Embedded Communication Networks

1. Credit requirement:(L-T-P: 3-0-0, Credit: 3)
2. Please select the committee for Approval: PGPEC
3. Name of the Dept: ATDC
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:** Developers are realizing that traditional, low-speed, point-to-point links are inadequate for increasingly complex distributed embedded applications. Consequently, they are investigating multiplexed communication network protocols to incorporate advanced system capabilities, increased reliability, and reduced wiring requirements. This course discusses special considerations for embedded system networks, a family tree of "standard" protocols and their limitations based on real-time performance, cost, and hardware availability. This course highlights the challenges of embedded communication in terms of error detection and correction and fault tolerant network design. Discussion also includes designing dependable and Intelligent I/O systems and realization of uncertainty effects in I/O for embedded communication.
8. **Study Materials:**

   This course is mostly based on "Embedded Communication" course structure from CMU (https://users. ece.cmu.edu/ koopman/des_s99/communications/) and "Real time networks " from EPFL (https://moodlearchive.epfl.ch/2017-2018/enrol/index.php?id=1076). In this course, majority of the topics will be covered through lectures on important concepts available in the recently published articles, and presentations of the related papers. Some of the important references are:

   - https://users.ece.cmu.edu/ koopman/protsrvy/protsrvy.html.
   - Koopman, P.J., and Upender, B.P, "Communication Protocols for Embedded Systems", Embedded Systems Programming, 7(11), November 1994, pp. 46-48, http://www.cs. cmu.edu/People/koopman/protsrvy/protsrvy.html.
   - Kopetz, H., Real-Time Systems, Design Principles for Distributed Embedded Applications, Klower Academic Publishers, 1997.
   - https://users.ece.cmu.edu/ koopman/thesis/morris$_m s.pdf$.
9. **Syllabus**

   (a) Introduction: Key Concepts, Event vs. State Based Communication, Finding the Best Real-Time Protocol [2]

   (b) Communication Protocols for Embedded Systems: Inter System Protocol and Intra System Protocol; - Inter system protocol:USB Communication protocols, UART Communication protocols, USART Communication protocols; -Intra System Communication Protocols: I2C Protocol, SPI Protocol, CAN Protocol, CAN FD; Flexray, JTAG and Boundary Scan. [6]

   (c) Advanced Topics: Industrial control network: Modbus, Smart Grid Communication Protocol Standards, Time Sensitive Networking, Remote Upgrade of Firmware,Automotive Ethernet and Time triggerred ethernet. [6]

   (d) Dependable I/O Systems: Redundancy, Dependable Individual Sensors and Actuators, Fieldbus, Intelligent I/O [4]

   (e) Error Detection and Correction: Key Concepts, Shannon's Theorem, Liner Block Codes, CRC Codes, Convolutional Codes, Data Error Detection and Recovery, Control Flow Error Detection, Detecting and correcting I/O and memory errors. [6]

(f) Uncertainty in I/O: Robust Control Theory, Effects of Uncertainty [4]

(g) Basics of Fault Tolerance Computing: Faults and their manifestation, System Fault Response stages, Reliability and Availability Techniques in Embedded System, Fault Injection , Basics of hardware fault tolerance and software fault tolerance. [4]

(h) Fault Tolerance Analysis of Safety-Critical Embedded Systems : Fault tolerant network, Software Defect Masquerade Faults in Distributed Embedded Systems, Critical Message Integrity Over a Shared Network, Fault Tolerance Tradeoffs in Moving from Decentralized to Centralized Embedded Systems. [6]

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)

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

    Related Subjects offered by the Institute:

    (CS60058) FAULT TOLERANT SYSTEMS: Fundamental concepts in the theory of reliable computer systems design. Introduction to redundancy theory, limit theorems; decision theory in redundant systems. Hardware fault tolerance, redundancy techniques, detection of faults, replication and compression techniques, self-repairing techniques, concentrated and distributed voters, models of fault tolerant computing systems. Case studies. Software fault tolerance: fault tolerance versus fault intolerance, errors and their management strategies. Implementation techniques: software defense, protective redundancy, architectural support. Fault recovery techniques. Coding theory: application to fault tolerant system design. Fault tolerance and reliability of multicomputer networks (direct and indirect) including fault-tolerant routing and sparing techniques. Yield and reliability enhancement techniques for VLSI/WSI array processors.

    DISTRIBUTED SYSTEMS - CS60002:

    SYLLABUS :- Basic concepts. Models of computation: shared memory and message passing systems, synchronous and asynchronous systems. Logical time and event ordering. Global state and snapshot algorithms, mutual exclusion, clock synchronization, leader election, deadlock detection, termination detection, spanning tree construction. Programming models: remote procedure calls, distributed shared memory. Fault tolerance and recovery: basic concepts, fault models, agreement problems and its applications, commit protocols, voting protocols, checkpointing and recovery, reliable communication. Security and Authentication: basic concepts, Kerberos. Resource sharing and load balancing. Special topics: distributed objects, distributed databases, directory services, web services.References1.Mukesh Singhal and Niranjan Shivaratri, Advanced Concepts in Operating Systems, McGraw-Hill.2.Nancy Lynch, Distributed Algorithms, Morgan Kaufmann.3.Andrew S. Tanenbaum, Distributed Operating Systems, ACM Press.4.Jie Wu, Distributed Systems, CRC Press.5.Hagit Attiya, Jennifer Welch, Distributed Computing: Fundamentals, Simulations and Advanced Topics, McGraw-Hill.6.Sape Mullender (ed.), Distributed Systems, AddisonWesley.

    - Approximate percentage of overlap: 10%
    - Reasons for offering the new subject in spite of the overlap:
      Both the existing courses mostly concentrate on fundamental theory of fault tolerant systems and distributed systems. However, the newly proposed course includes challenges in terms of real-time performance, cost, and hardware availability relevant to embedded systems.