智慧聯網導論
Introduction to machine-to-machine

Yen-Kuang Chen (陳彥光), Ph.D.
Associated Director
Intel-NTU Connected Context Computing Center
ykchen@cc.ee.ntu.edu.tw

Overview of the Course

- **Goals of the course**
  - **Overview M2M**
  - **Spot technology trends**
  - **Identify research opportunities**

- **Format**
  - **Lectures & seminars (internal and external)**
  - **Literature and project discussions**

Trend Spotting → Right Direction

- **In business practice, e.g.,**
  - 人口老化商機浮現　台大醫院周邊房價傲視群倫 **(NOWnews 今日新聞網 09/12/2011)**
    - 國內人口老化問題日益嚴重，但也出現不少商機，而除了醫院的醫護人員、職員外，近來也有不少家有長者的家庭選擇住在醫院周邊，帶動了醫院宅的行情，有房仲業者統計發現，大台北醫院商圈近1年來房價多有1成以上漲幅，其中又以台大醫院附近漲幅達38.5%最為亮眼。…

- **In research, e.g.,**
  - **Internet of things, machine-to-machine**

Today's Agenda

- **Technical presentation**
  - **Overview, motivation, and introduction of M2M**
  - **Introduction to Intel-NTU CCC Center**

- **Administrative information**
  - **Semester overview**
  - **Grouping, grading, homepage, etc.**

Connected Context Computing

Outline

- **How technologies have changed and will change our life?**

- **What is the new paradigm?**

- **What are the challenges and opportunities?**

Benefits of Today's Technologies

- **Mobile phone**
  - – Devices
  - – Wireless communication
- **Internet**
  - – Network
  - – Services

What's Next?

Imagine the Possibilities (CISCO)

http://youtu.be/RGk7lIP9Z8k

Discussion

- **What are the key takeaway messages?**
  - **More things connected to the internet than human**

- **Any trends?**
  - **Internet traffic increased significantly**
  - **More internet traffic will be generated by simple 20 households**

- **Any research gaps?**
  - **What do you think the world will look like in 2020?**
  - **What if we all live 200 years old?**
  - **What if every phone is a digital wallet?**
  - **What if video conference is everywhere, for home, for business?**

The Internet of Things (IBM)

http://youtu.be/sfEbMV295Kk

Discussion

- **What are the key takeaway messages?**
  - Connected embedded sensors help us "hear/see" things that we could not hear/see in the past.
  - Connected devices (sensors) can produce sea of data, which needs intelligence to transform it into wisdom.

- **Any trends?**
  - More human will live in the city than ever.

- **Any research gaps?**
  - Alarm clock, my calendar, ferry, heater, car, and so on can talk to each others, in turn to help me automatically.

Game Changing Capabilities

- **Sensing (enhance our sensory by sensors)**
- **Robotics (enhance our muscle by robot)**
- **Communication (enhance our collaboration by wireless and broadband internet)**
- **Analysis (enhance our brain by cloud computing and machine learning)**

Create Values to Users

- **Review of human needs**
  - **Predictive**
    - To know real world and to know the future
  - **Preventive**
    - Avoid from disaster, trouble, unhappy, …
  - **Personalized**
    - To be unique, to be special, ..
  - **Participatory**
    - Networking individual, to be social, …

Significantly Improve our Life

- **Drive cars, take care of people, farm, distribute/sell goods, use energy, mine, etc.**

Connected Context Computing

- **Definition**
  - **Smart devices will collect data**
  - **Relay information or context to each other**
  - **Process the information collaboratively**
  - **Prompt human or machine for further actions**
- **Status today**

15 billion intelligent, connected devices. Imagine the possibilities. Enter the embedded internet era at intel.com/embedded/15billion

Paradigm Shift

- **Revolution**
  - **Billions --> trillions of connected devices**
  - **Tera bytes --> Zeta bytes of captured data**
  - **TFLOPS --> ZFLOPS of available computation**

- **Biologic analogy**
  - **As species evolve, have better sensing and analysis capability**
  - **Eventually, communicate and collaborate with each other**

Different names or forms

- **Wireless sensor network, cyber-physics system: the tip of the iceberg**
- **Machine-to-machine or Internet of things aims toward this direction**
  - **Use a traffic control camera to help surveillance**
  - **Use a surveillance camera to monitor human activity for energy saving**

How the Internet of Things Will Change Everything (CISCO)

http://youtu.be/mf7HxU0ZR_Q

Discussion

- **What are the key takeaway messages?**
  - **Data → Information → Knowledge → Wisdom**

- **Any trends?**
  - **Help people (richer or poorer) on health, utility, etc.**

- **Any research gaps?**
  - **IPv6**
  - **Common standards**
  - **Energy source for sensors**

**Intelligence**
Wisdom
Knowledge
Information
Data

Context is important

- **Context vs. connection**
  - **Why internet is important to us?**
  - **Wiki**
  - **Google**
  - **Facebook**

- **Smart service is the key**
  - **User experience makes the difference**
  - **Connected context computing is more than just components (hardware, software, and/or internet)**

Largest Growth Opportunity in ICT

IT for Real World

IT for People

1965年
Large Machine

1980年
PC

1995年
Internet

2010年
M2M
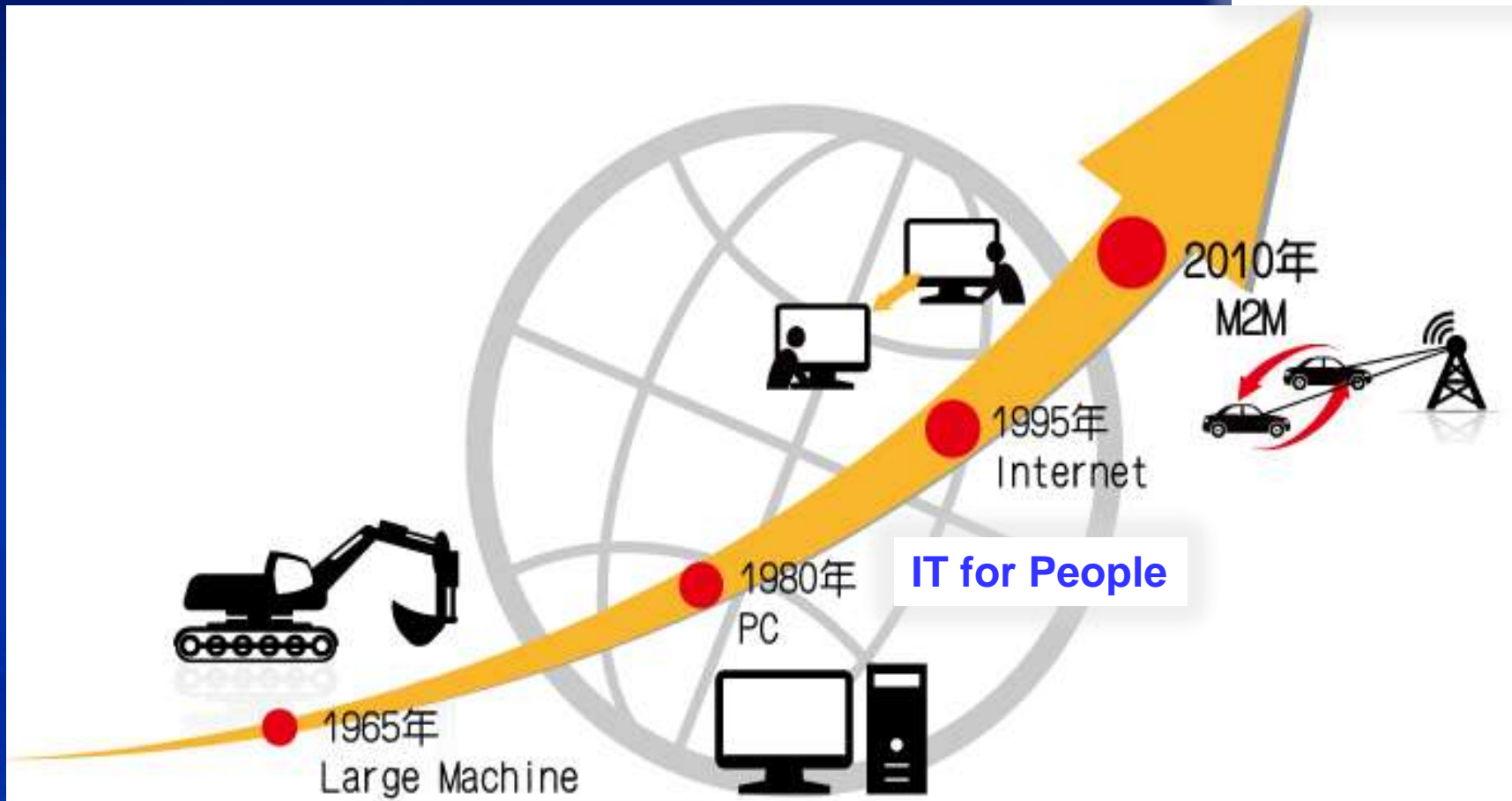
IT for Enterprise

# Paradigm Shift → Challenges

- **Internet of things (IoT)**
  - Large scale data communication and cloud computing are ready to reflect the new demand for serving the real world.

- **This motivates the research challenges on**
  - Data acquisition and communication platforms
  - Content & context analysis
  - Smart interaction & services

Challenges

- Collecting data → Sensors
  - Low-power so that no need to change battery
  - "Zero-touch" to deploy and manage devices
- Relaying information → Communication
  - Zero effort to connect large, dense populations of stationary and moving devices
  - Complete data security and privacy
- Analyzing the information → Computation
  - Answers are computed ahead of the questions
  - Optimum distribution of device & cloud intelligence
- Taking action → Service
  - Machines work for people frictionlessly & robustly

Opportunities in Sensing

- **Low power smart device with embedded wireless capability**
  - **Low power sensing**
  - **Low power pre-processing**
  - **Low power TX/RX**
  - **Energy harvesting**
- **Common programming platform across different sensors**
  - **Ease-of-development before deployment**
  - **Ease-of-reprogramming after deployment**
  - **Self-**
    - configuration, optimization, healing (reliability, or fail-safe), and protection (security)

Service

Computation

Communication
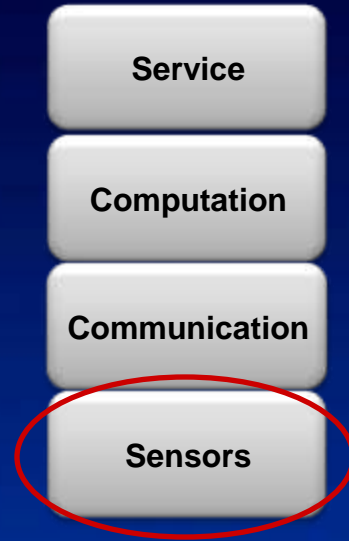
Sensors

Opportunities in Communication

- **More reliable, faster network for denser, faster-moving sensors with lower power across different protocols**

- **Automatic, seamless, persistent, and end-to-end data security**

Service

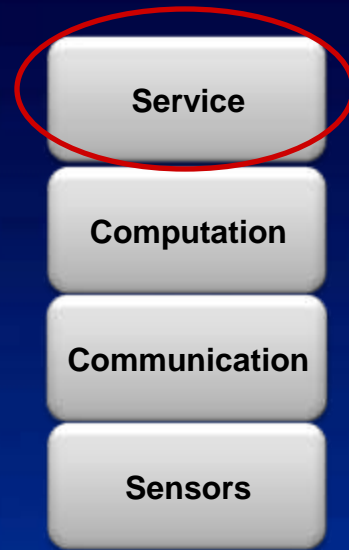Computation

Communication

Sensors

Opportunities in Computation

- **Analytic model that can process immense amount of heterogeneous data into proper context**
  - **Stream processing**
  - **Anomaly detection**

- **Distributed analysis architecture**
  - **Software stack on devices to enable local intelligence**

Service

Computation

Communication

Sensors

Opportunities in Service

- **Machines work for people not vice versa**

- **The success of M2M does not only depend on technology, but also service**

  – **Data centric, but user friendly**

- **Standardization & ecosystem**

  – **A standard for everyone to follow is critical for future large-scale M2M deployment**

  – **Major M2M standards still under development; emerging applications are using their own standards**

Summary

- **M2M will shape the way we live, play, work**

- **M2M is an exciting area for innovation**

- **There are many challenges & opportunities**

Intel-NTU CCC Center

Intel's Vision

This decade we will create and extend computing technology to connect and enrich the lives of every person on earth

Intel-NTU CCC Center

- Center
  - 3-5 year research center located at NTU
  - Around 13-16 projects
  - Around 30 professors and 100 students at NTU
  - Around 20 champions at Intel
- Vision
  - **To enrich our lives by providing end-end solution** for intelligent and secure interaction and information sharing amongst connected devices
- Mission
  - Address core challenges for **acquisition/communication platforms, context analysis, and smart interaction** that will increase the rate and breadth of M2M adoption across multiple vertical markets

Challenges

- Collecting data → Sensors
  - Low-power so that no need to change battery
  - "Zero-touch" to deploy and manage devices
- Relaying information → Communication
  - Zero effort to connect large, dense populations of stationary and moving devices
  - Complete data security and privacy
- Analyzing the information → Computation
  - Answers are computed ahead of the questions
  - Optimum distribution of device & cloud intelligence
- Taking action → Service
  - Machines work for people frictionlessly & robustly

Four Research Themes
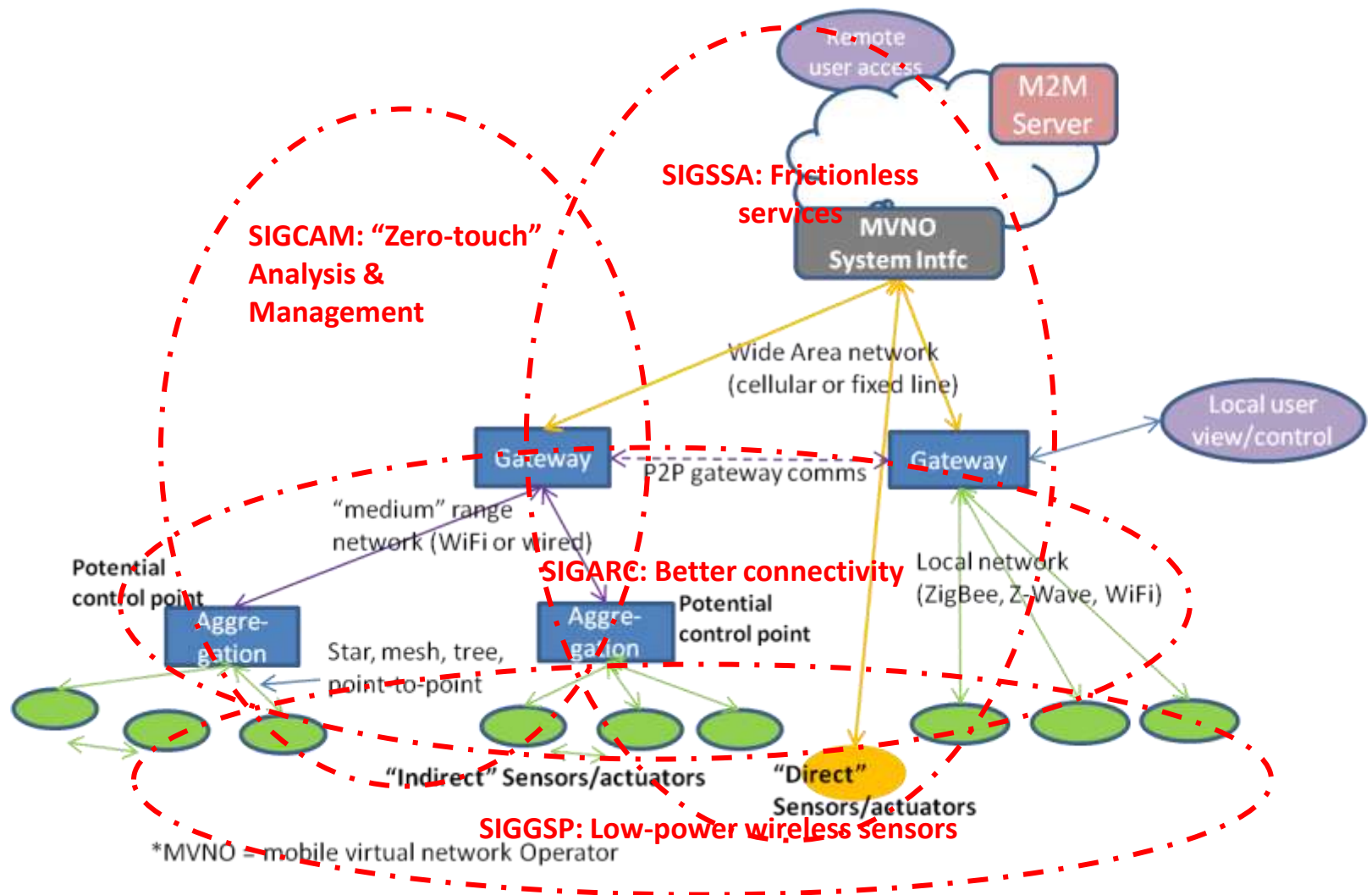
Smart Service for People

- **Context-aware home energy saving system**
  - Context inference engine, user comfort evaluation engine, & energy saving decision support engine to optimize energy saving policies while maintaining user comfort

- **Remote Ecological Monitoring System**
  - Real-world outdoor field trial and test-beds

- **Adaptive driver warning system**
  - (1) Ability to "see through" obstacles to enhance visibility, and (2) reduce annoying false alarms, via sensor fusion

"Zero-Touch" Management & Analysis

- **Self-configurable management middleware**
  - Frameworks for (1) device classes and profiles, (2) context-based configuration policy, and (3) gateway-driven control decisions, via virtual middleware

- **Comprehensive/scalable sensor data analytics**
  - API for anomaly detection, data representation, classification

- **Low-cost & future-proof public-key crypto (PKC) coprocessor**
  - Agile Algorithm on top of a crypto accelator

Better Connectivity

- **Flexible spectrum management**
  - – **Clustering, distributed coding, and interference mitigation to enable dense M2M network**

- **Energy efficient M2M communications**
  - – **Self-organizing hybrid distributed/centralized co-opetition framework for WiFi and cellular network**

- **Reliable V2V communication technology for vehicle early warning system**
  - – **Optimal combination of RF and visible-light communication via studying vehicle mobility model**

- **Heterogeneous information fusion and inference**
  - – **Smart algorithm to route information through multiple hops**

Low-Power Wireless Sensors

- **Low-power video coding**
  - DVC algorithm and ASIC design: shifting complexity from encoder to decoder

- **Low-power sensing**
  - Data-fusion of array of low-power, printable sensors

- **Low-power TX/RX**
  - Digitally-intensive transmitter via phase-switching circuit

- **High-efficient multi-source energy harvesting circuit**
  - RF (TV signals, GSM, WLAN), sun light, thermal, vibration

Administrative Information

Semester Outline

- **Course format**
  - **2 hours**
    - 90 minutes lecture by a professor from Intel-NTU CCC Center
    - 30 minutes group discussion led by the professor
  - **1 hour**
    - Video discussions, paper presentations, and guest seminars

Syllabus (I)

Date	Speaker	Topics (first two hours)	Third hour
2011/9/14	陳良基/陳彥光	Overview, motivation, and introduction of M2M	Administrative pass down of the class
2011/9/21	傅立成/陸敬互	M2M-Based Context-Aware Home Energy Saving System	1 hour seminar on Participatory mHealth: Opportunities and Challenges by Prof. Deborah Estrin, UCLA
2011/9/28	江昭皚	Development of a Remote Ecological Monitoring System	Discussion about M2M videos
2011/10/5	王傑智	M2M Sensor Fusion for Adaptive Driver Warning Systems	1 hour overview on National WSN Program by 呂學士教授
2011/10/12	林守德	A general framework for prediction, mining, and anomaly detection in heterogeneous sensor networks	Discussion about M2M videos
2011/10/19	鄭振牟	Low-cost Public-key Cryptography for M2M using Scalable Coprocessors	Each group to present your initial group topic (5 min/group)
2011/10/26	陳光禎	Cooperative Information Fusion and Inference	Technical paper presentations
2011/10/31 – 2011/11/1	9:00am-4:30pm	International Workshop on M2M Technology	Students must go to at least 6 talks/panel discussion

Syllabus (II)

Date	Speaker	Topics (first two hours)	Third hour
2011/11/2	施吉昇	Wu-Kong: A Self-Configurable M2M Management Middleware	Technical paper presentations
2011/11/9	蔡欣穆/逄愛君	An Early Warning System for Vehicles	1-hour seminar by Prof. Chang Wen Chen on video communication for WSN
2011/11/16 *	蘇炫榮/謝宏昀	Flexible Spectrum Management for Machine-to-Machine Wireless Networks	No class discussion after the talk, groups to discuss your project
2011/11/23	魏宏宇	Self-organizing Energy Efficient M2M Communications	Technical paper presentations
2011/11/30	林致廷/盧奕璋	Low Power Heterogeneous Sensor-System-on-Chip (S^{2}oC) in M2M Networks	Technical paper presentations
2011/12/7	簡韶逸	Coding and Analysis Subsystems of Distributed Video Sensors	Technical paper presentations
2011/12/14	林宗賢	Low-power Circuit Techniques for Intelligent Sensor Nodes	Technical paper presentations
2011/12/21	李致毅	High-Efficiency Energy Harvesting Techniques	Technical paper presentations
2011/12/28	Students	Group Project presentation (20 min. presentation and 5 min. Q&A)	
2012/1/4	Students		

Group Project/Presentation

- **Identify trends**
  - **From various videos/talks**
- **Create an ideal M2M service or application**
  - **Utilize existing or novel sensing, communication, computation technologies**
- **Identify gaps in the technologies**
- **A presentation at the end of the semester**
  - **User benefits**
    - What do you think our lives will be in 2020?
  - **Technology/service innovations to be done**

Grouping

- Groups
  - Students will be divided into 12 groups
  - Each group will have mixture of domain expertise
- Your action
  - Please fill in the information card

Student ID				
Chinese name		English name		
Email address				
Advisor				
Department				
M2M Area	( ) GSP	( ) ARC	( ) CAM	( ) SSA

Video to be Discussed

- **Everyone must watch the video before the class**
- **Discussion points**
  - **3 key takeaway messages**
  - **Trends**
  - **(Research to be done)**
- **One group will lead the discussion**
  1. **Imagine (Intel): http://youtu.be/UDoB4Acozp0**
  2. **System of Systems (IBM): http://youtu.be/h2br2_twHfw**
  3. **The Social Web of Things (Ercisson): http://youtu.be/i5AuzQXBsG4**
  4. **Machine to Machine Smart Services (Vodafone): http://youtu.be/ujk1cprLpD8**
  5. **Machine to Machine Services (Vodafone): http://youtu.be/UoarOwsAHcE**
  6. **The simple truth about LTE (uniteChannel): http://youtu.be/asxYJw7wlHE**
  7. **Smart Transportation: Integrating Systems for More Efficient Transportation (IBM): http://youtu.be/bUyourDcWzw**
  8. **Machine-to-Machine: the Connected World (Intel): http://edc.intel.com/Video-Player.aspx?id=5046**
  9. **Intelligent Transportation Systems (Intel): http://youtu.be/fegzbBhEQjY**
  10. **M2M Wireless Enterprise Solutions (AT&T): http://youtu.be/PSoGAqTn_Fk**
  11. **M2M (Maxis): http://youtu.be/hbG-ygWF_NM**
  12. **M2M services (nPhase): http://youtu.be/gKSlLRhhR7I**

Papers to be Discussed

1. **Machine-to-Machine: Reinventing Embedded Devices for Smart Services:** http://www.intel.com/content/dam/doc/technology-brief/m2m-reinventing-devices-for-smart-services.pdf
2. **Machine-to-machine technology gears up for growth: IEEE Xplore Article #1332996**
3. **Data Management in the Worldwide Sensor Web: IEEE Xplore Article #4160603**
4. **Trust in M2M communication: IEEE Xplore Article #5226943**
5. **Perci: Pervasive Service Interaction with the Internet of Things: IEEE Xplore Article #5262929**
6. **Smart objects as building blocks for the Internet of things: IEEE Xplore Article #5342399**
7. **Embedded Interaction: Interacting with the Internet of Things: IEEE Xplore Article #5342400**
8. **Internet Predictions (Participatory Sensing: Applications and Architecture by Deborah Estrin and The Internet of Things: Here Now and Coming Soon by Geoff Mulligan): IEEE Xplore Article #5370818**
9. **Embedded web services: IEEE Xplore Article #5675778**
10. **The Internet of nano-things: IEEE Xplore Article #5675779**
11. **Future Internet of Things Architecture: Like Mankind Neural System or Social Organization Framework?: IEEE Xplore Article #5722081**
12. **Global Wireless Machine-to-Machine Standardization: IEEE Xplore Article #5731588**
13. **GRS: The green, reliability, and security of emerging machine to machine communications: IEEE Xplore Article #5741143**
14. **M2M: From mobile to embedded internet: IEEE Xplore Article #5741144**
15. **Interacting with the SOA-Based Internet of Things: Discovery, Query, Selection, and On-Demand Provisioning of Web Services: IEEE Xplore Article #5416674**
16. **Toward intelligent machine-to-machine communications in smart grid: IEEE Xplore Article #5741147**
17. **Toward ubiquitous massive accesses in 3GPP machine-to-machine communications: IEEE Xplore Article #5741148**
18. **Multimedia traffic security architecture for the internet of things: IEEE Xplore Article #5772059**
19. **Vehicular ad hoc networks (VANETS): status, results, and challenges:** https://drivehq.com/file/df.aspx/shareID8149545/fileID660515258/spr98w74256.pdf

Bonus Short Topics During the Semester

- Why some people get promoted more quickly
- Intel's annual review process
- Should use your strength
- Presentation skills
- T-shape or ∏-shape expertise
- Team work
- How to change people's behavior
- Risk taking
- Constructive confrontation

Administrative Information

- **Course page**
  - – **Regular homepage:
    http://cc.ee.ntu.eud.tw/~ykchen/m2m.htm**
  - – **Facebook group:
    http://www.facebook.com/groups/intro.m2m**
- **Grades**
  - – **50%: participation (not just attendance but also discussions, questions, comments)**
  - – **50%: project & presentation**
- **Office Hour: By appointment**

Ground Rules

- **Close all laptops**
- **No phone calls in the classroom**