City College of San Francisco
Course Outline of Record
Course Status: Active

I. GENERAL DESCRIPTION

A. Approval Date	November 2016
B. Effective Semester	Fall 2017
C. Department	Computer Networking & Information Technology
D. Course Number	CNIT 209
E. Course Title	Internet of Things
F. Course Outline Originator	Richard Wu
F. Co-Contributor(s):	Samuel Bowne Dennis Frezzo Maura Devlin-Clancy
G. Department Chairperson	Maura Devlin-Clancy
H. Dean	David Yee

II. COURSE SPECIFICS

A. Hours	Lecture: 52.50 total
B. Units	3.00
C. Prerequisite	CNIT 106; CNIT 201C
Corequisite	None
Pre/Corequisite	None
Advisory	CS 131A; CNIT 202C
Advisory Pre/Corequisite	None
D. Course Justification	This course is designed to prepare students for the career opportunities afforded by the exponential increase in connected devices, embedded computing, and edge and cloud networking worldwide. The course uses new Cisco Networking Academy course materials, fitting organically into the CNIT Cisco course sequence. The course also integrates well with existing CNIT network security curriculum. The course will help students develop systems integration skills increasingly in demand as the world is "digitized" with analog and digital sensors generating big data connected by IPv4 and IPv6 networks.
E. Field Trips	No
F. Method of Grading	Letter or Pass/No Pass
G. Repeatability	Course is not repeatable

III. CATALOG DESCRIPTION
Introduction to the Internet of Things (IoT), where people, processes, things, and data are connected via emerging Internet technologies. A variety of networking and computer hardware devices will be integrated into end-to-end systems to solve practical problems.

IV. STUDENT LEARNING OUTCOMES
Upon completion of this course, a student will be able to:

A. Analyze the things and connections that make up the Internet of Things in relation to the physical world.
B. Use a variety of computer and networking hardware to build sensor/actuator systems.
C. Manipulate scripts to provide functionality for the Internet of Things.
D. Design, configure, and troubleshoot models of Internet of Things systems that address a real-world problem.
E. Use IP networks and cloud applications to interconnect end nodes.

V. CONTENTS

A. The things and connections that make up the Internet of Things (IoT)
    1. Devices and concepts
        a. The role of the IoT in the modern world

b. Types of things make up the IoT, such as fitness trackers and smart homes
c. Concepts of inputs, actions, and outputs in routine personal activities
d. Control theory applied to the operation of a simple control system
e. Open-loop vs. closed-loop control systems
1. Input
2. Output
3. System
f. Positive and negative feedback used in control systems
2. Connections in the IoT
a. Layers of connection for communication
b. Communication models for IoT processes
c. Device connections

B. Networking devices as part of end-to-end IoT system
1. Components and devices to build an end-to-end IoT system
a. Basic end-to-end concepts
b. Simple devices incorporated into IoT systems
2. Packet Tracer models
a. Demonstration network, how Packet Tracer models a sensor-actuator system
b. Microcontroller-focused models in Packet Tracer

C. Scripts that provide IoT functionality to simple network devices
1. The value of computer networking
a. Importance of networking
b. Different software applications
2. Simple network devices for simple applications
a. Single-board computers
b. End-to-end IoT network
c. The network operating system
3. Packet Tracer models single-board computers

D. An end-to-end Internet of things system
1. Network support for the IoT
a. Specific networks that make up IoT systems
b. Cloud and fog computing used in IoT
2. IoT systems for the Cloud
a. Hardware and software components
b. Types of diagrams used to document IoT projects

E. Sample IoT system
1. Cisco equipment, software, and services
2. Basic network security for IoT
3. An abstract business model using a diagram that includes product, customer interface, infrastructure management, and financial aspects
a. Internet of things solution that create business value and opportunity for industry verticals
b. Business model for a given business or social endeavor using applications such as the Business Model Canvas
4. IoT systems for real world solutions in areas such as healthcare, cities, energy systems, and manufacturing systems
5. IoT solutions that address real-world social and environmental problems
a. Contemporary problem priorities
b. Breakthrough IoT technology with global impact
c. Examples of IoT solutions that address global problems
d. Resources and communities of practice for IoT lifelong learning
e. Big data and analytics with IoT
f. Rapid Prototyping of IoT solutions

VI. INSTRUCTIONAL METHODOLOGY

A. Assignments
1. **In-class assignment**: Build a model of part of an Internet of Things system using real sensors, actuators, and a microcontroller.
2. **In-class assignment**: Build a model of an Internet of Things system using a real single board computer with Ethernet, WiFi, and Bluetooth connectivity.
3. **In-class assignment**: Build models of Internet of Things edge-computing, fog-computing, and cloud-computing using real switches, routers, servers, and firewalls connected via IPv4 and IPv6.
4. **In-class assignment**: Design, configure, and troubleshoot a model of an Internet of Things system using real and virtual sensors, actuators, microcontrollers, single board computers,

switched and routed TCP/IP Ethernet networks, and edge-, fog-, and cloud-computing services, that generates data to be stored in a spreadsheet.
5. **In-class assignment**: Use rapid prototyping techniques to design an Internet of Things system to meet user requirements. Analyze case study examples of Internet of Things systems relevant to informing iterative design processes.
6. **In-class assignment**: Discuss related reading assignment, Packet Tracer models and online research.
7. **Out-of-class assignment**: Do weekly reading assignments, and complete interactive activities, in the online course materials.
8. **Out-of-class assignment**: Design, configure, and troubleshoot increasingly sophisticated virtual models of Internet of Things systems in the Packet Tracer simulation-based learning environment. Model 1 will start with sensor, actuator and microcontroller systems with networking connectivity. Model 2 will include a single board computer with Ethernet, WiFi, and Bluetooth connectivity. Model 3 will include switches, routers, servers, and firewalls to model edge, fog, and cloud computing. Model 4 will be based on a specific technology (Smart Home, Smart Building, Smart City, Smart Factory, or Smart Grid). Model 5 will include aspects of all prior models and generate a data set representative of "Big Data." Student needs and interests will determine the final number of models, but at least five will be required.
9. **Out-of-class assignment**: Conduct online research into Internet of Things technologies and global and local social and environmental problems that might be addressed using Internet of Things systems.

B. Evaluation
1. **Written work**: Internet of Things design and model-building in-class activities addressing outcomes such as building systems, analyzing connections and connecting nodes.
2. **Performance**: In-class graded labs demonstrating proficiency with Arduino microcontrollers and Raspberry Pi Single Board Computers integrated in Ethernet and WiFi-connected TCP/IP networks built of switches, routers, servers, and firewalls.
3. **Performance**: Graded Packet Tracer projects building end-to-end models of Internet of Things systems
4. **Exams/Quizzes/Tests**: Periodic in-class written examinations, assessing the students' ability to explain the things and connections that make up the Internet of Things.
5. **Final Assessment**: The final assessment has three components: an exam delivered via the Cisco Networking Academy system; open-response questions on the design, configuration, and troubleshooting of end-to-end Internet of Things systems comprised of sensors, actuators, microcontrollers, single board computers, network switches, routers, WiFi devices, and mobile computing devices; and a skills performance using the Packet Tracer simulation-based learning environment.

C. Representative Textbooks and Other Instructional Materials
1. Bahga and Madisetti. 2014. *Internet of Things (A Hands-On Approach)*. VPT.
2. Introduction to the Internet of Things, Cisco Networking Academy Online Course, 2016.
3. Connecting Things, Cisco Networking Academy Online Course, 2016.
4. Big Data and Analytics, Cisco Networking Academy Online Course, 2016.
5. Hackathon Playbook, Cisco Networking Academy Online Course, 2016.
6. Website: Cisco Networking Academy Online Curriculum
7. Website: Cisco Packet Tracer Simulation-Based Learning Environment
8. Website: Internet of Things (IoT)
9. Website: Raspberry Pi3

VII. TITLE 5 CLASSIFICATION
CREDIT/DEGREE APPLICABLE (meets all standards of Title 5. Section 55002(a))

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