core IoT Functional Stack

Application and analytics layer:

- **At the upper layer, an application needs to process the collected data, not only to control the smart objects when necessary, but to make intelligent decision based on the information collected and, in turn, instruct the "things" or other systems to adapt to the analyzed conditions and change their behaviors or parameters.**

Module – 1 The Core IoT Functional Stack

1. "Things" layer
2. Communications network layer
    1. Access network sublayer
    2. Gateways and backhaul network sublayer
    3. Network transport sublayer
    4. IoT network management sublayer
3. Application and analytics layer

Module – 1 Layer -1 Things: Sensors and Actuators Layer

- **Most IoT networks start from the object, or "thing," that needs to be connected.**
- **From an architectural standpoint, the variety of smart object types, shapes, and needs drive the variety of IoT protocols and architectures.**
- **There are myriad ways to classify smart objects.**

Module – 1 Layer -1 Things: Sensors and Actuators Layer

One architectural classification could be:

➢ **Battery-powered or power-connected:**

- **This classification is based on whether the object carries its own energy supply or receives continuous power from an external power source.**
- **Battery-powered things can be moved more easily than line-powered objects.**
- **However, batteries limit the lifetime and amount of energy that the object is allowed to consume, thus driving transmission range and frequency.**

Module – 1 Layer -1 Things: Sensors and Actuators Layer

Mobile or static:

- This classification is based on whether the "thing" should move or always stay at the same location.
- A sensor may be mobile because it is moved from one object to another (for example, a viscosity sensor moved from batch to batch in a chemical plant) or because it is attached to a moving object (for example, a location sensor on moving goods in a warehouse or factory floor).
- The frequency of the movement may also vary, from occasional to permanent.
- The range of mobility (from a few inches to miles away) often drives the possible
- power source.

Module – 1 Layer -1 Things: Sensors and Actuators Layer

Low or high reporting frequency:

- **This classification is based on how often the object should report monitored parameters.**
- **A rust sensor may report values once a month.**
- **A motion sensor may report acceleration several hundred times per second.**
- **Higher frequencies drive higher energy consumption, which may create constraints on the possible power source (and therefore the object mobility) and the transmission range.**

Module – 1 Layer -1 Things: Sensors and Actuators Layer

Simple or rich data:

- This classification is based on the quantity of data exchanged at each report cycle.
- A humidity sensor in a field may report a simple daily index value (on a binary scale from 0 to 255), while an engine sensor may report hundreds of parameters, from temperature to pressure, gas velocity, compression speed, carbon index, and many others.
- Richer data typically drives higher power consumption.
- This classification is often combined with the previous to determine the object data throughput (low throughput to high throughput).
- A medium throughput object may send simple data at rather high frequency (in which case the flow structure looks continuous), or may send rich data at rather low frequency (in which case the flow structure looks bursty).

Module – 1 Layer -1 Things: Sensors and Actuators Layer

Report range:

- This classification is based on the distance at which the gateway is located.
- For example, for your fitness band to communicate with your phone, it needs to be located a few meters away at most.
- The assumption is that your phone needs to be at visual distance for you to consult the reported data on the phone screen.
- If the phone is far away, you typically do not use it, and reporting data from the band to the phone is not necessary.
- By contrast, a moisture sensor in the asphalt of a road may need to communicate with its reader several hundred meters or even kilometers away.

Module – 1 Layer -1 Things: Sensors and Actuators Layer

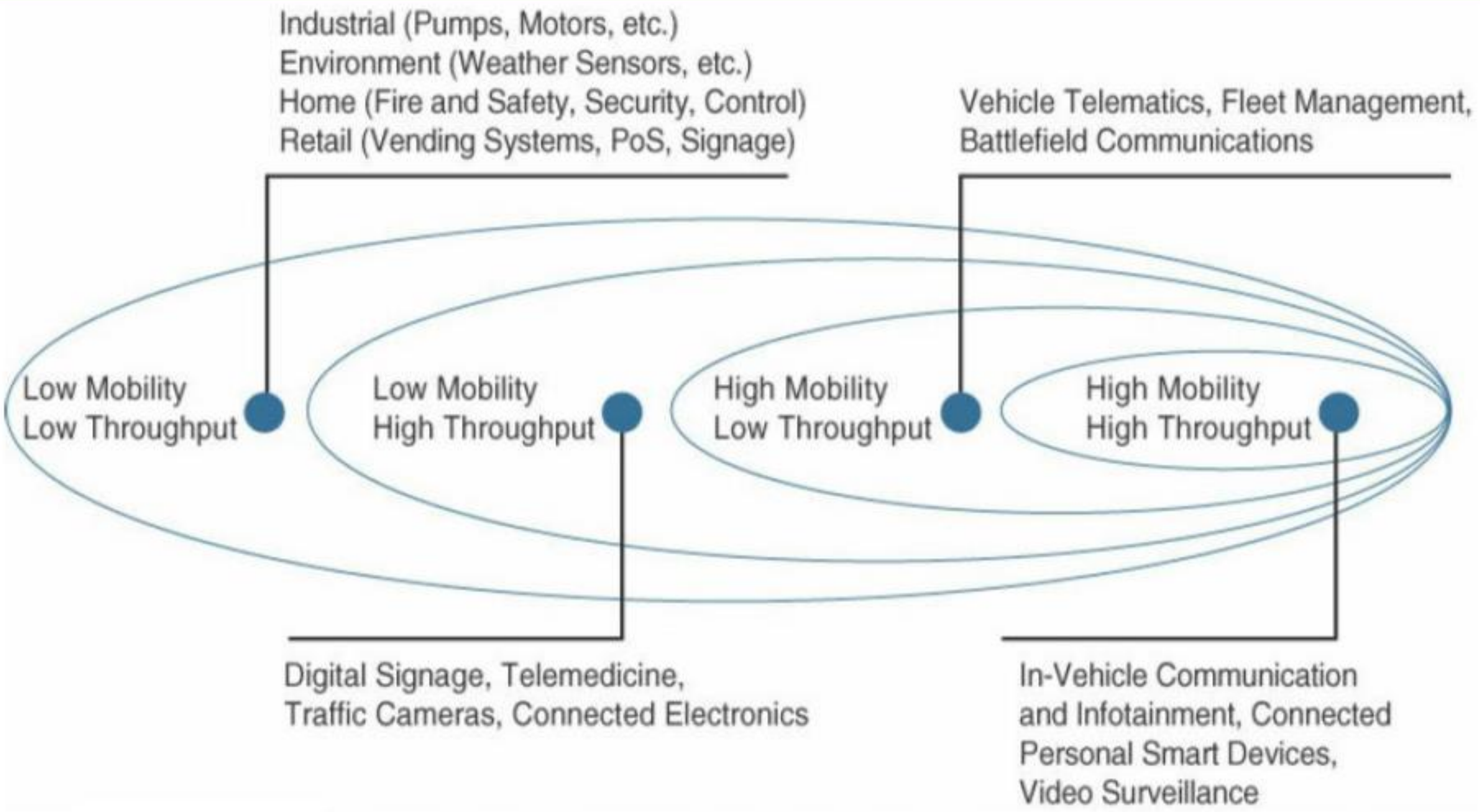
Object density per cell:

- This classification is based on the number of smart objects (with a similar need to communicate) over a given area, connected to the same gateway.
- An oil pipeline may utilize a single sensor at key locations every few miles.
- By contrast, telescopes like the SETI Colossus telescope at the Whipple Observatory deploy hundreds, and sometimes thousands, of mirrors over a small area, each with multiple gyroscopes, gravity, and vibration sensors.

Module – 1 Layer -1 Things: Sensors and Actuators Layer

- **From a network architectural standpoint, initial task is to determine which technology should be used to allow smart objects to communicate.**
- **This determination depends on the way the “things” are classified.**
- **However, some industries (such as manufacturing and utilities) may include objects in various categories, matching different needs**

Module – 1 Layer -1 Things: Sensors and Actuators Layer



Example of Sensor Applications Based on Mobility and Throughput

Module – 1 Layer -1 Things: Sensors and Actuators Layer

- **The categories used to classify things can influence other parameters and can also influence one another.**
- **For example, a battery-operated highly mobile object (like a heart rate monitor, for example) likely has a small form factor.**
- **A small sensor is easier to move or integrate into its environment.**
- **At the same time, a small and highly mobile smart object is unlikely to require a large antenna and a powerful power source.**
- **This constraint will limit the transmission range and, therefore, the type of network protocol available for its connections.**
- **The criticality of data may also influence the form factor and, therefore, the architecture.**

Module – 1 Layer -1 Things: Sensors and Actuators Layer

- **For example, a missing monthly report from an asphalt moisture sensor may simply flag an indicator for sensor (or battery) replacement.**
- **A multi-mirror gyroscope report missing for more than 100 ms may render the entire system unstable or unusable.**
- **These sensors either need to have a constant source of power (resulting in limited mobility) or need to be easily accessible for battery replacement (resulting in limited transmission range).**
- **A first step in designing an IoT network is to examine the requirements in terms of mobility and data transmission (how much data, how often).**

Module – 1 The Core IoT Functional Stack

1. **“Things” layer / Layer -1 Things: Sensors and Actuators Layer:**
    1. **Battery-powered or power-connected**
    2. **Mobile or static**
    3. **Low or high reporting frequency**
    4. **Simple or rich data**
    5. **Report range**
    6. **Object density per cell:**

Module – 1 Layer 2: Communications Network Layer

Layer 2: Communications Network Layer

Once we have determined the influence of the smart object form factor over its transmission capabilities (transmission range, data volume and frequency, sensor density and mobility), we are ready to connect the object and communicate. Computer and network assets used in IoT can be very different from those in IT environments. The difference in the physical form factors between devices used by IT and OT is obvious even to the most casual of observers

Module – 1 Layer 2: Communications Network Layer

- **The operational differences must be understood in order to apply the correct handling to secure the target assets.**

- **Temperature variances are an easily understood metric.**

- **The cause for the variance is easily attributed to external weather forces and internal operating conditions.**

- **Remote external locations, such as those associated with mineral extraction or pipeline equipment can span from the heat of the Arabian Gulf to the cold of the Alaskan North Slope. Controls near the furnaces of a steel mill obviously require heat tolerance, and controls for cold food storage require the opposite. Humidity fluctuations can impact the long-term success of a system as well**

Module – 1 Layer 2: Communications Network Layer

- **Hazardous location design may also cause corrosive impact to the equipment.**
- **Caustic materials can impact connections over which power or communications travel. Furthermore, they can result in reduced thermal efficiency by potentially coating the heat transfer surfaces.**
- **In some scenarios, the concern is not how the environment can impact the equipment but how the equipment can impact the environment.**
- **For example, in a scenario in which volatile gases may be present, spark suppression is a critical design criterion.**
- **DC power sources are also common in many environments.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Direct relationship exists between the IoT network technology and the type of connectivity topology this technology allows.**
- **Each technology was designed with a certain number of use cases in mind (what to connect, where to connect, how much data to transport at what interval and over what distance).**
- **These use cases determined the frequency band that was expected to be most suitable, the frame structure matching the expected data pattern (packet size and communication intervals), and the possible topologies that these use cases illustrate.**

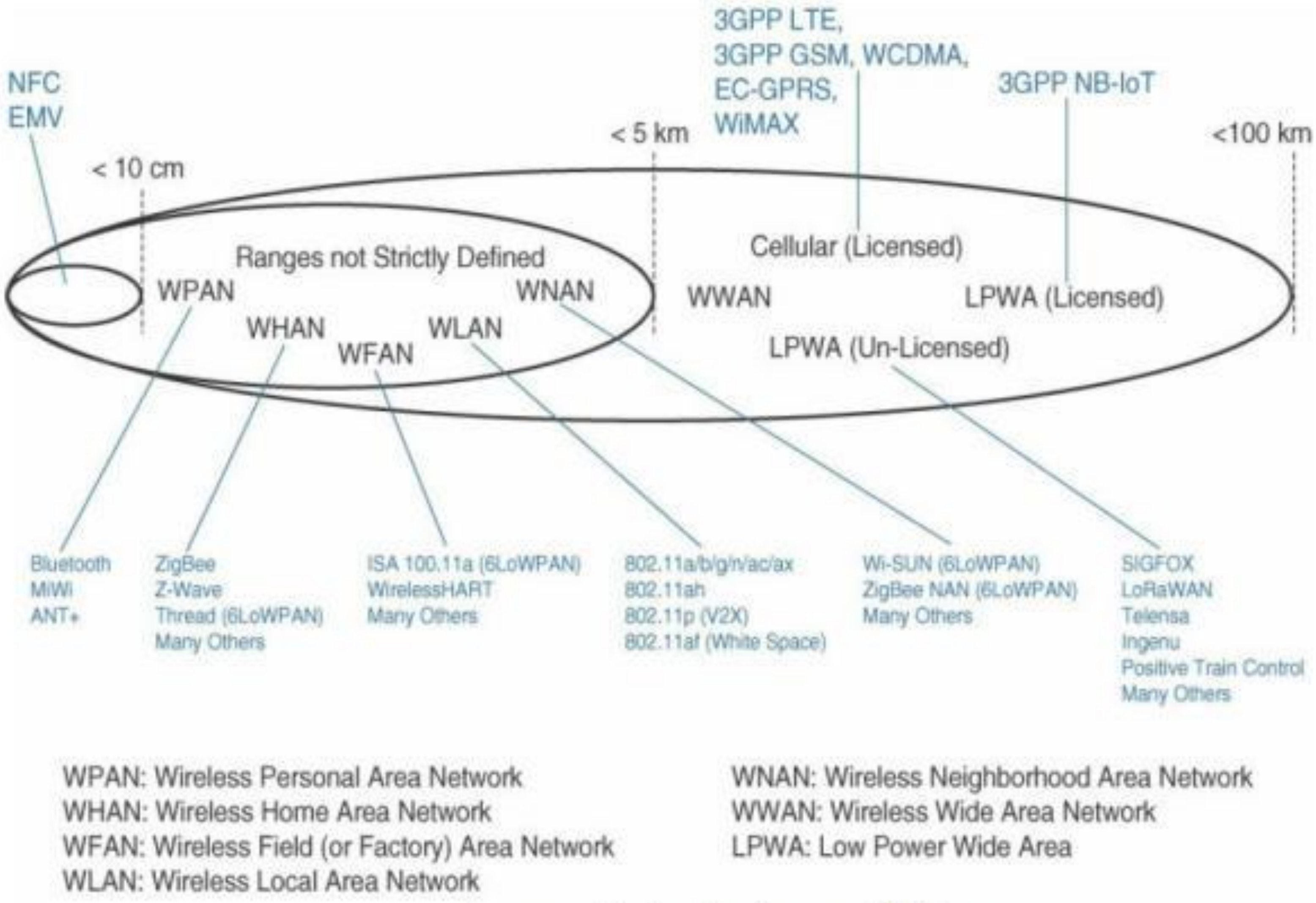
Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **IoT sometimes reuses existing access technologies whose characteristics match more or less closely the IoT use case requirements.**
- **Whereas some access technologies were developed specifically for IoT use cases, others were not.**
- **One key parameter determining the choice of access technology is the range between the smart object and the information collector.**
- **The following Figure lists some access technologies you may encounter in the IoT world and the expected transmission distances.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:



Access Technologies and Distances

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Cellular is indicated for transmissions beyond 5 km, but you could achieve a successful cellular transmission at shorter range (for example, 100 m).**

- **By contrast, ZigBee is expected to be efficient over a range of a few tens of meters, but would not expect a successful ZigBee transmission over a range of 10 km.**

- **Range estimates are grouped by category names that illustrate the environment or the vertical where data collection over that range is expected.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Common groups are as follows:**

1. PAN (personal area network):

- **Scale of a few meters.**
- **This is the personal space around a person.**
- **common wireless technology for this scale is Bluetooth.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

2. HAN (home area network):

- **Scale of a few tens of meters.**
- **At this scale, common wireless technologies for IoT include ZigBee andBluetooth Low Energy (BLE).**

3. NAN (neighborhood area network):

- **Scale of a few hundreds of meters.**
- **The term NAN is often used to refer to a group of house units from which data is collected.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

4. FAN (field area network):

- **Scale of several tens of meters to several hundred meters.**
- **FAN typically refers to an outdoor area larger than a single group of house units.**
- **The FAN is often seen as "open space" (and therefore not secured and not controlled).**
- **A FAN is sometimes viewed as a group of NANs, but some verticals see the FAN as a group of HANs or a group of smaller outdoor cells.**
- **FAN and NAN may sometimes be used interchangeably. In most cases, the vertical context is clear enough to determine the grouping hierarchy.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

5. LAN (local area network):

- **Scale of up to 100 m.**
- **This term is very common in networking, and it is therefore also commonly used in the IoT space when standard networking technologies (such as Ethernet or IEEE 802.11) are used.**
- **Other networking classifications, such as MAN (metropolitan area network, with a range of up to a few kilometers) and WAN (wide area network, with a range of more than a few kilometers), are also commonly used.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

Note:

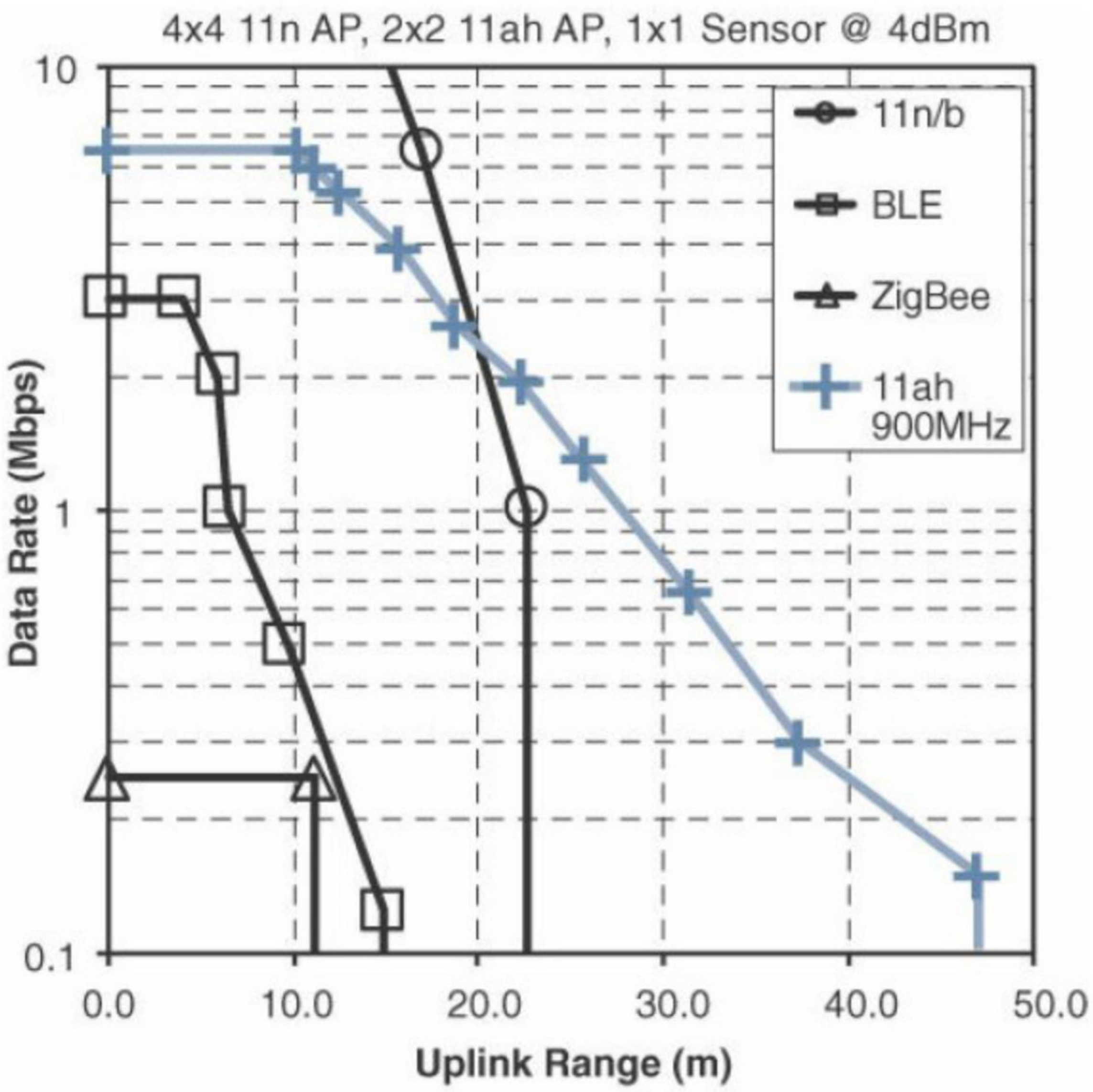
- **In the IoT network, a "W" can be added to specifically indicate wireless technologies used in that space.**
- **For example, HomePlug is a wired technology found in a HAN environment, but a HAN is often referred to as a WHAN (wireless home area network) when a wireless technology, like ZigBee, is used in that space.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

Simulation Assumptions: 1% PER, 4dB NF,
32 Bytes, D-NLOS Fading, Indoor-to-Outdoor
PL Model. 900MHz has12dB propagation gain.

Sensor Antenna Gain: 11ah (-6.5dB)
and 11n (-4dB). AP antenna gain = 2dB.
* BT Long Range Adds 125 kbps and 500 kbps Modes



Range Versus Throughput for Four WHAN to WLAN Technologies

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Each protocol uses a specific frame format and transmission technique over a specific frequency (or band). These characteristics introduce additional differences.**
- **For example, above Figure demonstrates four technologies representing WHAN to WLAN ranges and compares the throughput and range that can be achieved in each case.**
- **Figure supposes that the sensor uses the same frame size, transmit power, and antenna gain.**
- **The slope of throughput degradation as distance increases varies vastly from one technology to the other.**
- **This difference limits the amount of data throughput that each technology can achieve as the distance from the sensor to the receiver increases.**

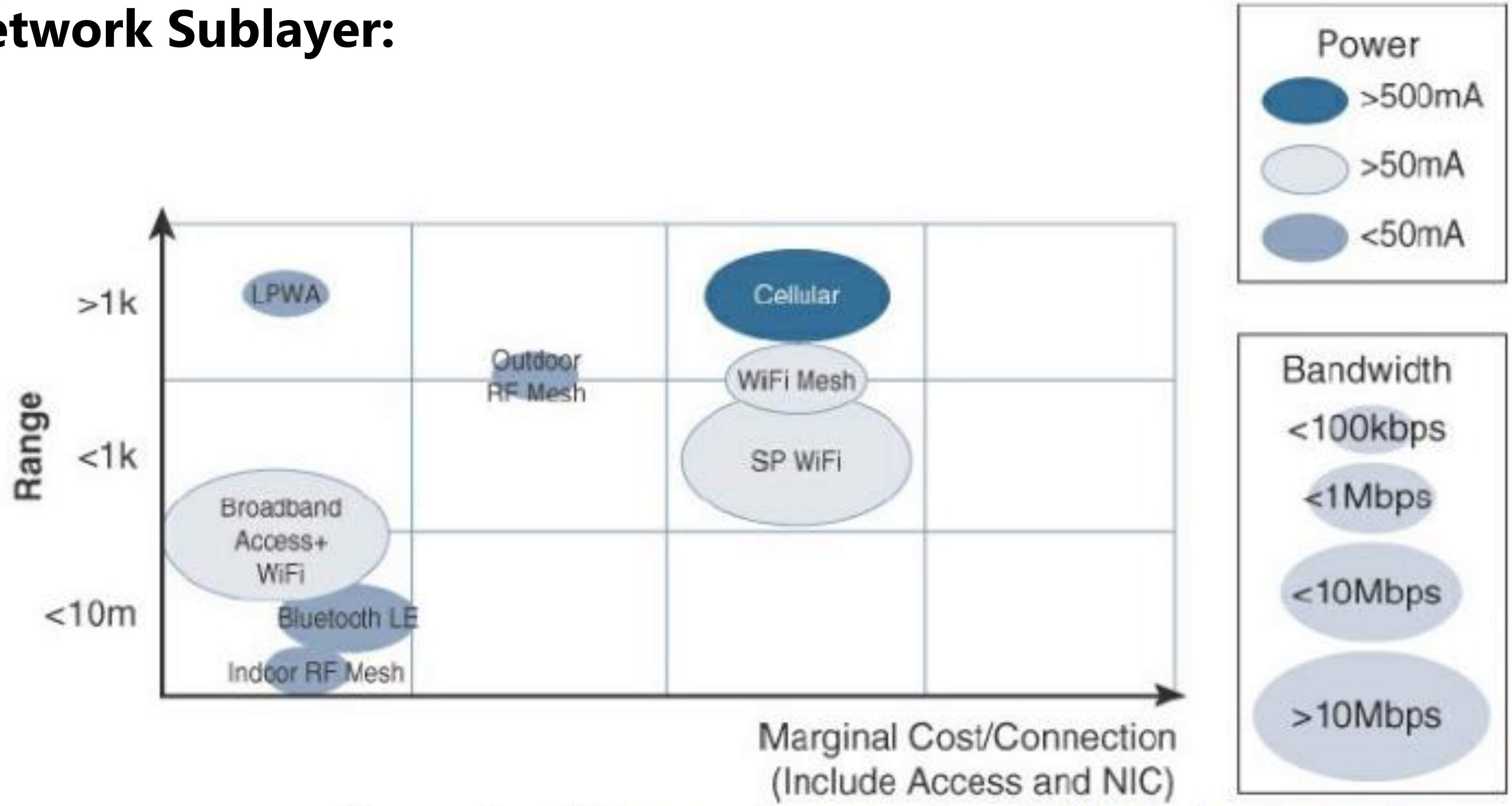
Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Increasing the throughput and achievable distance typically comes with an increase in power consumption.**
- **Therefore, after determining the smart object requirements (in terms of mobility and data transfer), a second step is to determine the target quantity of objects in a single collection cell, based on the transmission range and throughput required.**
- **This parameter in turn determines the size of the cell.**
- **It may be tempting to simply choose the technology with the longest range and highest throughput. However, the cost of the technology is a third determining factor.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:



Comparison Between Common Last-Mile Technologies in Terms of Range Versus Cost, Power, and Bandwidth

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

The amount of data to carry over a given time period along with correlated power consumption (driving possible limitations in mobility and range) determines the wireless cell size and structure.

Technologies offer flexible connectivity structure to extend communication possibilities:

1. Point-to-point topologies:

- **These topologies allow one point to communicate with another point.**
- **In this topology, a single object can communicate only with a single gateway.**
- **Several technologies are referred to as "point-to-point" when each object establishes an individual session with the gateway.**

Access Network Sublayer:

2. **Point-to-multipoint topologies:**

   - **This topologies allow one point to communicate with more than one other point.**
   - **Most IoT technologies where one or more than one gateways communicate with multiple smart objects are in this category.**
   - **Some nodes (for example, sensors) support both data collection and forwarding functions, while some other nodes (for example, some gateways) collect the smart object data, sometimes instruct the sensor to perform specific operations, and also interface with other networks or possibly other gateways.**
   - **For this reason, some technologies categorize the nodes based on the functions (described by a protocol) they implement.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **To form a network, a device needs to connect with another device.**
- **When both devices fully implement the protocol stack functions, they can form a peer-to peer network.**
- **In many cases, one of the devices collects data from the others.**
- **For example, in a house, temperature sensors may be deployed in each room or each zone of the house, and they may communicate with a central point where temperature is displayed and controlled.**
- **A room sensor does not need to communicate with another room sensor.**
- **In that case, the control point is at the center of the network.**
- **The network forms a star topology, with the control point at the hub and the sensors at the spokes.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **In such a configuration, the central point can be in charge of the overall network coordination, taking care of the beacon transmissions and connection to each sensor.**
- **In the IEEE 802.15.4 standard, the central point is called a coordinator for the network.**
- **With this type of deployment, each sensor is not intended to do anything other than communicate with the coordinator in a master/slave type of relationship.**
- **The sensor can implement a subset of protocol functions to perform just a specialized part (communication with the coordinator). Such a device is called a reduced-function device (RFD).**
- **An RFD cannot be a coordinator. An RFD also cannot implement direct communications to another RFD.**

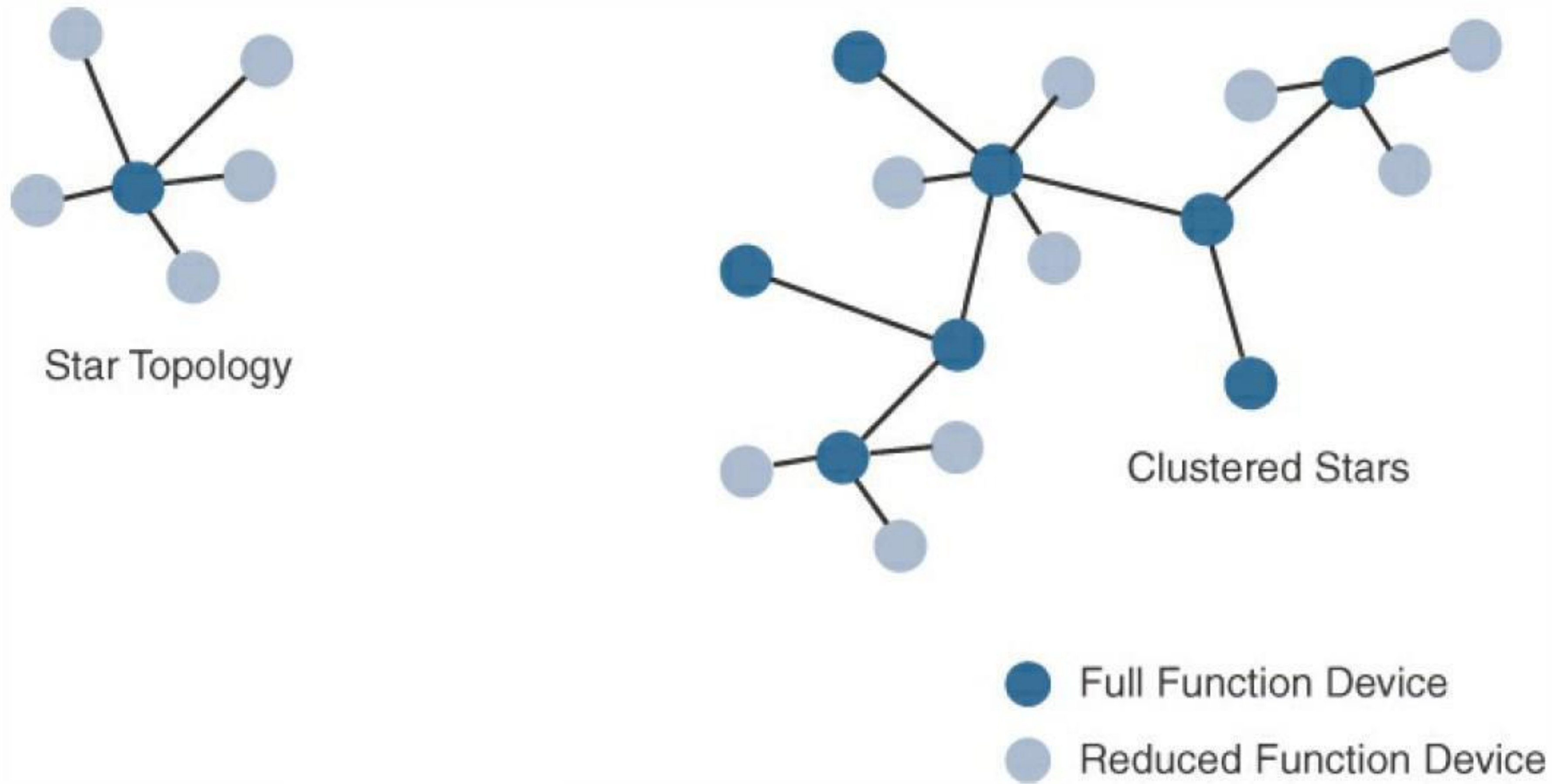
Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **The coordinator that implements the full network functions is called, by contrast, a full-function device (FFD).**
- **An FFD can communicate directly with another FFD or with more than one FFD, forming multiple peer-to-peer connections.**
- **Topologies where each FFD has a unique path to another FFD are called cluster tree topologies.**
- **FFDs in the cluster tree may have RFDs, resulting in a cluster star topology.**
- **The next Figure illustrates these topologies.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:



Star and Clustered Star Topologies

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Other point-to-multipoint technologies allow a node to have more than one path to another node, forming a mesh topology.**
- **This redundancy means that each node can communicate with more than just one other node.**
- **This communication can be used to directly exchange information between nodes (the receiver directly consumes the information received) or to extend the range of the communication link.**
- **In this case, an intermediate node acts as a relay between two other nodes.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **These two other nodes would not be able to communicate successfully directly while respecting the constraints of power and modulation dictated by the PHY layer protocol.**
- **Range extension typically comes at the price of slower communications (as intermediate nodes need to spend time relaying other nodes' messages).**
- **An example of a technology that implements a mesh topology is Wi-Fi mesh.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Another property of mesh networks is redundancy.**
- **The disappearance of one node does not necessarily interrupt network communications.**
- **Data may still be relayed through other nodes to reach the intended destination.**

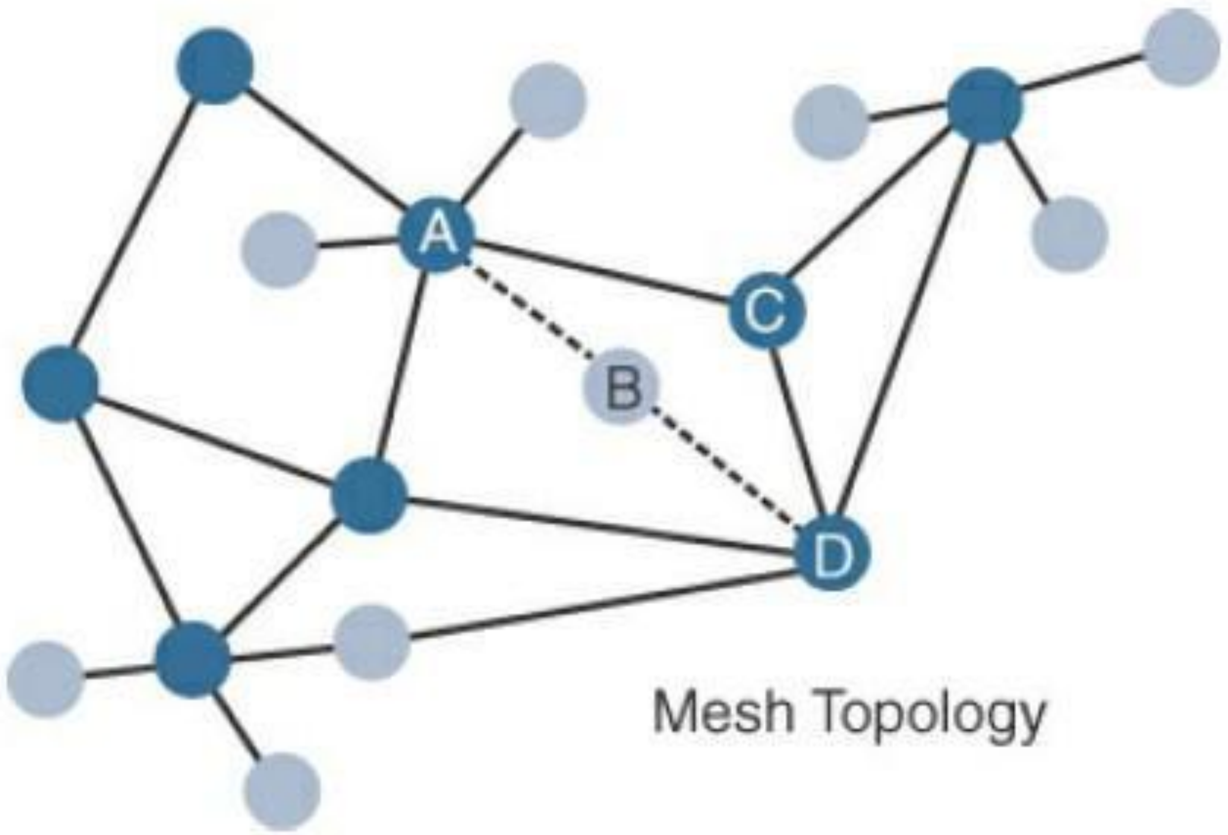
Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer:

- **Next Figure shows a mesh topology.**
- **Nodes A and D are too far apart to communicate directly.**
- **Communication can be relayed through nodes B or C. Node B may be used as the primary relay.**
- **The loss of node B does not prevent the communication between nodes A and D.**
- **Here, communication is rerouted through another node, node C.**

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer: Mesh Topology



Mesh Topology

Module – 1 Layer 2: Communications Network Layer

Access Network Sublayer: Mesh Topology

- **Figure shows a partial mesh topology, where a node can communicate with more than one other node, but not all nodes communicate directly with all other nodes.**
- **In a full mesh topology each node communicates with each other node.**
- **In the topology shown in Figure 2, which has 17 nodes, a full mesh structure would mean that each node would have 16 connections (one to each other node).**
- **Full mesh structures are computationally expensive (as each node needs to maintain a connection to each other node).**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **Data collected from a smart object may need to be forwarded to a central station where data is processed.**
- **As this station is often in a different location from the smart object, data directly received from the sensor through an access technology needs to be forwarded to another medium (the backhaul) and transported to the central station.**
- **The gateway is in charge of this inter-medium communication.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **In most cases, the smart objects are static or mobile within a limited area.**
- **The gateway is often static.**
- **However, some IoT technologies do not apply this model.**
- **For example, dedicated short-range communication (DSRC) allows vehicle-to-vehicle and vehicle-to-infrastructure communication.**
- **In this model, the smart object's position relative to the gateway is static.**
- **The car includes sensors and one gateway.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **Communication between the sensors and the gateway may involve wired or wireless technologies.**
- **Sensors may also be integrated into the road infrastructure and connect over a wired or wireless technology to a gateway on the side of the road.**
- **A wireless technology (DSRC operates in the upper 5 GHz range) is used for backhaul communication, peer-to-peer, or mesh communication between vehicles.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **In the DSRC case, the entire "sensor field" is moving along with the gateway, but the general principles of IoT networking remain the same.**
- **The range at which DSRC can communicate is limited.**
- **Similarly, for all other IoT architectures, the choice of a backhaul technology depends on the communication distance and also on the amount of data that needs to be forwarded.**
- **When the smart object's operation is controlled from a local site, and when the environment is stable (for example, factory or oil and gas field), Ethernet can be used as a backhaul.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **In unstable or changing environments (for example, open mines) where cables cannot safely be run, a wireless technology is used.**
- **Wi-Fi is common in this case, often with multiple hops between the sensor field and the operation center.**
- **Mesh is a common topology to allow communication flexibility in this type of dynamic environment.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **Throughput decreases as node-to-node distance increases, and it also decreases as the number of hops increases.**
- **In a typical Wi-Fi mesh network, throughput halves for each additional hop.**
- **WiMAX (802.16) is an example of a longer-range technology.**

Module – 1 Layer 2: Communications Network Layer

Gateways and Backhaul Sublayer:

- **WiMAX can achieve ranges of up to 50 kilometers with rates of up to 70 Mbps.**
- **The choice of WiMAX or a cellular technology depends on the vertical and the location (local preferences, local costs).**

Module – 1 Layer 2: Communications Network Layer

Gateways and

Backhaul Sublayer:

Architectural

Considerations for

WiMAX and Cellular

Technologies

Technology	Type and Range	Architectural Characteristics
Ethernet	Wired, 100 m max	Requires a cable per sensor/sensor group; adapted to static sensor position in a stable environment; range is limited; link is very reliable
Wi-Fi (2.4 GHz, 5 GHz)	Wireless, 100 m (multipoint) to a few kilometers (P2P)	Can connect multiple clients (typically fewer than 200) to a single AP; range is limited; adapted to cases where client power is not an issue (continuous power or client battery recharged easily); large bandwidth available, but interference from other systems likely; AP needs a cable
802.11ah (HaloW, Wi-Fi in sub-1 GHz)	Wireless, 1.5 km (multipoint), 10 km (P2P)	Can connect a large number of clients (up to 6000 per AP); longer range than traditional Wi-Fi; power efficient; limited bandwidth; low adoption; and cost may be an issue
WiMAX (802.16)	Wireless, several kilometers (last mile), up to 50 km (backhaul)	Can connect a large number of clients; large bandwidth available in licensed spectrum (fee-based); reduced bandwidth in license-free spectrum (interferences from other systems likely); adoption varies on location
Cellular (for example, LTE)	Wireless, several kilometers	Can connect a large number of clients; large bandwidth available; licensed spectrum (interference-free; license-based)

Module – 1 Layer 2: Communications Network Layer

Network Transport Sublayer:

- **communication structure may involve peer-to-peer (for example,meter to meter), point-to-point (meter to headend station), point-to-multipoint(gateway or head-end to multiple meters), unicast and multicastcommunications (software update to one or multiple systems).**

- **In a multitenantenvironment (for example, electricity and gas consumption management),different systems may use the same communication pathways.**

- **This communication occurs over multiple media (for example, power lines inside your house or a short-range wireless system like indoor Wi-Fi and/or ZigBee), a longer-range wireless system to the gateway, and yet another wireless or wired medium for backhaul transmission.**

Module – 1 Layer 2: Communications Network Layer

Network Transport Sublayer:

- **To allow for such communication structure, a network protocol with specific characteristics needs to be implemented.**
- **The protocol needs to be open and standard-based to accommodate multiple industries and multiple media.**
- **Scalability (to accommodate thousands or millions of sensors in a single**
- **network) and security are also common requirements.**
- **IP is a protocol that matches all these requirements**

Module – 1 Layer 2: Communications Network Layer

Network Transport Sublayer:

- **The flexibility of IP allows this protocol to be embedded in objects of very different natures, exchanging information over very different media, including low-power, lossy, and low-bandwidth networks.**

- **For example, RFC 2464 describes how an IPv6 packet gets encapsulated over an Ethernet frame and is also used for IEEE 802.11 Wi-Fi.**

- **Similarly, the IETF 6LoWPAN working group specifies how IPv6 packets are carried efficiently over lossy networks, forming an "adaption layer" for IPv6, primarily for IoT networks**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **IP, TCP, and UDP bring connectivity to IoT networks.**
- **Upper-layer protocols need to take care of data transmission between the smart objects and other systems.**
- **Multiple protocols have been leveraged or created to solve IoT data communication problems.**
- **Some networks rely on a push model (that is, a sensor reports at a regular interval or based on a local trigger), whereas others rely on a pull model (that is, an application queries the sensor over the network), and multiple hybrid approaches are also possible.**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **IP logic, some IoT implementers have suggested HTTP for the data transfer phase.**
- **HTTP has a client and server component.**
- **The sensor could use the client part to establish a connection to the IoT central application (the server), and then data can be exchanged.**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **One example is WebSocket. WebSocket is part of the HTML5 specification, and provides a simple bidirectional connection over a single connection.**

- **Some IoT solutions use WebSocket to manage the connection between the smart object and an external application.**

- **WebSocket is often combined with other protocols, such as MQTT (described shortly) to handle the IoT-specific part of the communication.**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **With the same logic of reusing well-known methods, Extensible Messaging andPresence Protocol (XMPP) was created.**
- **XMPP is based on instant messaging and presence.**
- **It allows the exchange of data between two or more systems and supports presence and contact list maintenance.**
- **It can also handle publish/subscribe, making it a good choice for distribution of information to multiple devices.**
- **A limitation of XMPP is its reliance on TCP, which mayforce subscribers to maintain open sessions to other systems and may be a limitation for memory-constrained objects.**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **To respond to the limits of web-based protocols, another protocol was created by the IETF Constrained Restful Environments (CoRE) working group: Constrained Application Protocol (CoAP).**
- **CoAP uses some methods similar to those of HTTP (such as Get, Post, Put, and Delete) but implements a shorter list, thus limiting the size of the header.**
- **CoAP also runs on UDP (whereas HTTP typically uses TCP).**
- **CoAP also adds a feature that is lacking in HTTP and very useful for IoT: observation.**
- **Observation allows the streaming of state changes as they occur, without requiring the receiver to query for these changes.**

Module – 1 Layer 2: Communications Network Layer

IoT Network Management Sublayer:

- **Another common IoT protocol utilized in these middle to upper layers is Message Queue Telemetry Transport (MQTT).**
- **MQTT uses a broker-based architecture.**
- **The sensor can be set to be an MQTT publisher (publishes a piece of information), the application that needs to receive the information can be set as the MQTT subscriber, and any intermediary system can be set as a broker to relay the information between the publisher and the subscriber(s).**
- **MQTT runs over TCP. A consequence of the reliance on TCP is that an MQTT client typically holds a connection open to the broker at all times.**
- **This may be a limiting factor in environments where loss is high or where computing resources are limited.**

Module – 1 The Core IoT Functional Stack

2. Communications network layer/ Layer 2: Communications Network Layer

1. **Access network sublayer**
   1. PAN (Personal Area Network)
   2. HAN (Home Area Network)
   3. NAN (Neighborhood Area Network)
   4. FAN (Field Area Network)
   5. LAN (Local Area Network)
2. **Gateways and backhaul network sublayer**
3. **Network transport sublayer**
4. **IoT network management sublayer**

1. Point-to-point topologies
2. Point-to-multipoint topologies

Module – 1 Layer 3: Applications and Analytics Layer

Applications and Analytics Layer:

- **Once connected to a network, smart objects exchange information with other systems.**
- **As soon as IoT network spans more than a few sensors, the power of the Internet of Things appears in the applications that make use of th einformation exchanged with the smart objects.**

Module – 1 Layer 3: Applications and Analytics Layer

Analytics Versus Control Applications:

- **Multiple applications can help increase the efficiency of an IoT network.**
- **Each application collects data and provides a range of functions based on analyzing the collected data.**
- **It can be difficult to compare the features offered**

Module – 1 Layer 3: Applications and Analytics Layer

Analytics Versus Control Applications:

- **From an architectural standpoint, one basic classification can be as follows:**

1. **Analytics application:**
    - **This type of application collects data from multiple smart objects, processes the collected data, and displays information resulting from the data that was processed.**
    - **The display can be about any aspect of the IoT network, from historical reports, statistics,or trends to individual system states.**
    - **The important aspect is that the application processes the data to convey a view of the network that cannot be obtained from solely looking at the information displayed by a single smart object.**

Module – 1 Layer 3: Applications and Analytics Layer

Analytics Versus Control Applications:

2. **Control application:**

- **This type of application controls the behavior of the smart object or the behavior of an object related to the smart object.**
- **For example, a pressure sensor may be connected to a pump.**
- **A control application increases the pump speed when the connected sensor detects a drop in pressure.**
- **Control applications are very useful for controlling complex aspects of an IoT network with a logic that cannot be programmed inside a single IoT object, either because the configured changes are too complex to fit into the local system or because the configured changes rely on parameters that include elements outside the IoT object.**

Module – 1 Layer 3: Applications and Analytics Layer

Analytics Versus Control Applications:

- **Many advanced IoT applications include both analytics and control modules.**
- **In most cases, data is collected from the smart objects and processed in the analytics module.**
- **The result of this processing may be used to modify the behavior of smart objects or systems related to the smart objects.**
- **The control module is used to convey the instructions for behavioral changes.**
- **When evaluating an IoT data and analytics application, we need to determine the relative depth of the control part needed for our use case and match it against the type of analytics provided.**

Module – 1 Layer 3: Applications and Analytics Layer

Data Versus Network Analytics

Analytics is a general term that describes processing information to make sense of collected data.

In the world of IoT, a possible classification of the analytics function is as follows:

1. Data analytics:

- **This type of analytics processes the data collected by smart objects and combines it to provide an intelligent view related to the IoT system.**
- **At a very basic level, a dashboard can display an alarm when a weight sensor detects that a shelf is empty in a store.**
- **In a more complex case, temperature, pressure, wind, humidity, and light levels collected from thousands of sensors may be combined and then processed to determine the likelihood of a storm and its possible path.**
- **In this case, data processing can be very complex and may combine multiple changing values over complex algorithms.**

Module – 1 Layer 3: Applications and Analytics Layer

Data Versus Network Analytics

1. Data analytics:

- **Data analytics can also monitor the IoT system itself.**
- **For example, a machine or robot in a factory can report data about its own movements.**
- **This data can be used by an analytics application to report degradation in the movement speeds, which may be indicative of a need to service the robot before a part breaks.**

Module – 1 Layer 3: Applications and Analytics Layer

Data Versus Network Analytics

2. Network analytics:

- Most IoT systems are built around smart objects connected to the network.
- A loss or degradation in connectivity is likely to affect the efficiency of the system.
- Such a loss can have dramatic effects.
- For example, open mines use wireless networks to automatically pilot dump trucks.

Module – 1 Layer 3: Applications and Analytics Layer

Data Versus Network Analytics

2. Network analytics:

- **A lasting loss of connectivity may result in an accident or degradation of operations efficiency (automated dump trucks typically stop upon connectivity loss).**
- **On a more minor scale, loss of connectivity means that data stops being fed to your data analytics platform, and the system stops making intelligent analyses of the IoT system.**
- **A similar consequence is that the control module cannot modify local object behaviors anymore.**

Most analytics applications employ both data and network analytics modules

Module – 1 Layer 3: Applications and Analytics Layer

Data Analytics Versus Business Benefits

Almost any object can be connected, and multiple types of sensors can be installed on a given object.

Collecting and interpreting the data generated by these devices is where the value of IoT is realized.

From an architectural standpoint, we can define static IoT networks where

a clear list of elements to monitor and analytics to perform are determined.

Module – 1 Layer 3: Applications and Analytics Layer

Data Analytics Versus Business Benefits

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clear list of elements to monitor and analytics to perform are determined.

An example of a flexible analytics and control application is Cisco Jasper, which provides a turnkey cloud-based platform for IoT management and monetization.

Module – 1 Layer 3: Applications and Analytics Layer

Data Analytics Versus Business Benefits

An example of a flexible analytics and control application is Cisco Jasper, which provides a turnkey cloud-based platform for IoT management and monetization.

Example:

Vending machines deployed throughout a city. At a basic level, these machines can be connected, and sensors can be deployed to report when a machine is in an error state. A repair person can besent to address the issue when such a state is identified. This type of alert is a time saver and avoids the need for the repair team to tour all the machines in turn when only one may be malfunctioning

Module – 1 The Core IoT Functional Stack

3. Application and analytics layer/ Layer 3: Applications and Analytics Layer

1. **Analytics Versus Control Applications**
   1. **Analytics application**
   2. **Control application**
2. **Data Versus Network Analytics**
   1. **Data Analytics**
   2. **Network Analytics**
3. **Data Analytics Versus Business Benefits**

Module – 1 Layer 3: Applications and Analytics Layer

Smart Services:

- **The ability to use IoT to improve operations is often termed "smart services."**
- **Fundamentally, smart services use IoT and aim for efficiency.**
- **For example, sensors can be installed on equipment to ensure ongoing conformance with regulations or safety requirements.**
- **This angle of efficiency can take multiple forms, from presence sensors in hazardous areas to weight threshold violation detectors on trucks.**

Module – 1 Layer 3: Applications and Analytics Layer

Smart Services:

- **Smart services can also be used to measure the efficiency of machines by detecting machine output, speed, or other forms of usage evaluation.**
- **Entire operations can be optimized with IoT.**
- **In hospitality, for example, presence and motion sensors can evaluate the number of guests in a lobby and redirectpersonnel accordingly.**
- **Movement of people and objects on factory floors can be analyzed to optimize the production flow.**
- **A sensor can turn a light on or off based on the presence of a human in the room.**

Module – 1 Layer 3: Applications and Analytics Layer

IoT Data Management and Compute Stack:

- **The data generated by IoT sensors is one of the single biggest challenges in building an IoT system.**
- **In modern IT networks, the data sourced by a computer or server is typically generated by the client/server communications model, and it serves the needs of the application.**
- **In sensor networks, the vast majority of data generated is unstructured and of very little use on its own.**
- **For example, the majority of data generated by a smart meter is nothing more than polling data; the communications system simply determines whether a network connection to the meter is still active.**
- **This data on its own is of very little value.**
- **The real value of a smart meter is the metering data read by the meter management system (MMS)**

Module – 1 Layer 3: Applications and Analytics Layer

IoT Data Management and Compute Stack:

As data volume, the variety of objects connecting to the network, and the need for more efficiency increase, new requirements appear, and those requirements tend to bring the need for data analysis closer to the IoT system.

These new requirements include the following:

1. **Minimizing latency:**

Milliseconds matter for many types of industrial systems, such as when we are trying to prevent manufacturing line shutdowns or restore electrical service.

Analyzing data close to the device that collected the data can make a difference between averting disaster and a cascading system failure.

Module – 1 Layer 3: Applications and Analytics Layer

IoT Data Management and Compute Stack:

2. **Conserving network bandwidth:**

- **Offshore oil rigs generate 500 GB of data weekly.**
- **Commercial jets generate 10 TB for every 30 minutes of flight.**
- **It is not practical to transport vast amounts of data from thousands or hundreds of thousands of edge devices to the cloud. Nor is it necessary because many critical analyses do not require cloud-scale processing and storage.**

Module – 1 Layer 3: Applications and Analytics Layer

IoT Data Management and Compute Stack:

3. Increasing local efficiency:

- **Collecting and securing data across a wide geographic area with different environmental conditions may not be useful.**
- **The environmental conditions in one area will trigger a local response independent from the conditions of another site hundreds of miles away.**
- **Analyzing both areas in the same cloud system may not be necessary for immediate efficiency**

Module – 1 Fog Computing

Fog Computing:

- **The solution to the challenges in IoT is to distribute data management throughout the IoT system, as close to the edge of the IP network as possible.**
- **The best-known embodiment of edge services in IoT is fog computing.**
- **Any device with computing, storage, and network connectivity can be a fog node.**
- **Examples include industrial controllers, switches, routers, embedded servers, and IoT gateways. Analyzing IoT data close to where it is collected minimizes latency, offloads gigabytes of network traffic from the core network, and keeps sensitive data inside the local network.**

Module – 1 Fog Computing

Fog Computing:

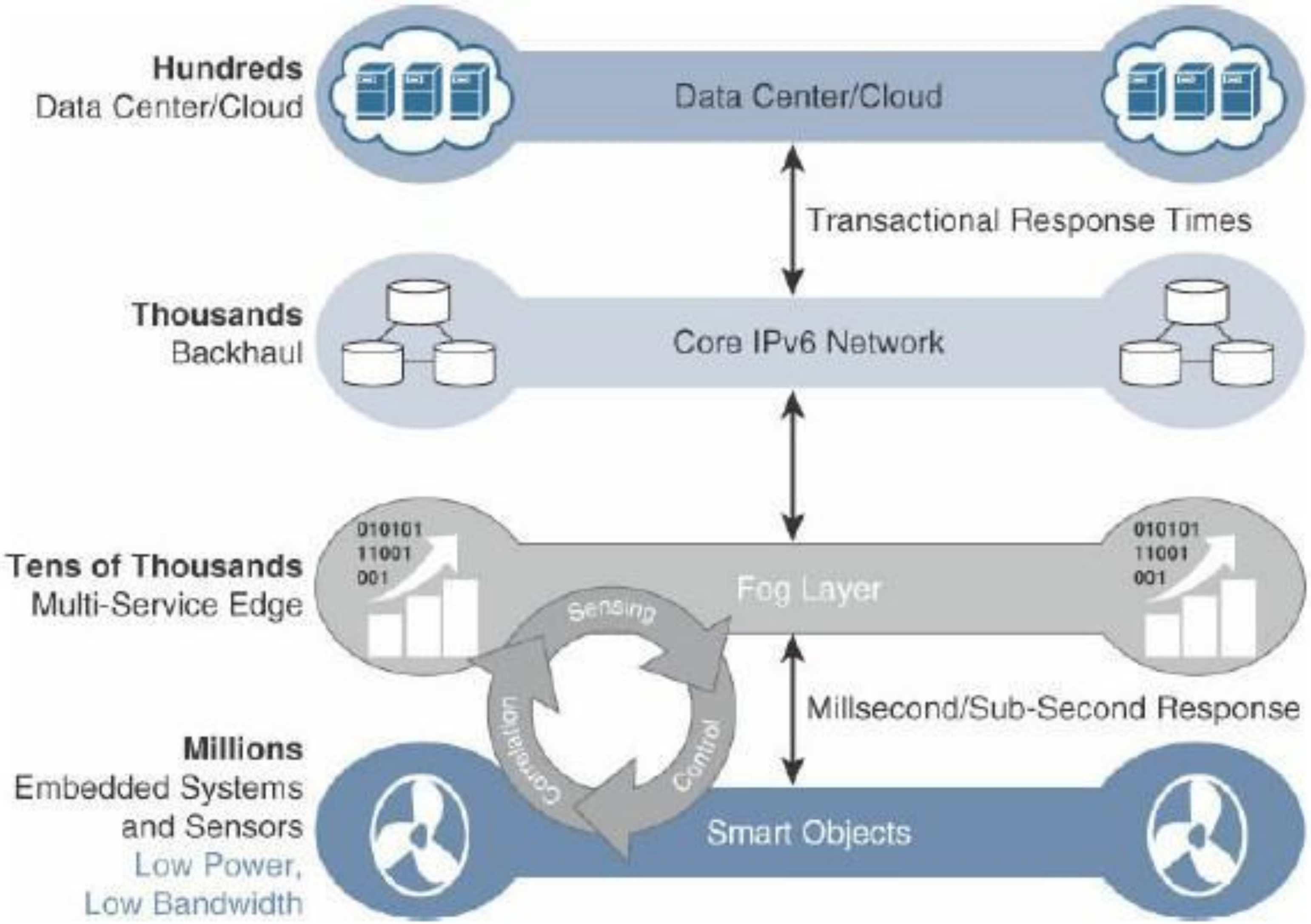
- **An advantage of structure is that the fog node allows intelligence gathering (such as analytics) and control from the closest possible point, and in doing so, it allows better performance over constrained networks.**

- **This introduces a new layer to the traditional IT computing model, one that is often referred to as the "fog layer."**

Module – 1 Fog Computing

Fog Computing:

Figure shows the placement of the fog layer in the IoT Data Management and Compute Stack.



Module – 1 Fog Computing

Fog Computing:

- **Fog services are typically accomplished very close to the edge device, sitting as close to the IoT endpoints as possible.**
- **One significant advantage of this is that the fog node has contextual awareness of the sensors it is managing because of its geographic proximity to those sensors.**
- **For example, there might be a fog router on an oil derrick that is monitoring all the sensor activity at that location.**
- **Because the fog node is able to analyze information from all the sensors on that derrick, it can provide contextual analysis of the messages it is receiving and may decide to send back only the relevant information over the backhaul network to the cloud.**
- **In this way, it is performing distributed analytics such that the volume of data sent upstream is greatly reduced and is much more useful to application and analytics servers residing in the cloud.**

Module – 1 Fog Computing

Fog Computing:

- **In addition, having contextual awareness gives fog nodes the ability to react to events in the IoT network much more quickly than in the traditional IT compute model, which would likely incur greater latency and have slower response times.**

- **The fog layer thus provides a distributed edge control loop capability, where devices can be monitored, controlled, and analyzed in real time without the need to wait for communication from the central analytics and application servers in the cloud.**

Module – 1 Fog Computing

Fog Computing:

- **For example, tire pressure sensors on a large truck in an open-pit mine might continually report measurements all day long.**
- **There may be only minor pressure changes that are well within tolerance limits, making continual reporting to the cloud unnecessary.**
- **With a fog node on the truck, it is possible to not only measure the pressure of all tires at once but also combine this data with information coming from other sensors in the engine, hydraulics, and so on.**
- **With this approach, the fog node sends alert data upstream only if an actual problem is beginning to occur on the truck that affects operational efficiency.**

Module – 1 Fog Computing

Fog Computing:

- **IoT fog computing enables data to be preprocessed and correlated with other inputs to produce relevant information.**
- **This data can then be used as real-time, actionable knowledge by IoT-enabled applications.**
- **Longer term, this data can be used to gain a deeper understanding of network behavior and systems for the purpose of developing proactive policies, processes, and responses.**

Module – 1 Fog Computing

Fog Computing:

The defining characteristic of fog computing are as follows:

1. Contextual location awareness and low latency:

- **The fog node sits as close to the IoT endpoint as possible to deliver distributed computing.**

2. Geographic distribution:

- **In sharp contrast to the more centralized cloud, the services and applications targeted by the fog nodes demand widely distributed deployments.**

3. Deployment near IoT endpoints:

- **Fog nodes are typically deployed in the presence of a large number of IoT endpoints.**
- **For example, typical metering deployments often see 3000 to 4000 nodes per gateway router,which also functions as the fog computing node.**

Module – 1 Fog Computing

Fog Computing:

The defining characteristic of fog computing are as follows:

4. Wireless communication between the fog and the IoT endpoint:

- **Although it is possible to connect wired nodes, the advantages of fog are greatest when dealing with a large number of endpoints, and wireless access is the easiest way to achieve such scale.**

5. Use for real-time interactions:

- **Important fog applications involve real-time interactions rather than batch processing.**
- **Preprocessing of data in the fog nodes allows upper-layer applications to perform batch processing on a subset of the data.**

Module – 1 Edge Computing

Edge Computing:

- **The natural place for a fog node is in the network device that sits closest to the IoT endpoints, and these nodes are typically spread throughout an IoT network.**
- **In recent years, the concept of IoT computing has been pushed even further to the edge, and in some cases it now resides directly in the sensors and IoT devices.**
- **Edge computing is also sometimes called “mist” computing.**

Module – 1 Edge Computing

Edge Computing:

- **Some new classes of IoT endpoints have enough compute capabilities to perform at least low-level analytics and filtering to make basic decisions.**
- **For example, consider a water sensor on a fire hydrant.**
- **While a fog node sitting on an electrical pole in the distribution network may have an excellent view of all the fire hydrants in a local neighborhood, a node on each hydrant would have clear view of a water pressure drop on its own line and would be able to quickly generate an alert of a localized problem.**

Module – 1 Edge Computing

Edge Computing:

- **Another example is in the use of smart meters.**
- **Edge compute–capable meters are able to communicate with each other to share information on small subsets of the electrical distribution grid to monitor localized power quality and consumption, and they can inform fog node of events that may pertain to only tiny sections of the grid.**
- **Models such as these help ensure the highest quality of power delivery to customers.**

Module – 1 The Hierarchy of Edge, Fog, and Cloud

The Hierarchy of Edge, Fog, and Cloud:

- **Edge or fog computing in no way replaces the cloud but they complement each other, and many use cases actually require strong cooperation between layers.**
- **Edge and fog computing layers simply act as a first line of defense for filtering, analyzing, and otherwise managing data endpoints.**
- **This saves the cloud from being queried by each and every node for each event.**
- **This model suggests a a hierarchical organization of network, compute, and data storage resources.**

Module – 1 The Hierarchy of Edge, Fog, and Cloud

The Hierarchy of Edge, Fog, and Cloud:

- **At each stage, data is collected, analyzed, and responded to when necessary, according to the capabilities of the resources at each layer.**
- **As data needs to be sent to the cloud, the latency becomes higher.**
- **The advantage of this hierarchy is that a response to events from resources close to the end device is fast and can result in immediate benefits, while still having deeper compute resources available in the cloud when necessary.**

Module – 1 The Hierarchy of Edge, Fog, and Cloud

The Hierarchy of Edge, Fog, and Cloud:

- **heterogeneity of IoT devices also means a heterogeneity of edge and fog computing resources.**

- **While cloud resources are expected to be homogenous, it is fair to expect that in many cases both edge and fog resources will use different operating systems, have different CPU and data storage capabilities, and have different energy consumption profiles.**

Module – 1 The Hierarchy of Edge, Fog, and Cloud

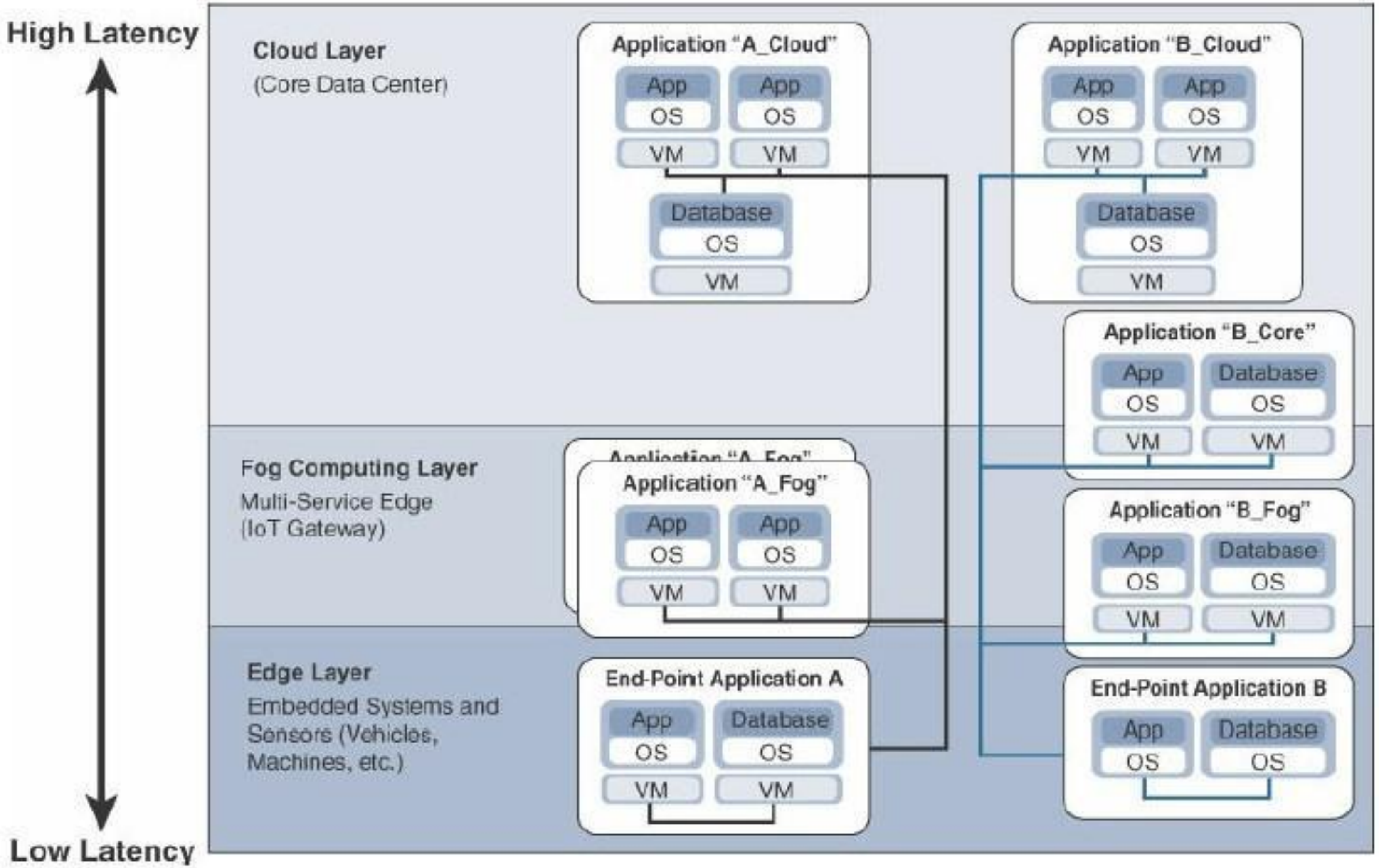
The Hierarchy of Edge, Fog, and Cloud:

- **Edge and fog thus require an abstraction layer that allows applications to communicate with one another.**
- **The abstraction layer exposes a common set of APIs for monitoring, provisioning, and controlling the physical resources in a standardized way.**
- **The abstraction layer also requires a mechanism to support virtualization, with the ability to run multiple operating systems or service containers on physical devices to support multitenancy and application consistency across the IoT system.**

Module – 1 The Hierarchy of Edge, Fog, and Cloud

Figure illustrates the hierarchical nature of edge, fog, and cloud computing across an IoT system.

Distributed Compute and Data Management Across an IoT System



Module – 1 The Hierarchy of Edge, Fog, and Cloud

The Hierarchy of Edge, Fog, and Cloud:

From an architectural standpoint, fog nodes closest to the network edge receive the data from IoT devices.

The fog IoT application then directs different types of data to the optimal place for analysis:

The most time-sensitive data is analyzed on the edge or fog node closest to the things generating the data.Data that can wait seconds or minutes for action is passed along to an aggregation node for analysis and action. Data that is less time sensitive is sent to the cloud for historical analysis, big data analytics, and long-term storage. For example, each of thousands or hundreds of thousands of fog nodes might send periodic summaries of data to the cloud for historical analysis and storage.