

CNT5517/CIS4930 Mobile Computing

CNT 5517: Mobile Computing - Class Number: 26366

CIS 4930: Special Topics in CISE: Mobile Computing - Class Number: 26369 Credits:

3

Class Periods: T | Period 7 (1:55 PM - 2:45 PM) & R | Period 7 - 8 (1:55 PM - 3:50 PM)

Location: ~~TURL L007~~ <https://ufl.zoom.us/j/3731476875>

Academic Term: Fall 2020

Instructor: Professor Abdelsalam (Sumi) Helal, helal@cise.ufl.edu

Office Hours: Thursdays 4:00-6:00PM, via Zoom.

Teaching Assistants:

Please contact TAs through the Canvas website

- Kriti Desai, desai.kriti@ufl.edu
- A second TA, TBD

Learning Objectives

This is a combined Graduate/Undergraduate level class on mobile and pervasive computing. You should expect to learn fundamental concepts as well as key emerging technology, including architectures, platforms and protocols. The class will cover mobile platforms, smart spaces and the Internet of Things (IoT) but a major emphasis this semester will be placed on IoT, specifically Personal IoT. You should gain hands-on experience in designing and building systems and applications that utilize smartphones, sensors and other IoT things. If you finish this class successfully, you should be skilled in creating “programmable” smart spaces – spaces that you will be able to create IoT applications for. You will be challenged to innovate new ideas and applications through lab assignments and a group project. You should not expect hand holding or spoon-feeding in this class! A high level of maturity and independence is expected of each student. As a class, you are supposed to collaborate and share helpful information, but a red line is sharing your own code for an assignment with your classmate.

More specifically, you should expect to learn the following:

1. **Mobile Computing** - an introduction to mobile computing followed by analysis of the particularities, limitations and opportunities of mobile computing systems. Special emphasis will be given to **mobile computing models** and to covering the **basics of mobile platforms** particularly Android and HTML5.
2. **Smart Spaces** – Fundamentals of what makes a smart space and how to design them. Issues and requirements will be covered with emphasis on **safety and programmability**.
3. **Internet of Things** - an introduction to the Internet of Things covering key IoT scenarios, and thing hardware and architectures. **IoT interactions models and protocols** will be covered. **Energy-savings design** and new IoT-appropriate communication protocols will be covered. **Emerging Thing Architectures** and **IoT programming models** will be emphasized.

Points of Assessment

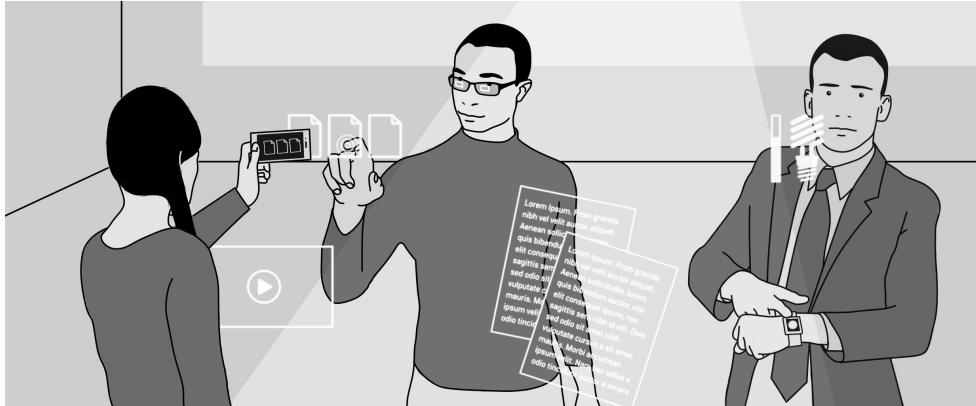
- Four lab assignments
- Group-based term project
- Two exams

Reading Material

You are not required to purchase any textbooks for this class. Reading materials, mostly published research papers, are specified along with the topics covered in the class schedule below. You should also be able to access other sources and reports from the IEEE Xplore Digital Library, and the IEEE Internet of Things Initiative web site (<http://iot.ieee.org>) Examples of additional references are cutting edge research papers that can be found in the proceedings of the following relevant conferences:

- IEEE World Forum on Internet of Things ([WF-IoT](#))
- The ACM [UbiComp](#) Conference Proceedings series.
- The ACM [HotMobile](#) Workshop Proceedings series.
- The IEEE [PerCom](#) Conference Proceedings series.
- The ACM [MobiCom](#) Conference Proceedings series.
- The ACM [SenSys](#) Conference Proceedings series.

Virtual Smart Space



A virtual smart space will be established for all assignments as well as the term project. The space will consist of three layers: Cloud, Edge and Thing. The cloud layer will offer a classdedicated VPN to virtualize the network where all your IoT elements would appear connected to the same Smart Space “LAN”. In addition to VPN, the cloud layer will offer other important services that will be utilized by the assignments and the term project. An Edge Layer will be provided by each of you, where your laptop will serve as an edge layer. The edge does not need to be connected through the VPN. Minimal (if any) requirements will be placed on the edge layer in terms of software you may need to download and install (both Windows and Mac) and you will be informed in due time. You are required to purchase and set up a Thing. The Thing will be a Raspberry Pi and minimal sensor/actuator devices, plus a USB-ethernet adaptor to connect the Raspberry Pi to your laptop. The specific model required is **Raspberry Pi 3 Model B**. You may purchase it from any of the vendors listed on the Raspberry Pi [web site](#).

Class Schedule & Planned Lectures

Date	Topics Covered
PART I	Mobile Computing

Tuesday
1 Sept

- Review of Syllabus
- Historical Perspective: From the Newton to the iPhone - Understanding the Mobile Computer Evolution
- Constraints, Requirements & Limitations of Mobile Computing Systems
- Mobile Computing Models I: Adaptations, mobile proxies, Ad-hoc peer to peer, and disconnected operation.
- Reading Materials:
 - J. Jing, A. Helal, and A. Elmagarmid, "Client-Server Computing in Mobile Environments," *ACM Computing Surveys*, vol. 31, no. 2, June 1999, pp. 117– 157.
 - Douglas Terry, "[Replicated Data Management for Mobile Computing](#)," Morgan & Claypool Publishing ([Morgan & Claypool Publisher](#))

- J. Kistler and M. Satyanarayanan, "Disconnected Operation in the Coda File System," *ACM Transactions on Computer Systems*, Vol. 10, No. 1, February 1992.

Thursday
3 Sept

- Mobile Computing Models II (Cont'd): thin client, Edge Computing, location-based services (LBS)
- Reading Materials:
 - Jason Flinn, "[Cyber Foraging: Bridging Mobile and Cloud Computing](#)," Morgan & Claypool Publishing ([Morgan & Claypool Publisher](#))
 - Paolo Bellavista, Axel Küpper and Sumi Helal "Location Based Services – Back to the Future," the Standards, Tools and Emerging Technologies Department, IEEE Pervasive Computing, Sumi Helal, Editor, vol. 7, no. 2, AprJune 2008.

Tuesday
8 Sept

- Mobile Computing Models III (Cont'd) - mobile service discovery, ad-hoc service discovery, and mobile crowdsourcing.
- Reading Materials:
 - C. Lee, A. Helal, N. Desai, V. Verma, and B. Arslan, "Konark-A System and Protocols for Device Independent, Peer-to-Peer Discovery and Delivery of Mobile Services," *IEEE Transactions on Systems, Man and Cybernetics*, vol. 33, no. 6, Nov 2003, pp. 682-696.
 - Sumi Helal, "Service Discovery Standards," the Standards, Tools and Best Practice Department, IEEE Pervasive Computing, Sumi Helal, Dept. Editor, vol. 1, no. 3, Sept 2002.
 - C. Lee and A. Helal, "Protocols for Service Discovery in Dynamic and Mobile Networks," *International Journal of Computer Research*, special issue on Wireless Systems and Mobile Computing, Sept 2000.

Thursday 10 Sept	<ul style="list-style-type: none"> • Mobile Platforms: Android • Lab assignment 1 handout: Possibly Your First Android App • Reading Materials: <ul style="list-style-type: none"> ○ A. Helal, R. Bose and W. Li, "Mobile Platforms and Development Environments," Morgan & Claypool Publishing Company, 2013 (Morgan & Claypool Publisher) ○ https://www.w3.org/TR/html5
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PART II	Internet of Things
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Tuesday 15 Sept	<ul style="list-style-type: none"> • Lab 1 due • Historical Perspective: from the <i>Jetsons</i> to the Internet of Things • Introduction to the Internet of Things • Constraints, Requirements and Smart Space Challenges. • Reading Materials: <ul style="list-style-type: none"> ○ Sumi Helal, "Programming Pervasive Spaces," the Standards, Tools, and Emerging Technologies Department, IEEE Pervasive Computing, Sumi Helal, Dept. Editor, vol. 4, no. 1, Jan-Mar 2005. ○ Sumi Helal and Sasu Tarkoma, "Smart Spaces," Introduction to the Special Issue. IEEE Pervasive Computing, vol. 14, no. 2, 2015, pp. 22-23.
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Thursday	<ul style="list-style-type: none"> • Things
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17 Sept	<ul style="list-style-type: none"> ○ Thing Platforms: Raspberry Pi, Arduino, Nordic, etc. ○ Identification (ID) Things: RFID, QR Codes, Beacons ○ Things, Internet of Things, and Internet of Thing Applications • Lab assignment 2 handout: Setup and Simple Interactions with the Virtual Smart Space • Reading Materials: <ul style="list-style-type: none"> ○ A. Helal, A. Khaled, and W. Lindquist, "The Importance of Being Thing, Or the Trivial Role of Powering Serious IoT Scenarios," In Proceedings of the 39th IEEE International Conference on Distributed Computing Systems (ICDCS), Dallas, Texas, July 7-10, 2019. **Exam Q** ○ Roy Want et al, R. "Enabling the Internet of Things," IEEE Computer, Jan 2015 **Exam Q** ○ Roy Want, "RFID Explained: A Primer on Radio Frequency Identification Technologies," Morgan & Claypool Publishing Company, 2013 (Morgan & Claypool Publisher)
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<p>Tuesday 22 Sept</p>	<ul style="list-style-type: none"> • IoT Architectures <ul style="list-style-type: none"> ◦ Service Oriented Device Architecture (SODA) ◦ Atlas Thing Architecture ◦ Atlas Cloud-Edge-Beneath (CEB) Architecture ◦ Atlas IoT Device Description Language (IoT-DDL) ◦ Android Things (Brillo), ARM mbed architecture • Lab 2 due • Lab assignment 3 handout: Integrating your Things into the Virtual Smart Space using IoT-DDL • Reading Materials: <ul style="list-style-type: none"> ◦ J. King, R. Bose, H. Yang, S. Pickles and A. Helal, "Atlas – A Service-Oriented Sensor Platform," Proceedings of the first IEEE International Workshop on Practical Issues in Building Sensor Network Applications (SenseApp 2006). Tampa, Florida, November 2006 ◦ W. Lindquist, A. Khaled, and A. Helal, "IoT-DDL: Device Description Language for a Programmable IoT," In proceedings of the 5th International Symposium on Smart and Sustainable Technologies (SpliTech 2020), Sept 23, 2020, Split, Croatia. (Copy of this paper will be provided – not yet available online). ◦ A. Khaled, A. Helal, W. Lindquist and C. Lee "IoT-DDL-Device Description Language for the "T" in IoT," IEEE Access, Vol 6, Issue 1, PP(24048-24063), December 2018. DOI: 10.1109/ACCESS.2018.2825295
<p>Thursday 24 Sept</p>	<ul style="list-style-type: none"> • IoT Architectures (Cont'd)
<p>Tuesday 29 Sept</p>	<ul style="list-style-type: none"> • IoT Architectures (Cont'd)
<p>Thursday 1 Oct</p>	<ul style="list-style-type: none"> • Exam 1
<p>Tuesday 6 Oct</p>	<ul style="list-style-type: none"> • Gator Tech Smart House - An Assistive Environment for Active and Healthy Aging (Smart Space Case Study)

	<ul style="list-style-type: none"> • Lab 3 due • Reading Materials: <ul style="list-style-type: none"> ○ A. Helal, W. Mann, H. Zabadani, J. King, Y. Kaddoura, and E. Jansen, "The Gator Tech Smart House: A Programmable Pervasive Space," cover feature, Computer, vol. 38, no. 3, Mar 2005, pp. 64–74 ○ A. Helal, C. Chen, R. Bose, E. Kim and C. Lee "Towards an Ecosystem for Developing and Programming Assistive Environments," Proceedings of the IEEE, Vol. 100, No. 8, pp. 2489 – 2504, August 2012.
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Thursday 8 Oct	<ul style="list-style-type: none"> • IoT Interaction Protocols <ul style="list-style-type: none"> ○ Topics - Blending communication & computation in IoT ○ Explicit Interactions: RESTful Protocols ○ Intentional Interaction: Pub/Sub Protocols (MQTT/MQTT-SN) ○ Conscious Interactions: The Constrained Application Protocol (CoAP) ○ Social IoT Interactions • Lab assignment 4 handout: Messing around with MQTT in the Virtual Smart Space • Reading Materials: <ul style="list-style-type: none"> ○ Select papers in the Proceedings of the IoT Semantic Interoperability Workshop, 2016, (https://www.iab.org/activities/workshops/iotsi/) ○ https://mqtt.org/
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Tuesday 13 Oct	<ul style="list-style-type: none"> • IoT Interaction Protocols (Cont'd)
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PART 3	Advanced Internet of Things
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Thursday 15 Oct	<ul style="list-style-type: none"> • MAAT: Mobile Apps As Things in the IOT • Lab 4 due • Reading Materials: <ul style="list-style-type: none"> ○ W. Lindquist, A. Helal, A. Khaled, "MAAT: Mobile Apps As Things in the IoT," to be presented in the Ubicomp 2020 Conference to be held Sept 12-16, Cancun, Mexico, and pre-published in the Proceedings of the ACM Journal on Interactive, Mobile, Wearable and Ubiquitous Technologies (IMWUT), Vol. 3, No. 4, Article 143, December 2019. ○ A. Helal, A. Khaled, and V. Gutta, "Demo: Atlas Thing Architecture - Enabling Mobile Apps as Things in the IoT," Proceedings of the 23rd Annual International Conference on Mobile Computing and Networking (MobiCom), Snowbird, Utah, USA, Oct 2017.
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<p>Tuesday 20 Oct</p>	<ul style="list-style-type: none"> • Group Project Handout • Project discussion • Getting organized with Slack
<p>Thursday 22 Oct</p>	<ul style="list-style-type: none"> • Project Q/A session
<p>Tuesday</p>	<ul style="list-style-type: none"> • Emerging Programming Models for the IoT
<p>27 Oct</p>	<ul style="list-style-type: none"> ○ Relational SODA Model under the Atlas Thing Architecture ○ IoTranx - Safety-oriented Programming Models • Reading Materials: <ul style="list-style-type: none"> ○ A. Khaled, A. Helal, W. Lindquist and C. Lee "IoT-DDL-Device Description Language for the "T" in IoT," IEEE Access, Vol 6, Issue 1, PP(24048-24063), December 2018. DOI: 10.1109/ACCESS.2018.2825295 ○ A. Khaled, Y. Lindquist, and A. Helal, "Service-Relationship Programming Framework for the Social IoT," the Open Journal of Internet of Things (OJIOT), ISSN ISSN 2364-7108. Presented in the Very Large Internet of Things (VLIoT) Workshop, in conjunction with the VLDB conference held August 2018 in Rio de Janeiro, Brazil. ○ C. Chen, A. Helal, J. Jin, M. Zhang and C. LEE, "IoTranx: Transactions for Safer Smart Spaces," under review. March 2020. (A copy will be provided by Prof Helal – paper not yet published)
<p>Thursday 29 Oct</p>	<ul style="list-style-type: none"> • Emerging Programming Models for the IoT (Cont'd)
<p>Tuesday 3 Nov</p>	<ul style="list-style-type: none"> • Project progress review and group presentations • Feedback and discussion (Zoom and Slack for individual groups)
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Thursday 5 Nov	<ul style="list-style-type: none"> Feedback and discussion (Zoom and Slack for individual groups)
Tuesday 10 Nov	<ul style="list-style-type: none"> Project progress review and group presentations Feedback and discussion (Zoom and Slack for individual groups)
Thursday 12 Nov	<ul style="list-style-type: none"> Project Support Session (Zoom and Slack for individual groups)
Tuesday 17 Nov	<ul style="list-style-type: none"> Project Support Session (Zoom and Slack for individual groups)
Thursday 19 Nov	<ul style="list-style-type: none"> Projects due (final project code and report due 60 minutes before class starts) Final Project Presentations
Tuesday 24 Nov	<ul style="list-style-type: none"> Final Project Presentations
Tuesday 1 Dec	Review Session for Exam II
Thursday 3 Dec	EXAM II
Tuesday	Course assessment review & tips to developing an Internet of Things CV

Grading Policies

Exams	40% (20% each)
Lab Assignments	30% (8%, 5% & 8%, 9%)
Project	30%

Please note:

- Absence from Exams or missing due dates of assignments will be accommodated only if they are due to sickness (a letter from the infirmary will be required). Job interviews or attending events will NOT be accepted excuses.
- Late submissions of assignments will get penalized 10% for the first 24 hours, additional 15% penalty for the second 24 hours, and will receive no credit if submitted any later.

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://www.dso.ufl.edu/scr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.