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# **INTELLIGENCE OF THINGS**

**CSCI 7000-005/6  
TUE/THU @5:30PM,**

**Danny Dig**



University of Colorado  
Boulder



# Today's goals

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- Discovery: learning about each other (Family Occupation  
Recreation Motivation)
- What is Pervasive Personalized Intelligence?
- Examples of Research themes on IoT
- How can I be successful in CSCI 7000-005/6?

# Family

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# Occupation: Faculty in Software Engineering

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Change is the heart of software development

Programming is program transformation

Q1: Analyze what software changes occur in practice?

Q2: How can we automate them?

Q3: Can we represent programs as transformations? Archive, retrieve, and visualize them?

Q4: Can we infer higher-level transformations?



Automated changes in (i) upgrading library APIs, (ii) convert sequential to parallel code, (iii) improve responsiveness in



Visual Studio



NetBeans IDE



# Work in Your Strength Zone but Reinvent Yourself



Mobile ['13 - '18]

- add async
- fix async
- privacy

Parallelism & Concurrency

- ['08-'13]
- make thread-safe
  - improve throughput
  - improve scalability

Refactoring

Library migration ['02-'07]

- upgrade APIs

IoT and ML ['19– TBD]

- from deterministic to probabilistic

Principles for changing between different programming models



# What is Your Dream? Mine is Practical Impact on SW Development

Automating  
-ship with official



Visual Studio

- hundreds of  
accepted patches



- first open-source  
refactoring



Google™



Inferring

- used at Google™  
IBM®  
- dozen labs

founded Workshop  
on Refactoring Tools,  
HotSwUp, Dagstuhl S.

Understanding

- shaped APIs in Java  
and .NET official  
concurrency libraries

Testing  
ORACLE®

-learnparallelism.net  
150,000+ visitors

# Recreation

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On Aug 5, 2015 ...



**From personal success to significance**



**From a ladder climber to a ladder holder**





# Quiz #1: About YOU

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- Write down your name
- **FORM** (family, occupation, recreation, motivation)
- **Grad Program** (e.g., CS PhD, MS, etc.), year of study, who is your grad advisor
- Your **background** (e.g., industry experience, other CS background – such as strong ML, Systems, IoT, SE, etc.)
- What is the ONE Thing that you **expect** to take out of CSCI 7000-005/6?
- What are your plans **post graduation?**



# **What are your expectations from CSCI 7000-005?**

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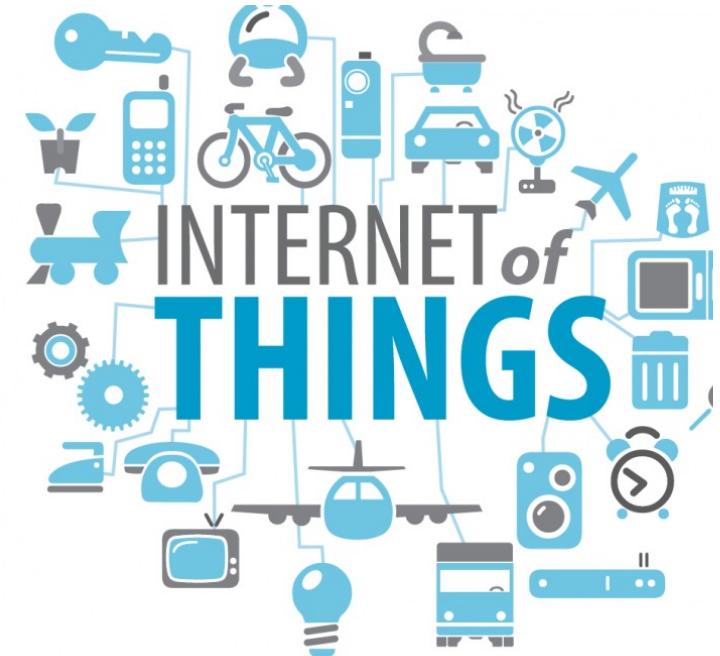
- A. ..How to communicate technical material to outsiders**
- B. ..**
- C. ..**
- D. ...**
- E. ...**
- F. ....**

## Theme: IoT

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**IoT revolution: digitization & connection of everything**

**In 15 years, smart  
Infrastructure estimated to  
become \$59T market**



**Q: What do you envision as some Killer Feature for IoT?**

# **Q: What are the Killer Features for IoT?**

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**K1:** ...

**K2:** ...

**K3:** ....

**K4:** ...

**K5:** ...

**K6:** ...

**K7:** ...

# **Q: What are the Killer Features for IoT?**

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## **Smart home:**

- managing the home (monitoring energy and resources), scheduling family activities, housekeeping (auto-replenish consumables, cleaning, pet feeding), health monitoring (assistive care)**

## **Smart City:**

- transportation (find parking), environmental monitoring of pollution, manage resources (control street lighting), enhances perception of city activities (e.g., sporting events)**

## **Smart Manufacturing:**



**virtual chief foreman assisting managers**

# **From IoT 1.0 to 2.0**

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**V 1.0: sensors and actuators to collect data**

**V 2.0: augmenting our intelligence with knowledge to expedite decision-making, everyday activities, and processes**

# Center on Pervasive Personalized Intelligence



# Listening to Industry during Discovery Visits



# Pervasive Personalized Intelligence (PPI)

Connecting everything for remote monitoring and service



## From Reactive to Predictive Analytics:

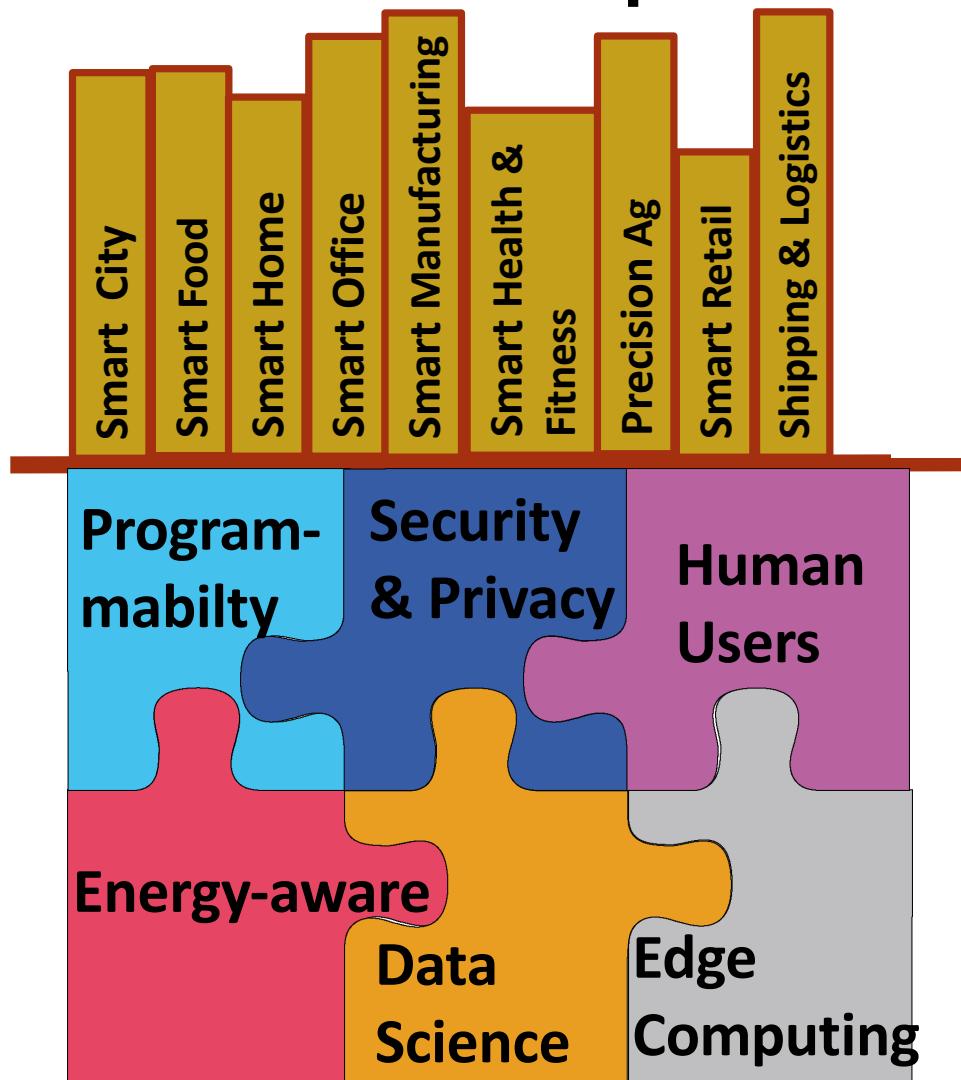
- Smart Energy: safe energy mode for e-cars
- Precision Ag: predict diseases, harvest
- Industry 4.0: preventive maintenance

**Pervasive to the Edge**

**Personalized**



# Research Thrusts and Capabilities of PPI





## **Value that PPI Center brings to you, students in CSCI 7000-005/6**

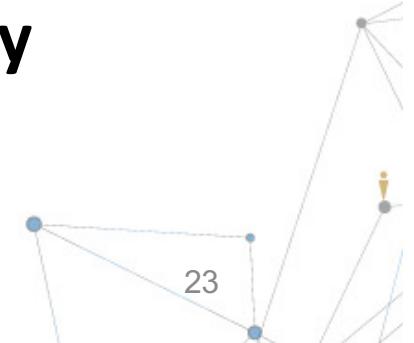
**Connecting you with movers and shakers in IoT:**

- access to thinking partners from industry
- broadens your perspective

**Networking opportunities: internships, jobs**

**Practical impact for your projects:**

- gives you a chance for significance, not only personal success



# Course Administration

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**Check webpage:**

**[https://danny.cs.colorado.edu/courses/csci7000-005\\_F21/](https://danny.cs.colorado.edu/courses/csci7000-005_F21/)**

**Work items due Thu (Aug 26):**

- Familiarize with class webpage
- sign up on Piazza (all communications through Piazza, no email after this week)
- Read and write a critique for a research paper (see template on webpage)

**Check prereqs: computing background (either practical experience or undergrad-level knowledge of SE, Systems, ML), please check with me after the class**



# CS 7000-005/6 is Different!!!

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## Research-based course:

- at times it would feel it is not "organized"
- there are lots of choices, you need to select
- structure is fixed, but content is dynamic

Complete a research or industrial-novel project of your choice (teams of 2-3 students)

- follow the steps of open-ended/risky research (proposal, fit in literature, evaluate empirically)
- at the end of the term you would have produced a research paper that you can submit to conference
- WHY: equips you to conduct **novel R&D**

# CS 7000-005/6 is Different!!!

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**Participate in class discussion and activities.**

**Read 1-2 research papers for every class meeting (11 pages each, double column => total of 500+ research pages)**

- later on, you choose papers that match your project
- 1 book chapter /week (**Put Your Dream to the Test**)

**Paper Critiques: for each class meeting, for each research paper, submit before class (by 11:59pm previous day)**

- WHY: equips you with **critical thinking**

**Research presentation: you prepare and deliver for the selected research papers**

- WHY: equips you to **communicate** your ideas

# Projects Focus on IoT-related topics

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**For new grad student, project gives ideas for dissertation**

**For experienced PhD student, project advances your research**

**Technological shifts/opportunities for IoT:**

- constraints on memory/CPU/bandwidth/battery usage
- connectivity with the cloud
- rapid evolution of the platform
- reliance on ML/AI solutions

**Industrial-innovation: availability of rich data from sensors  
(e.g., dataset from City of Denver)**



**Research projects (not an app), teams of 2-3 people**

# Example Transformations for IoT

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**What are the new transformations we need to automate?**

- inspiration from explorative studies
- empirical studies to find performance or energy anti-patterns

**Examples of transformations:**

- candidate programs with trade-offs between performance & power consumption
  - adaptation to different display technologies
  - split functionality between the device and cloud

# CS 7000-005/6 is Different! Lots of Guests

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**Interviews with C-level executives from PPI Center:**

- e.g., Jason Shepherd, CTO of Dell Technologies
- Bob Wold, VP of Trimble
- Rahul Khanna (Lead ML architect Intel IoT Group)

**Live from IoT World 2021 (Nov 2<sup>nd</sup> and 4<sup>th</sup>)**

- Broadcast of keynote speakers
- Interviews with people on the booths

**Faculty:**

- E.g., Tom Dietterich, father of the ML field, ACM Fellow

# 1-hour Group Discussion

**Soft Skills: leadership, creating a vision and plan for accomplishing**

**WHY: Soft Skills make a greater Difference in life than “Hard Skills”**

**WHAT: Take your dream through 10-step process to see, own, reach it**

**HOW: learning environment in a roundtable format**

