Title of the course: Architecture and Protocols for Internet of Things

1. Credit requirement:(L-T-P: 3-1-0, Credit: 4)

2. Please select the committee for Approval: PGPEC

3. Name of the Dept: CSE

4. Please Specify the Level of the Subject: PG level

5. Whether the subject will be offered as compulsory or elective: Elective

6. Prerequisite(s) for the subject, if any
   (Please give the subject numbers and names): Not required

7. Course Objective

Internet of Things (IoT) is the inter-networking of everyday objects that surround us. These devices are the active actors of the internet that generate and exchange data using embedded sensors. IoT is a giant network, which not only connects the objects, but also exhibits the relationship between people-people, people-devices, and devices-devices. The rapid developments in this emerging field, on a broader scale, are used to build efficient transportation networks called as smart cities, to make our life much easier. Similarly, agricultural, healthcare, and many other applications of IoT are impactful to the human society.

However, along with many opportunities, IoT opens the door to several challenges. Different parameters such as the capacity of IoT devices, quality, and network complexity limit some real-life applicability of IoT. In order to understand the opportunities and limitations of Internet of Things, its potential for growth, the proposed course intends to bring the insight and knowledge of the underlying networking technologies, architectures and protocols, analytics with IoT data, as well as real-life case studies and its enabling technologies together.

This course introduces the basic components of IoT and their interdependencies, deployment models, and fundamental concepts of IoT networking. This will be followed by more IoT network topics such as data and communication protocols. To have an in-depth understanding of data handling in IoT, this course has lectures on data handling, analytics, and data management for IoT devices. Cloud-centric IoT and virtualization with IoT system management are the key aspects, which will constitute the topics for further exploration. Apart from IoT networking and data management, the students will also be exposed to emerging topics like industrial IoT and interoperability in IoT. Case studies of IoT, tutorials and hands-on implementation of IoT environments will give the students a realistic view of the subject in whole. In summary, students will learn the networking with IoT, its enabling technologies, and explore a young, but rich, body of exciting ideas, solutions, and paradigm shifts.

8. Study Materials

In this course, we will use textbooks only for building up the fundamental concepts. However, majority of the topics will be covered through lectures on important concepts available in the recently published articles, and presentation of the related papers.

Books:

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press).
2. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press).

9. Syllabus:

1. Introduction to IoT [2L]

Definition, Trend, IoT applications, Sensing and Actuation, IoT Devices and deployment models.

2. IoT Networking [3L]

Basic IoT Components, Interdependencies, Service Oriented Architecture.

3. IoT Data Protocols [5L]

MQTT, SMQTT, CoAP, XMPP, AMQP

4. IoT Communication Protocols and their applications [5L]

IEEE 802.15.4, ZigBee, 6LoWPAN, Wireless HART, Z-Wave, ISA 100, Bluetooth, and Bluetooth low energy (BLE), NFC, RFID, WiFi for IoT communications.

5. Data Handling, Analytics, Data management for IoT [6L]

Data cleaning and processing, Data storage models, Searching in IoT, Deep Web Semantic Sensor Web, Semantic web data management, Real-time and Big data analytics for IoT, High-dimensional data processing, Parallel and Distributed data processing.

6. Interoperability in IoT [1L]

Low power Interoperability for IPV6 IoT

7. Cloud-Centric IoT [3L]

Architecture, Open Challenges, Energy efficiency, QoS, QoE.

8. Industrial IoT (IIoT) [3L]

Industrial IoT and its benefits, Future of IIoT, Challenges, Examples.

9. IoT System Management and Virtualization [3L]

IoT environment management over Cloud computing framework, Fog Computing paradigm for IoT with case studies, Softwarized control and virtualization technologies for IoT network and computation resource managements.

10. Case Studies **[3L]**
Sensor body-area-network, Smart cities and Smart homes, Agriculture.

11. Tutorial (Network Framework) **[8L]**
Wireless Network Fundamental for IoT communications - tutorials with demonstrations and hands-on: 802.11 and 802.15.4 MAC Fundamentals, Management Operations, Security Overview, Network Core Protocols, Tizen Network Stack Architecture, Introduction, CAPI Architecture Overview, Sync/Async Operation Sequence, Interaction of Network Core Components, P2P Core Component Overview, OEM Layer, Supplicant Plugin Architecture overview.

12. Tutorials (IoT OS) **[4L]**
Tutorials and hands-on on practical implementation of IoT environments using IoT based operating systems.

10. Names of the faculty members of the Department/Centers/School who have the necessary expertise and will be the willing to teach the subject (Minimum two faculty members should be willing to teach the subject)

Sudip Misra, Bivas Mitra, and Sandip Chakraborty

11. Do the contents of the subject have an overlap with any other subject offered in the Institute?

Related Subjects offered by the Institute:

EC60054 MOBILE COMMUNICATIONS AND FADING
EC60106 MOBILE COMPUTING
IT60119 WIRELESS ADHOC & SENSOR NETWORKS
CS60055 UBIQUITOUS COMPUTING

a) Approximate percentage of overlap: 5%

b) Reasons for offering the new subject in spite of the overlap:

IoT is the rapidly emerging internet technology that connects real-world objects wirelessly. IoT made it possible to connect every device in our surroundings, monitor the environmental changing conditions and automate the real time actions through these devices. However, IoT devices are characterized by limited processing, memory, and storage capabilities; mobility across different types of networks (untrusted WiFi hotspots, various cellular data services) that have intermittent connectivity in some cases.

Realizing the potential of such devices, support for networking according to the protocol standards, and being able to program them, would be useful for the students of our Institute. Additionally, the course would be

of tremendous help for researcher scholars working in the area of IoT, data analysis with IoT, and cloud-centric IoT, and fog computing. This proposed course primarily covers IoT networking, protocols and data management for the IoT devices, related case studies, tutorials and hands-on to have practical knowledge of IoT environments. This course has *minimal* overlap with the subjects currently offered by the Institute.

Related Subjects offered by the Institute

EC600543 Mobile Communication and Fading
Syllabus:
Historical review; Uses of mobile radio-different services; Land, maritime and air services; Relation to navigational systems; Cordless telephones and wireless PABXs; Cellular system and frequency reuse; Analog and digital modulation techniques for mobile radio, signaling, control and connection to fixed network; Multipath and fading channels; Path loss, Diversity techniques; Mobile radio transmitters, receivers and link designing;

EC60106 Mobile Computing
Syllabus:
Mobile channel characterization : Fading and shadowing, communication issues, review of cellular schemes, model and methodology, mobile computing topologies, networks and protocols, file system, wiring the campus, mobility management, wireless LAN and data PCS, application frameworks, exploiting mobility commercially, accessing the world wide web, privacy, and anonymity.

Comment: The above two courses mostly focus on the physical layer and electronic aspects of the mobile network. However, the proposed course aims at the different aspects of Internet of Things and its wide variety of applications. Syllabus wise, it has a minimal overlap with the proposed one.

IT60119 WIRELESS ADHOC AND SENSOR NETWORKS
Syllabus:
Introduction: Basics of wireless networks, Properties of wireless ad hoc networks, types of ad hoc networks, applications. Mobile Ad Hoc Networks: History, properties, medium access control, routing including multicasting and broadcasting, mobility models, transport layer issues, congestion and flow control, quality of service, security issues. Wireless Sensor Networks: History, properties, medium access control, routing, energy efficiency, topology management, coverage, congestion and flow control, quality of service, resource allocation, scheduling, security, multimedia transmission, mobile sensor networks, applications. Wireless Mesh Networks: Evolution, medium access control, channel assignment, routing, transport protocols, congestion control, scalability, mobility management, applications. Vehicular Ad Hoc Networks: Introduction, applications and their classification, VANET communication stack, medium access control, routing, security, mobility models, vehicular sensor networks.

Comment: This course mostly covers the wireless network, sensors, and basic protocols for the mobile adhoc networks and wireless sensor networks. Internet of Things has its own architecture, protocols, data management issues, and challenges which are different from the aspects of traditional wireless adhoc and sensor networks.

CS60055 UBIQUITOUS COMPUTING

Syllabus:

Overview of wireless technologies, Signal propagation, Multiplexing, Modulation, and Spread spectrum techniques. Media access control: FDMA, TDMA, CDMA. Cellular systems: AMPS, GSM, DECT, UMTS, IMT-2000. CDMA-based cellular systems. Satellite systems: basic routing, localization, and handoff issues. Wireless Networks: packet radio network, Wireless LAN, IEEE 802.11b, Blue-tooth, Wireless ATM. Wireless Application Protocol (WAP) and WML. Mobile Networking: Mobile IP, Ad-Hoc Networks: AODV, DSR, DSDV routing. Wireless TCP: indirect TCP, Snooping TCP, Mobile TCP. Information Management, Location-Independent and Location-dependent computing models, Mobile applications and services, Security.

Comment: This course covers different kinds of ubiquitous networks such as wireless networks, adhoc networks, cellular networks, mobile networks. It introduces fundamental properties of all these networks with different protocols associated with this. A small part of the course discusses about the wireless applications with no emphasis on Internet of Things (which is the main theme of the proposed course).