Key Applications of the IoT/M2M

國立交通大學資訊工程系
Department of Computer Science
National Chiao Tung University
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Outline

1. **Industrial IoT/M2M**
   - Industrial Automation
   - eHealth
   - Smart Grid
2. **Consumer IoT/M2M**
   - Smart Home
   - Smart Cities
   - Connected Car

Industrial Automation

Outline

- Service-oriented architecture(SOA)-based device integration
- **SOCRADES**: Realizing the enterprise integrated web of things
- **IMC-AESOP**: from the web of things to the cloud of things
- Conclusion

Service-Oriented Architecture

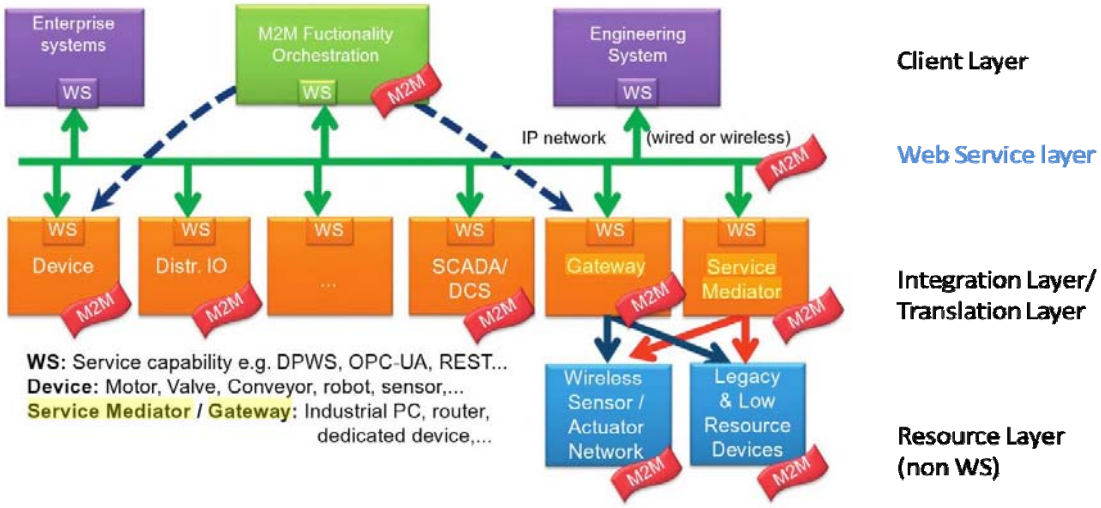
- A **service-oriented architecture (SOA)** is an architectural pattern in computer software design in which application components provide services to other components via a service bus. (typically over a network)
- The principles of service-orientation are independent of any vendor, product or technology.
- A **service** is a self-contained unit of functionality, such as retrieving an online bank statement. By that definition, a service is a discretely invokable operation.

Service-Oriented Architecture

- SOA can act as a unifying technology that spans several layers.
  - direct device interaction
  - a wide range of interactions in a cross-layer way with a variety of heterogeneous devices

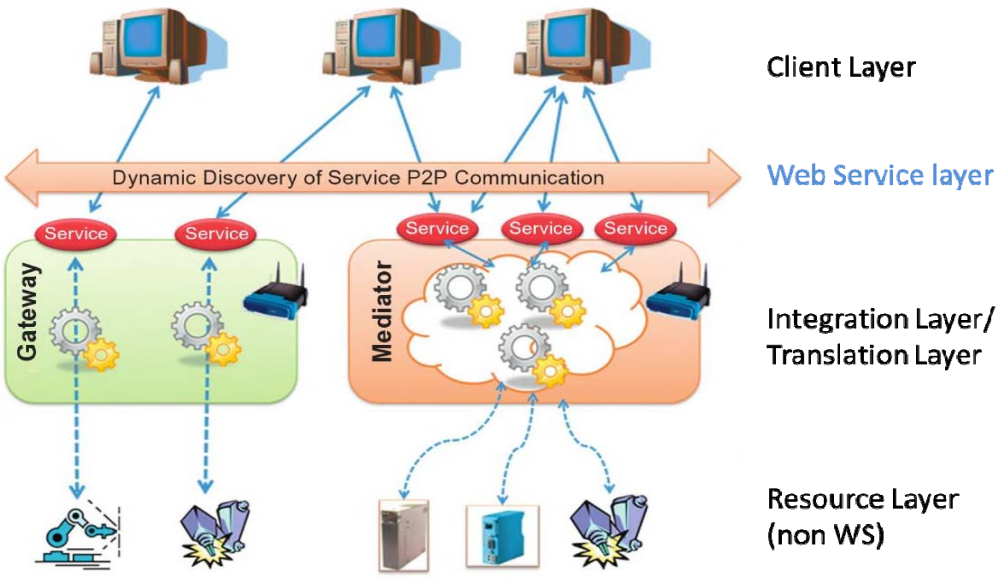
M2M SOA-based integration

DPWS: Devices Profile for Web Services
OPC-UA: Open Platform Communications – Unified Architecture
REST: Representational State Transfer based on a stateless, client-server, cacheable communications protocol



Source: Book by Jan Holler, Catherine H. Mulligan, Stamatis Karnouskos, Vlasios Tsiatsis, David Boyle, Stefan Avesand, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence" .

Non-service-enabled Device Integration



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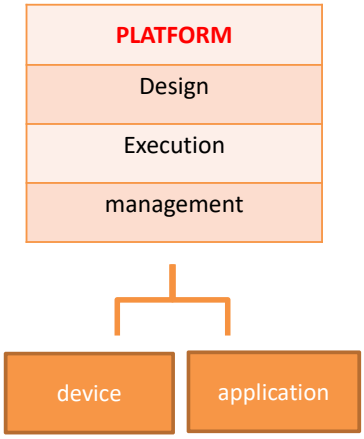
- **Gateway**
  - A device controls a set of lower-level non-service-enabled devices.

  - Replacing limited-resource devices or legacy devices by natively WS-enabled devices without impacting the applications using these devices.

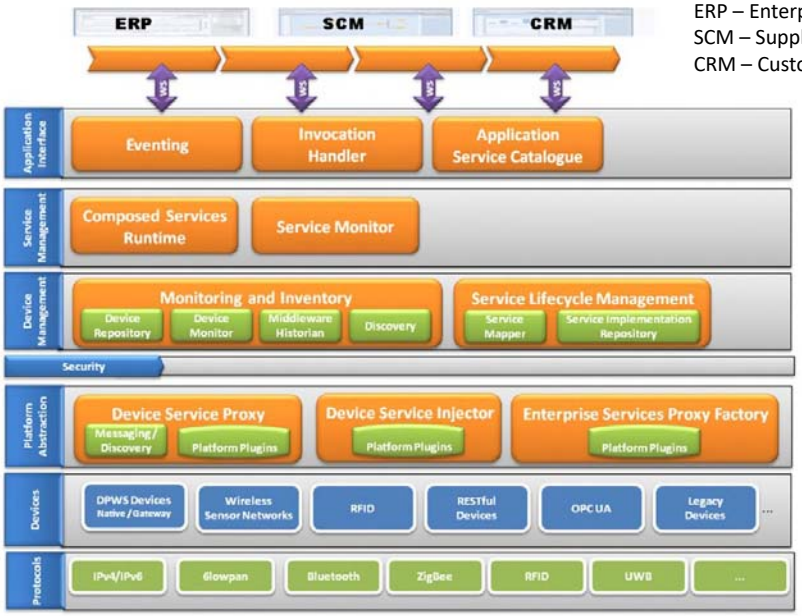
SOCRADES

(Service Oriented Cross-layer infRAstructure for Distributed smart Embedded deviceS)

- The SOCRADES project (2006-2009) is a European research and advanced development project.
- Its primary objective is to develop a design, execution and management platform for next-generation industrial automation systems, exploiting the Service Oriented Architecture paradigm both at the device and at the application level.



SOCRADES Integration Architecture (SIA)



ERP – Enterprise Resource Planning
SCM – Supply Chain Management
CRM – Customer Relation Management

Source: Book by Jan Holler, Catherine H. Mulligan, Stamatis Karnouskos, Vlasios Tsiatsis, David Boyle, Stefan Avesand, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence".

Local Discovery Unit(LDU)

- To realize discovery and interaction in a P2P way, a local gateway/service-mediator is implemented.
- LDU would enable the dynamic discovery of devices on premise and their coupling with the SIA.

- SIA has been used in several scenarios as a proof of concept for the integration among different devices, both locally and with enterprise systems.
- Example: passive energy monitoring via the usage of sensors and gateways.

IMC-AESOP

Intelligent Monitoring & Control - ArchitEcture for Service Oriented Process monitoring & control

- The IMC-AESOP project is a European research and development project and is a part of the Collaborative Project initiative of the European Union's 7th Framework Programme from Sep. 2010 to Dec. 2013.
- The project goes beyond WS-enabled devices towards the cloud in order to harness its benefits, such as resource flexibility, scalability.
- The result is a highly dynamic flat information-driven infrastructure that will empower the rapid development of better and more efficient next generation industrial applications, while in parallel satisfying the agility required by modern enterprises.
- IMC-AESOP primarily realizes a SoA-based approach for next generation of SCADA (Supervisory Control And Data Acquisition)/DCS (Distributed Control System) systems targeting Process Control Applications.

IMC-AESOP

MES - Manufacturing Execution Systems
ERP - Enterprise Resource Planning system
SCADA - Supervisory Control And Data Acquisition

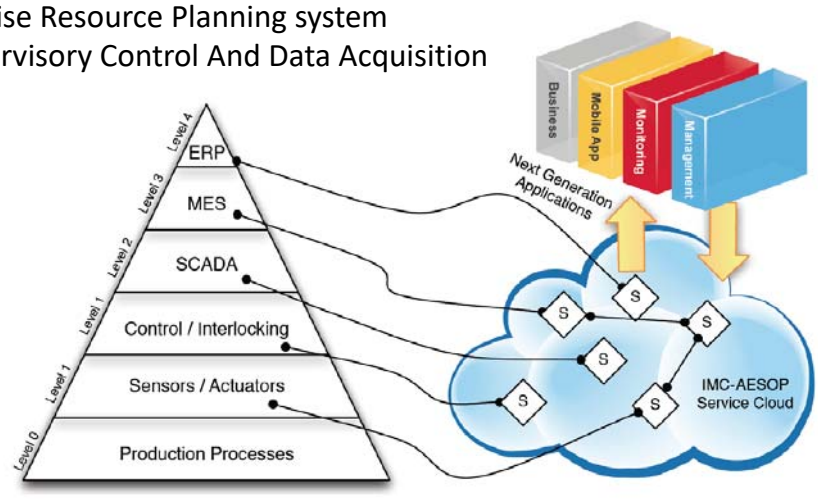


Figure 1. Future industrial system view of cloud-based composition of cyber-physical services

Source: Book by Jan Holler, Catherine H. Mulligan, Stamatis Karnouskos, Vlasios Tsiatsis, David Boyle, Stefan Avesand, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence" .

IMC-AESOP

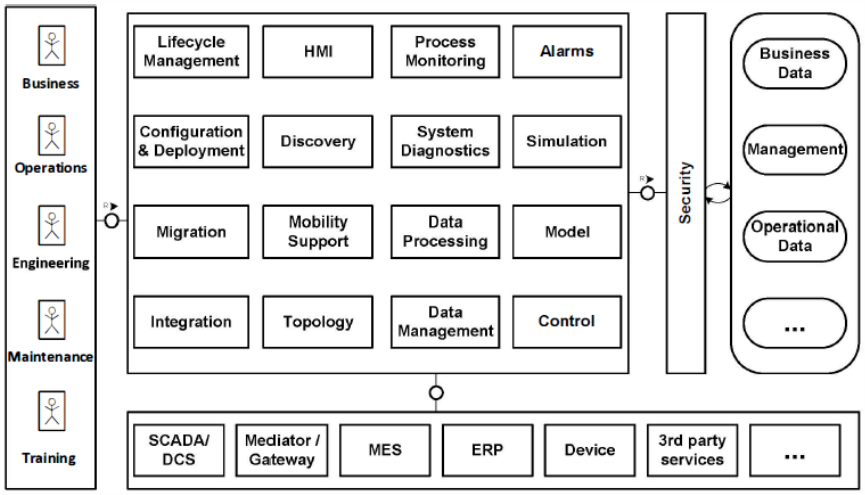


Figure 2. Architecture overview

Source: Book by Jan Holler, Catherine H. Mulligan, Stamatis Karnouskos, Vlasios Tsiatsis, David Boyle, Stefan Avesand, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence" .

References

From "**Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence**", Chapter 11.

Difference between DCS and SCADA
http://control.com/thread/1365080091

OPC-UA http://matrikonopc.cn/opc-ua/

SCADA https://en.wikipedia.org/wiki/SCADA

IMC-AESOP Project http://www.imc-aesop.org/index.html

http://www.hs-emden-leer.de/forschung-transfer/projekte/imc-aesop-project.html

eHealth

Outline

R&D Projects at CGU (Chang-Gung University)

1. The intelligent elderly care equipment R & D projects
2. Home Gateway and Community Platform for the Elderly

1. The intelligent Elderly Care Equipment R & D Projects

- Wearable medical equipment
- Function-Strengthened “Action Care“ Medical Equipment
- Clinical Interaction Module and System

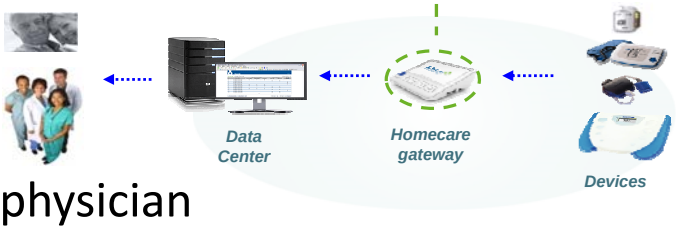
Wearable Medical Equipment

- Wearable watch
  - Life sensing and watches
  - Function: time, weather conditions, and medication remind mechanism
- Wearable physiological monitoring device
  - Real-time, continuous
  - Future applications: hyperactive children, Parkinson's disease, epilepsy

Function-Strengthened "Action Care" Medical Equipment

- Intelligent human factor auxiliary semi-automatic wheelchair cum foot rehabilitation board
  - Power assistance for personal fitness and function strengthening for rehabilitation needs
  - Real-time remote network monitoring navigation
  - The lightweight pedals can do multi-angle movement for foot rehabilitation.

Clinical Interaction Module and System

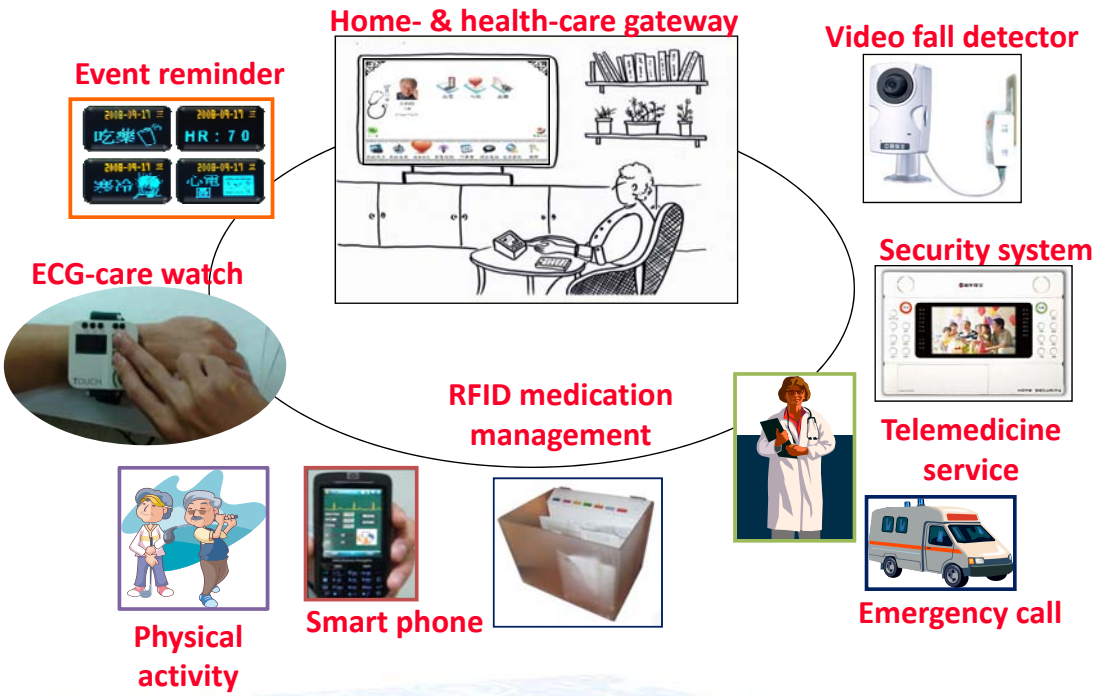


- Dr.e portable electronic physician
  - Chronic disease emergency advisory system
  - Blood pressure monitor communications assistant
- Metabolic syndrome health management system
  - Provide healthcare self-management module (different diagnostic paths and physical conditions)
  - Provide automatic classification of health education and personalized diet and exercise recommendations
  - Enable self-care at home

2. Home Gateway and Community Platform for the Elderly

- Goal: to provide basic necessities, recreation, interactive entertainment platform and security care
- Achievement:
  - Implementation and application of home personal gateway
  - Medication reminders and drug identification
  - Smart Entertainment Platform
  - Design of indoor positioning and navigation system
  - Fall detection system
  - Cloud-Based Health Promotion and Care Platform

Home and Community Platform System Architecture



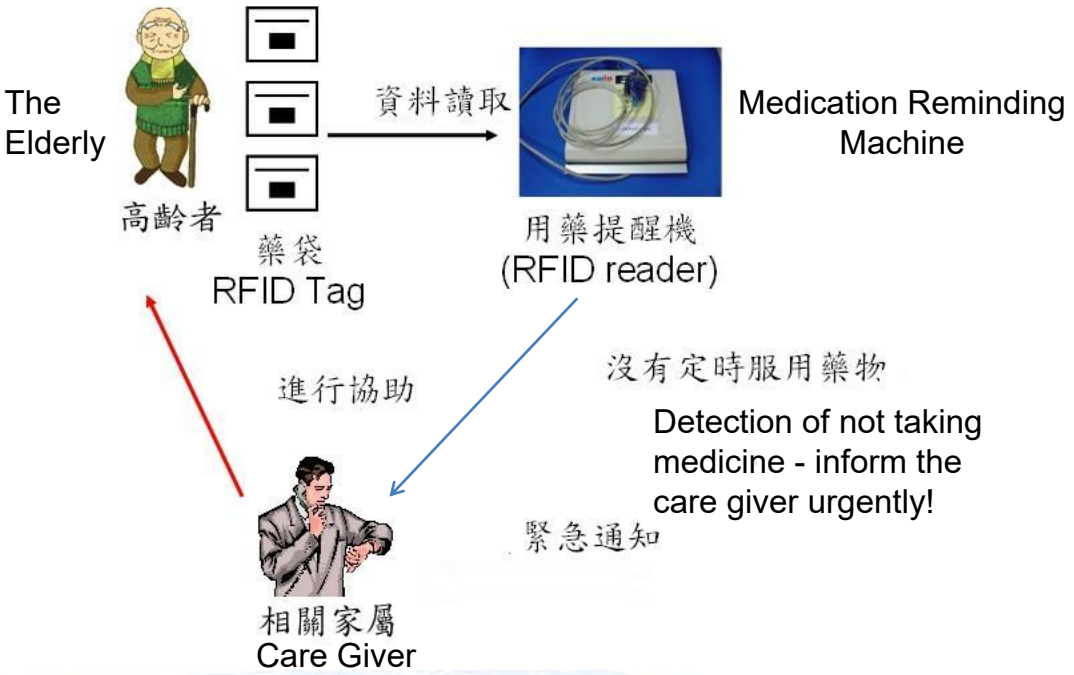
Home and Health-Care Gateway System Implementation and Application

- Through a remote control, you can use the services in the living room or in any corner of your home.
- The concept of a digital home is to protect the quality of life for the elderly, improve health care for the elderly, and finally to bring much convenience to the elderly.

Drug Identification and Medication Reminders

- Control of chronic diseases normally is done by long-term medication.
- However, the memory degradation of the elderly often causes the risk of taking the wrong drug.
- Use sensing and network technology to develop a system that reminds the elderly to take medicine according to doctors' prescription and also informs the elderly's children remotely.
- The purpose is to reduce the risk of taking the wrong medicine by those seniors who live alone and also help them to establish the good habit of taking medicine regularly.

Drug Identification and Medication Reminders (Cont.)

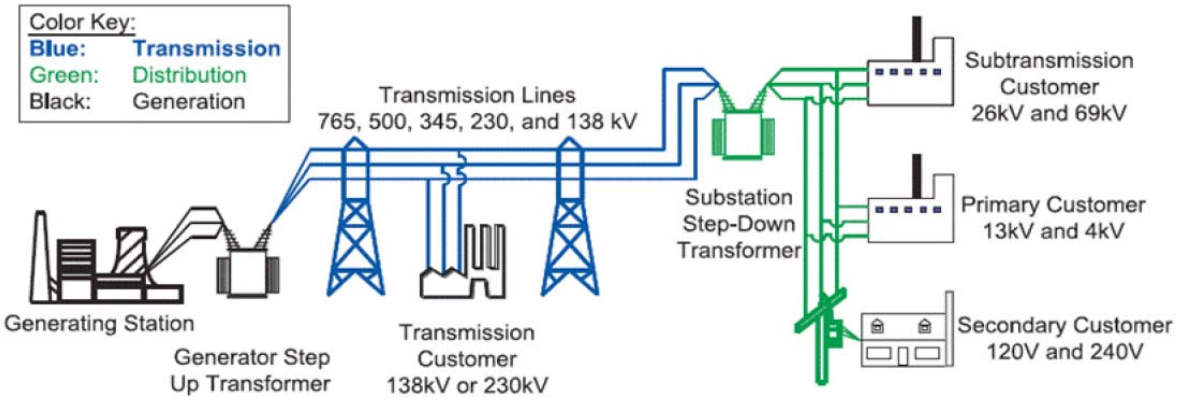


Smart Grid

Outline

1. What's Smart Grid?
2. Requirements and Architectural Goals of Smart Grid
3. NIST Architectural Models
4. ITU-T Architectural Models

Legacy Electric Grid Architecture



Source: NIST Smart Grid Program Review

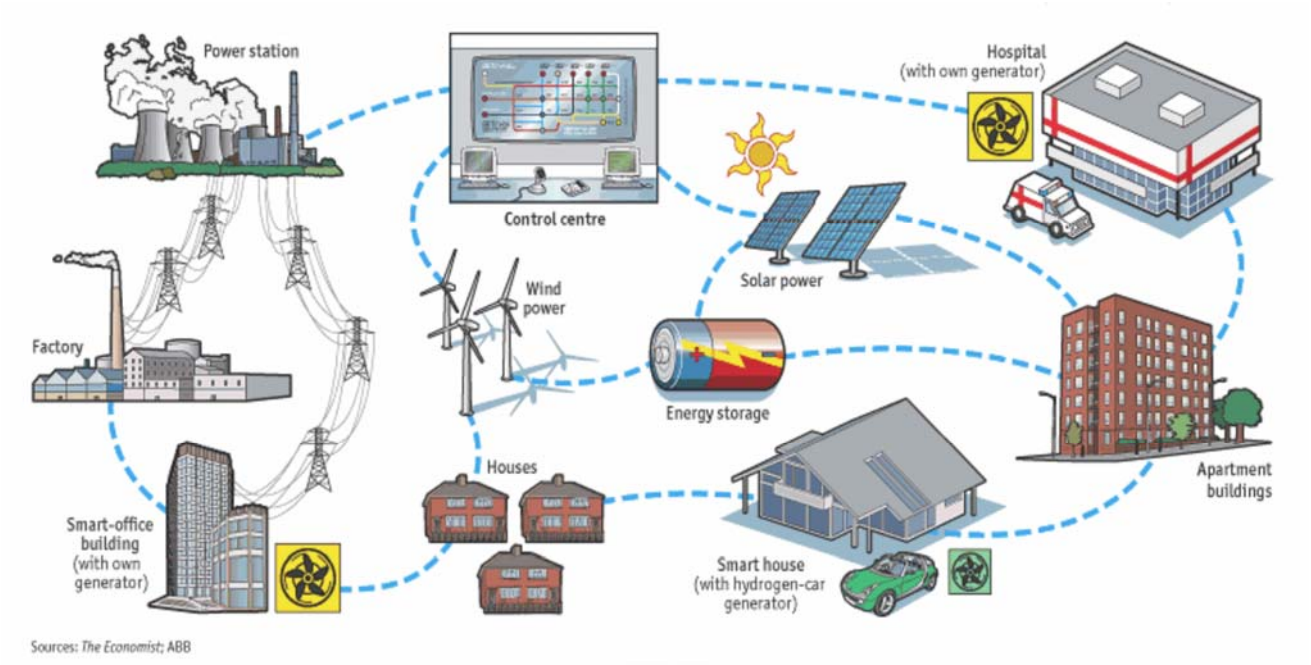
One-way flow of electricity

- **Centralized, bulk generation, mainly coal and natural gas**
- **Responsible for 40% of human-caused CO2 production**
- **Controllable generation and predictable loads**
- **Sized for infrequent peak demand – operates at 50% capacity**
- **Limited automation and situational awareness**
- **Lots of customized proprietary systems**
- **Lack of customer-side data to manage and reduce energy use**

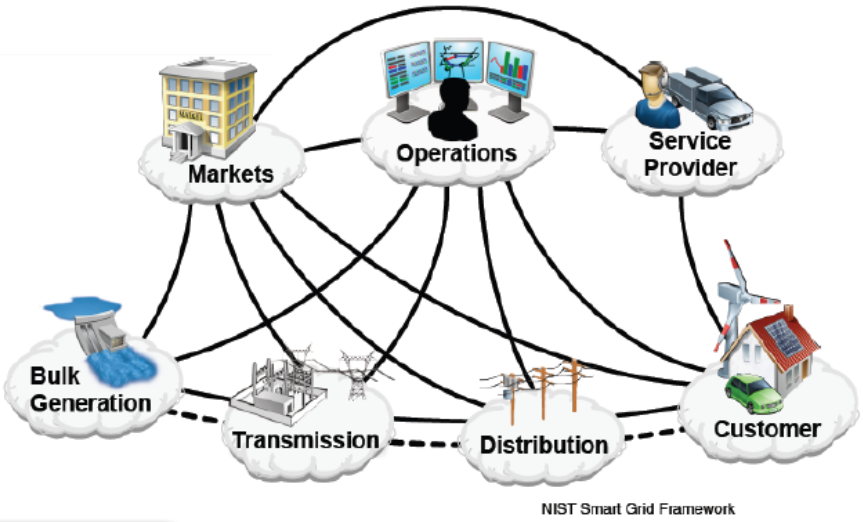
Smart Grid = Electric Grid + Intelligence

- The *smart grid* is a radical evolution of the energy supply and consumption infrastructure that will provide providers and consumers with unprecedented levels of reliability and control while reducing the adverse environmental impact of energy generation and consumption
- A smart grid delivers electricity from suppliers to consumers using two-way technology to control appliances at consumers' homes to save energy, reduce cost and increase reliability and transparency.
- Smart meters are part of a smart grid, but alone do not constitute a smart grid

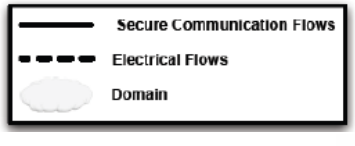
Smart Grid



NIST Conceptual Reference Model



NIST Smart Grid Framework



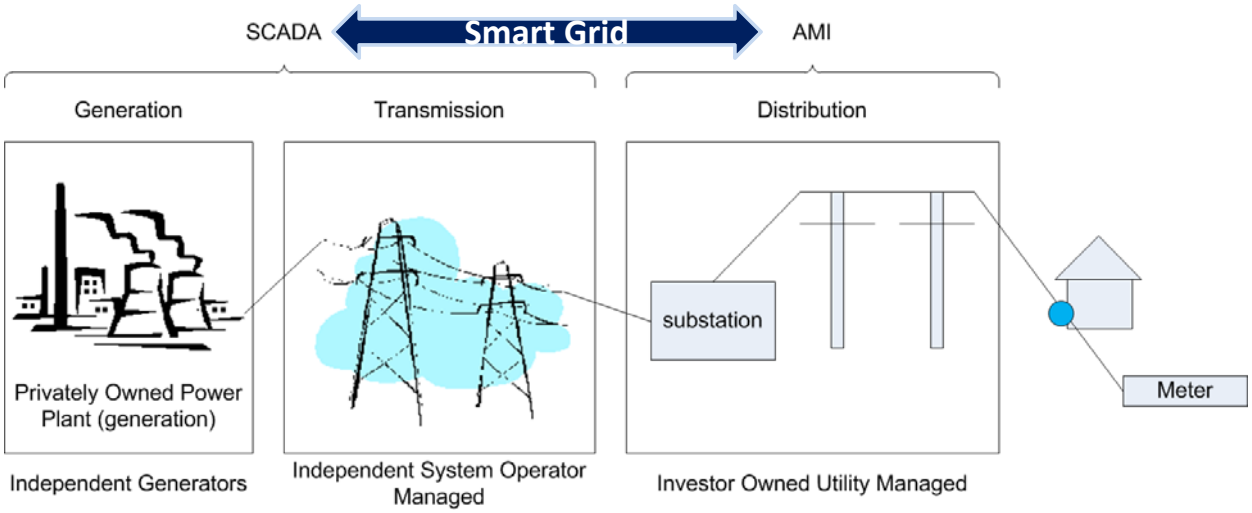
Interaction of Actors in Different Smart Grid Domains through Secure Communication

Source: NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0

Domains and Actors in the NIST Smart Grid Conceptual Model

	Domain	Actors in the Domain
1	Consumers	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: residential, commercial, and industrial
2	Markets	The operators and participants in electricity market
3	Service providers	The organizations providing services to electrical customers and to utilities
4	Operations	The managers of the movement of electricity
5	Bulk generation	The generators of electricity in bulk quantities. May also store energy for later distribution.
6	Transmission	The carriers of bulk electricity over long distances. May also store and generate electricity.
7	Distribution	The distributors of electricity to and from customers. May also store and generate electricity.

Smart Grid – A Simple Concept

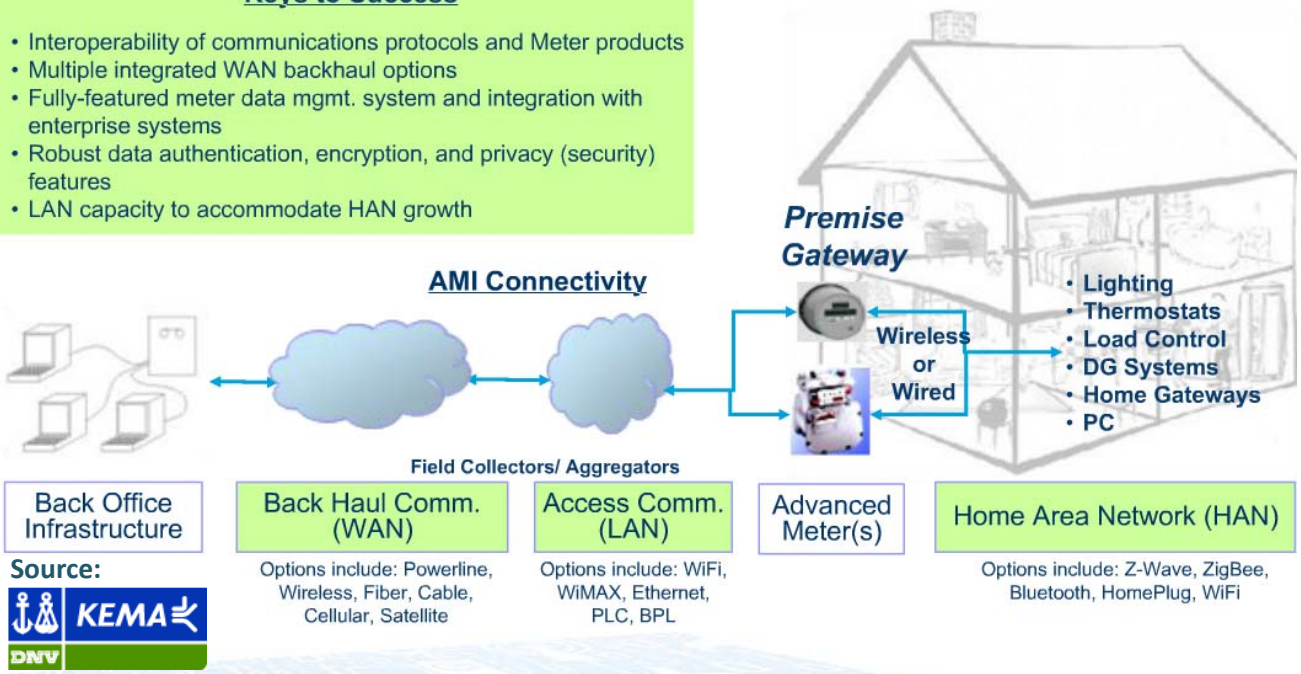


AMI: Advanced Meter Infrastructure is the infrastructure for power distribution.
SCADA: Supervisory Control And Data Acquisition
SCADA is a type of industrial control systems (ICS) that are computer controlled systems for monitoring and controlling the processes of power generation and transmission.

Smart Grid Communication Networks

Keys to Success

- Interoperability of communications protocols and Meter products
- Multiple integrated WAN backhaul options
- Fully-featured meter data mgmt. system and integration with enterprise systems
- Robust data authentication, encryption, and privacy (security) features
- LAN capacity to accommodate HAN growth



Source: KEMA DNV

References

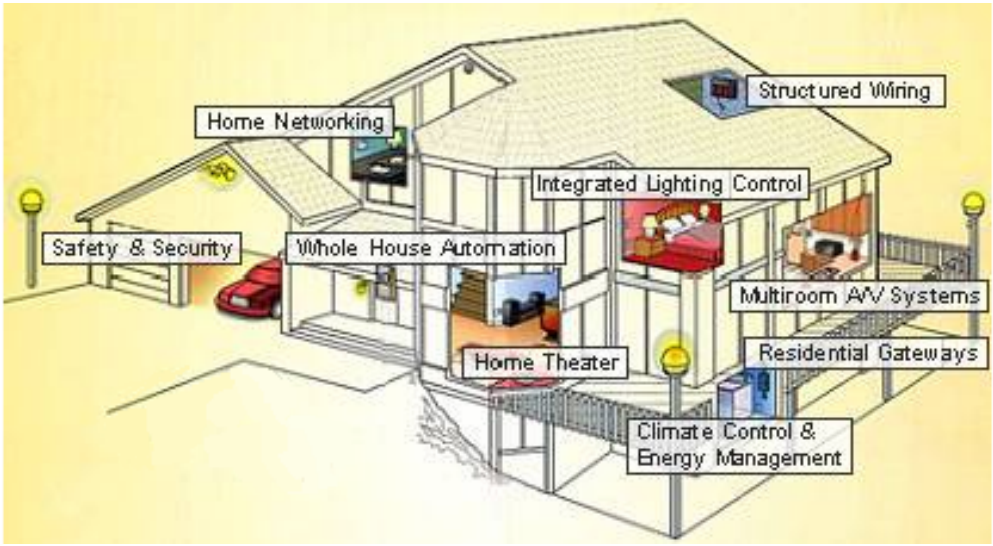
- NIST Smart Grid, NIST Releases Final Smart Grid 'Framework 2.0' Document; http://www.nist.gov/smartgrid/
- IEEE P2030 Smart Grid Series: http://grouper.ieee.org/groups/scc21/dr_shared/2030/
- ITU-T Focus Group on Smart Grid (FG Smart) http://www.itu.int/en/ITU-T/focusgroups/smart/Pages/Default.aspx
- ETSI M2M Smart Grids http://www.etsi.org/WebSite/Technologies/SmartGrids.aspx
- IETF RFC 6272, Internet Protocols for the Smart Grid. June 2011.

Smart Home

Outline

- M2M Area Networks: A Variety of Device Types and Protocols
- Smart Home Demonstration
  - Case 1: Home AV Entertainment
  - Case 2: Home Gateway

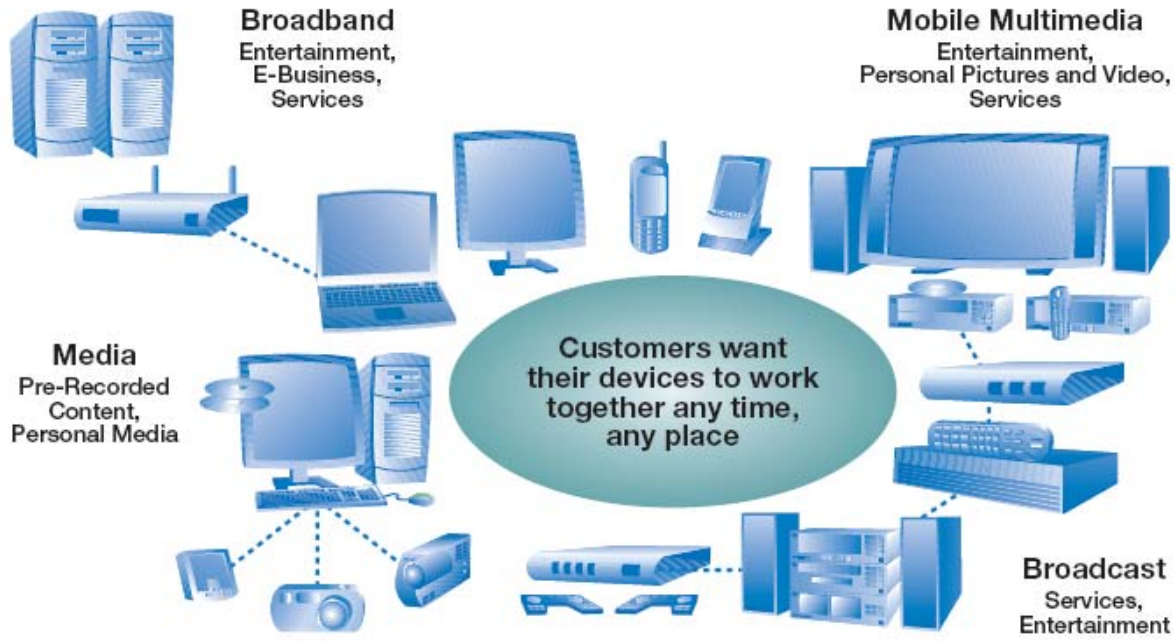
Household Environment



Home Automation
http://www.caba.org/

HOME AV ENTERTAINMENT (WITH DLNA, UPNP AND UPNP AV)

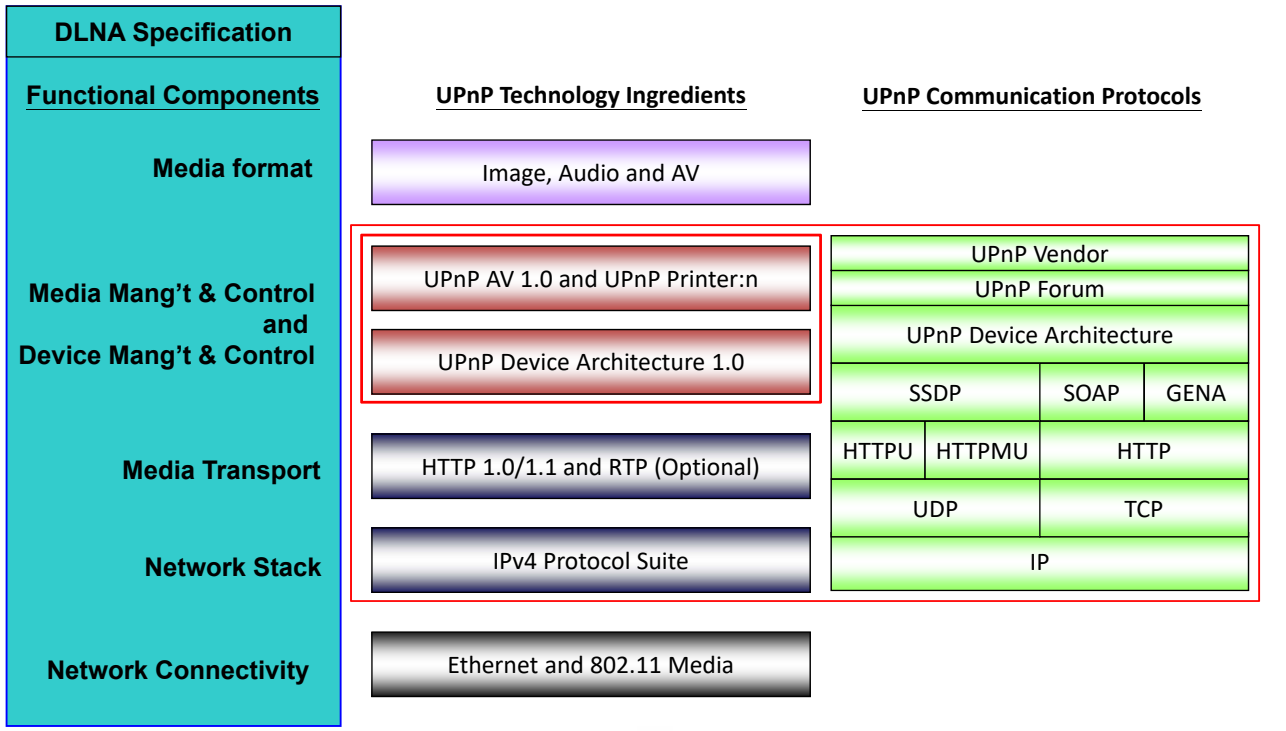
Home AV Entertainment



Home AV Entertainment

- Home networked devices (HNDs)
  - Mobile, PC, and CE product domains
    - TV, mobile phone, game console, personal video recorder, IP set-top-box, network attached storage (NAS), desktop, and laptop
    - Upgraded capabilities: computation, networking, multimedia processing, storage
- Standard bodies
  - Interoperability for distributed multimedia services among PC, CE and mobile devices in home networks
    - Digital Living Network Alliance (DLNA)
    - Universal Plug and Play (UPnP) Forum
      - UPnP networking middleware is to be a uniform device and service discovery framework.
      - UPnP AV Profile is for AV playback services in UPnP-based networks

DLNA and UPnP



Digital Living Network Alliance (DLNA)

UPnP Functionality

- An open standard based on the widely known Internet technology.
  - Leveraging the TCP/IP and Web protocols to enable
    - Seamless proximity networking,
    - Control among networked devices, and
    - Data transfer among networked devices
  - UPnP is a discovery framework
    - To enable devices and services to properly discover, configure, and communicate with each other.
    - To know the availability and capability of peer devices without explicit administration.
    - To find resources automatically rather than needing pre-configured bindings to specific resources

UPnP Functionality (Cont.)

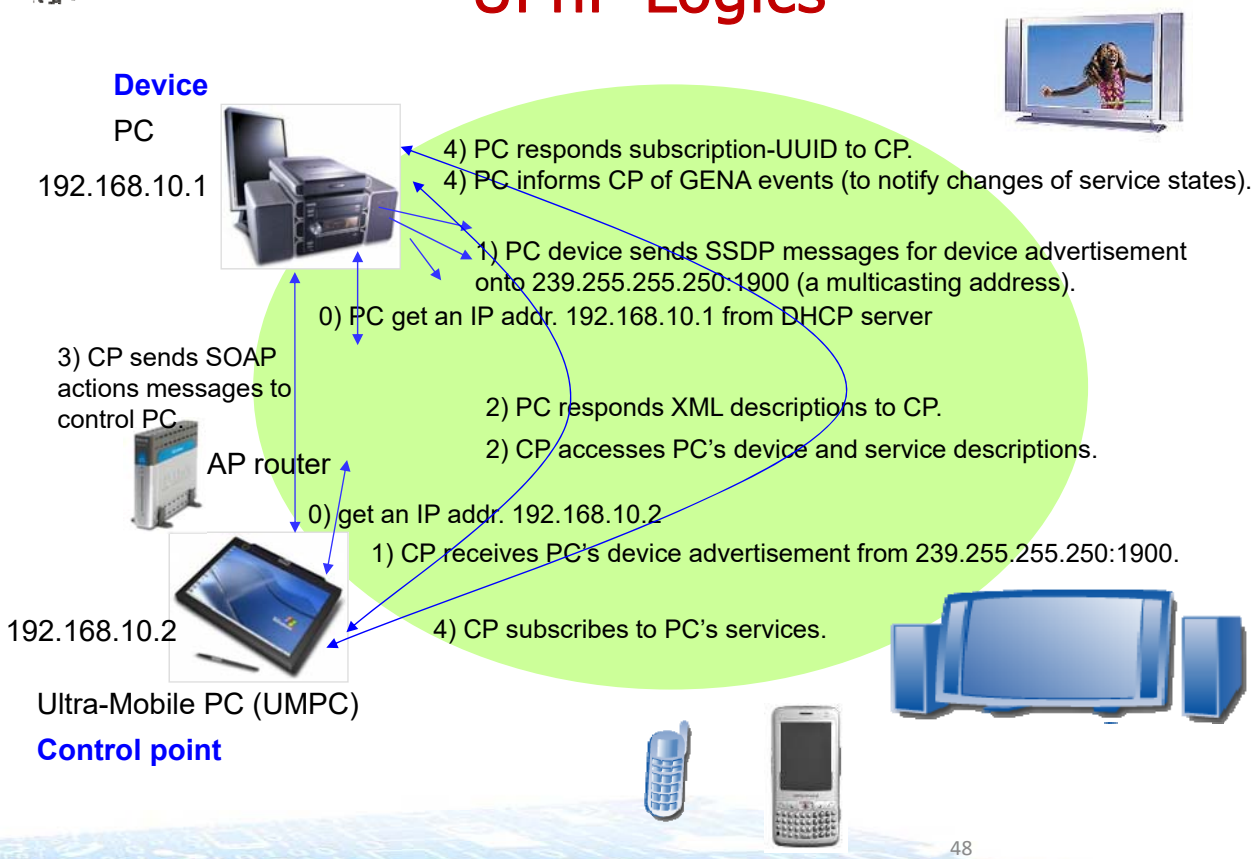
Two UPnP entities

Controlled Device	In the role of server, offering services to be used by CPs.
Control Point (CP)	To monitor or control devices

Six functional layers

5	Presentation	Device and service information with HTML file
4	Eventing	Event notification by GENA message
3	Control	Action invocation by SOAP message
2	Description	Device and service description files with XML templates
1	Discovery	Device and service discovery by SSDP
0	Addressing	Network address assignment by DHCP or Auto-IP

UPnP Logics



UPnP Service Profiles: UPnP Device Categories

- **Audio/Video**
  - **MediaServer V2.0 & MediaRenderer V2.0**
  - **MediaServer V1.0 & MediaRenderer V1.0**
- **Basic**
  - Basic Device V1.0
- **Home Automation**
  - Digital Security Camera V1.0
  - HVAC V1.0
  - Lighting Controls V1.0
- **Networking**
  - Internet Gateway V1.0
  - WLAN Access Point V1.0
- **Printer**
  - Printer Enhanced V1.0
  - Printer Basic V1.0
- **Remoting**
  - Remote UI Client V1.0 & Remote UI Server V1.0
- **Scanner**
  - Scanner V1.0
- **Add-on Services**
  - Device Security V1.0 & Security Console V1.0
  - Quality of Service V1.0
  - Quality of Service V2.0
  - Lower Power V1.0

Smart Cities

Outline

- Introduction
- Smart cities – the need
- Smart cities – a working definition
- Smart cities – some examples
- Roles, actors, engagement
- Transport and logistics – an IoT perspective
- Conclusion

Introduction

- It is predicted that 70% of the world's population will be living in cities by 2050.
- Increasing natural resource constraints, marked increases in population, and a restructuring of the global economy.
- Cities need to handle massive tensions in environmental impact, economic growth, and social evolution.

- As a result, so-called "Smart Cities" have rapidly become a hot topic within technology communities.

Smart cities – the need

- Cities now account for 75% of the world's greenhouse emissions, but take only 2% of the earth's surface area. As the same time, the size and economic outputs of cities is on par with small nations.

- Cities need to provide for the majority of the world's citizens while rapidly decreasing environmental impact. As the result, the need for smart cities is discussed in a variety of settings, including the need for climate change mitigation.

Smart cities – the need

- Technical innovation has the opportunity to provide some of the solutions to the era of urbanization, thus helping to both reduce environmental impact and also create new jobs and promote growth and citizen engagement.

- Information and Communications Technology (ICT) can be applied in the built environment to help solve issues such as traffic congestion, energy consumption, and behavioral change.

Smart cities – a working definition

- We define a smart city as one that uses data and ICT in order to :
  - Manage and optimize existing infrastructure investments
  - More efficient, new, or enhanced services
  - Climate change mitigation
  - Innovative business models

Smart cities some examples

- Smart Transportation
  - Solutions for parking traffic monitoring, public transport management
- Smart Healthcare
  - Electronic records, hospital asset, remote monitoring management
- Smart Education
  - eLearning, MOOCs, and connected campuses
- Security and Public Safety
  - Video surveillance, and workflows for emergency services
- Smart Buildings
  - Smart meters, light, heating, and water and waste management

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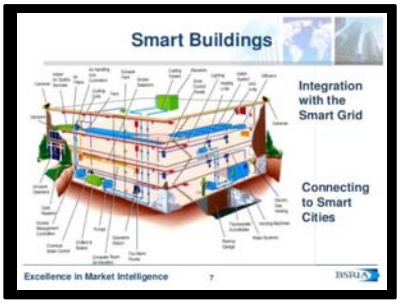

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Conclusions

- The role of IoT in cities is one that will only increase as the **pressure on cities** to deliver services at reduced costs for an **expanding population increases**.
- Due to the complexity in cities, the best way for them to achieve the desired outcomes of smart cities is to utilize an **information marketplace** approach.

Connected Car

Outline

- GM OnStar
- Ford SYNC
- GM OnStar versus Ford SYNC

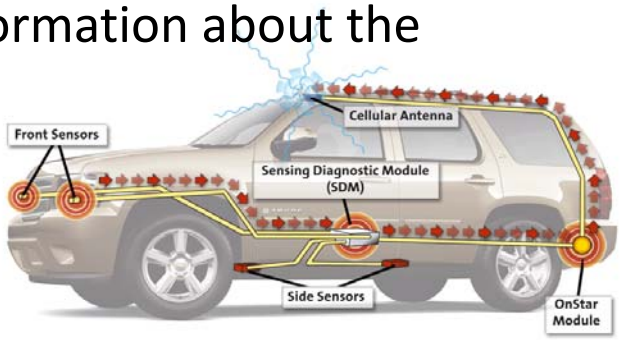
ONSTAR

OnStar

- Since beginning operations in 1995, General Motors' OnStar system has grown to become the nation's leading provider of in-vehicle safety, security and communications services using wireless and Global Positioning System (GPS) satellite technology.
- OnStar is available on more than fifty 2009 and newer GM models. There are already 6 million OnStar subscribers in the U.S. and Canada in July 2012.

Technical

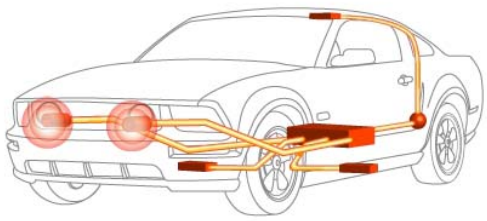
- the service relies on CDMA mobile phone voice and data communication, as well as location information using GPS technology
- In the event of a collision, detected by airbag deployment or other sensors, it can automatically send information about the vehicle's condition and GPS location to OnStar call centers



Advanced Automatic Crash Notification System(AACN)

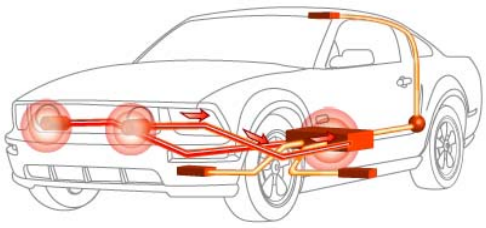
- Starts recording in the event of a crash , like an airplane's black box.
- Comprises four components: sensors, the Sensing Diagnostic Module, the Vehicle Communication and Interface Module(VCIM) and the cellular antenna
- When the car is in a crash, sensors transmit information to the Sensing Diagnostic Module(SDM)
  - SDM includes an accelerometer, which measures the severity of the crash based on gravitational force

1



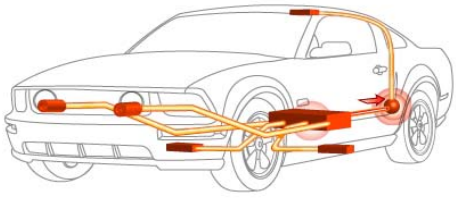
Impact data is transmitted to the SDM, which also measures the severity of the crash.

2



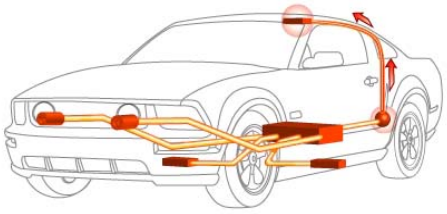
The SDM transmits the crash data to the OnStar module.

3



Within seconds, the OnStar module sends a message to the Call Center using the cellular antenna.

4



An OnStar advisor answers the call .

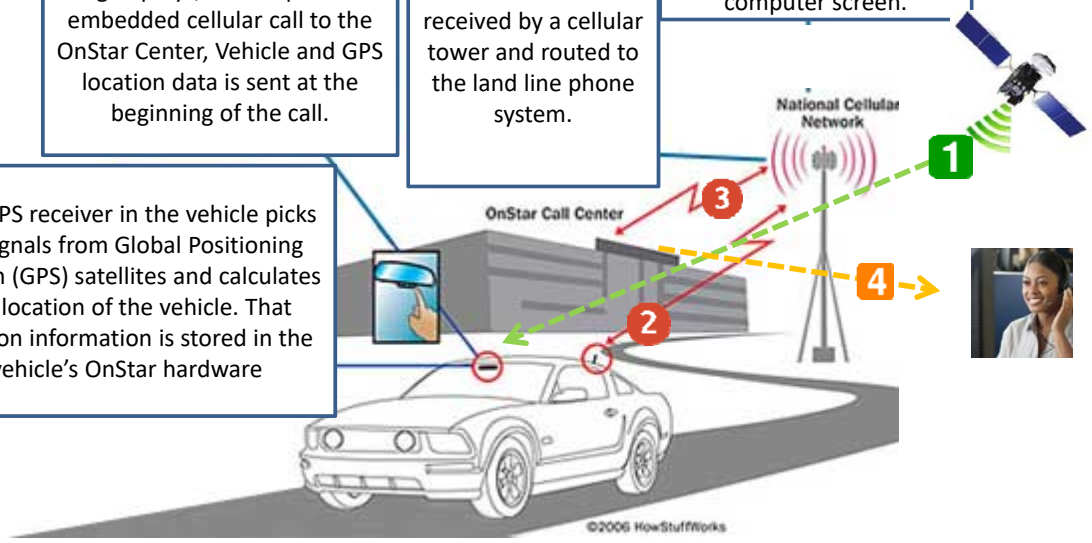
How OnStar Works

2. When the driver pushes the blue OnStar button or red Emergency button, or an air bag deploys, OnStar places a embedded cellular call to the OnStar Center, Vehicle and GPS location data is sent at the beginning of the call.

3. The cellular call is received by a cellular tower and routed to the land line phone system.

4. The OnStar switch sends the call to the first available advisor, who has the location of the vehicle and the customer's information on her computer screen.

1. A GPS receiver in the vehicle picks up signals from Global Positioning System (GPS) satellites and calculates the location of the vehicle. That location information is stored in the vehicle's OnStar hardware



Features

- Emergency Services
- Security Services
- Navigation
- Connections
- Diagnostics

Emergency Services

- **Automatic Crash Response**
  - In a crash, built-in sensors can automatically alert an OnStar Advisor who is immediately connected into the vehicle to see if driver or passengers need help sent to their exact location — even if they can't say a word.
- **Crisis Assist**
  - During severe weather and other natural disasters, an OnStar Advisor can help the users navigate their way to safety and provide a reliable connection to loved ones.

Security Services

- **Stolen Vehicle Assistance**
  - OnStar can use GPS technology to pinpoint the stolen car's exact location
  - Remote Ignition Block: prevent the stolen vehicle from being restarted once the engine has been turned off.
  - Stolen Vehicle Slowdown: gradually slow down the stolen vehicle to an idle speed
- **Remote Door Unlock**
- **Roadside Assistance**
- **Remote Horn and Lights**
  - If can't locate the vehicle, OnStar advisor will sending a remote signal that triggers its horn and flash its lights

Navigation

- **Turn-by-Turn Navigation**
  - push the OnStar button and tell the Advisor where you want to go, and turn-by-turn directions are downloaded to your vehicle.

Connections

- **Hands-Free Calling**
  - Wireless services built into OnStar-equipped vehicle, for use when call phone is out of reach, out of range or battery low
- **OnStar RemoteLink(TM) Mobile App**
  - Check fuel level, oil life and tire pressure from cell phone
  - Start car or unlock the doors from anywhere

Diagnostics

- **OnStar Vehicle Diagnostics**
  - vehicle can run hundreds of diagnostic checks on engine, transmission, anti-lock brakes and more
  - automatically send driver an easy-to-read email summary, giving the confidence to vehicle
- **Low Mileage Discount**
  - If drive less than 15,000 miles a year, OnStar offer a discount from their cooperative insurance companies

FORD SYNC

Ford SYNC

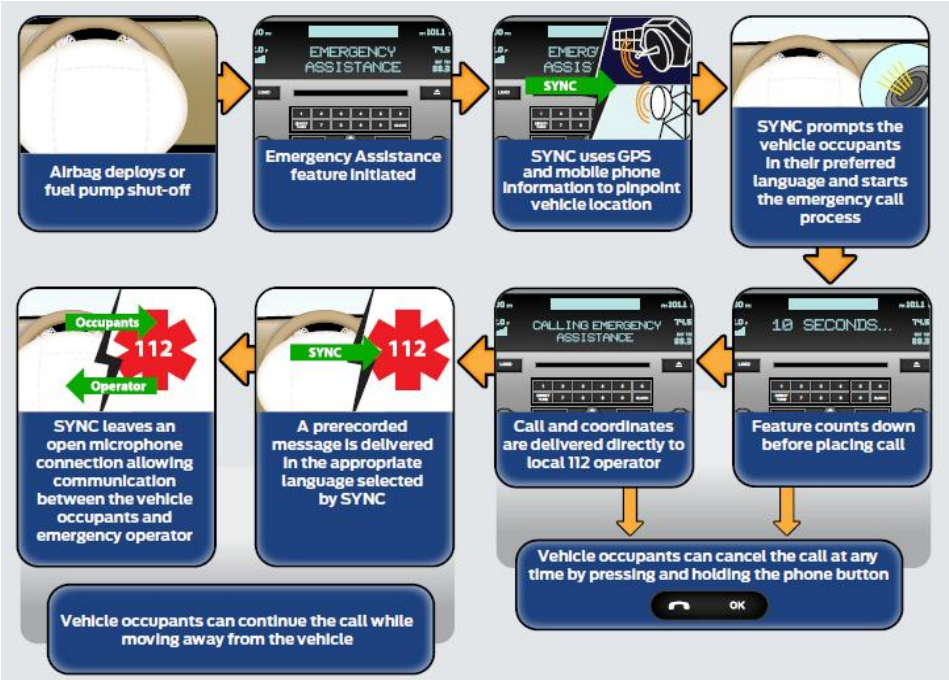
- Developed with Microsoft, is an advanced software platform that provides consumers the convenience and flexibility to bring digital media players and Bluetooth-enabled mobile phones into their vehicles and operate the devices via voice commands or with steering wheel's redundant radio controls.
- In Nov. 2012, Ford announced SYNC had been installed in 5 million cars.

SYNC Powered by Microsoft

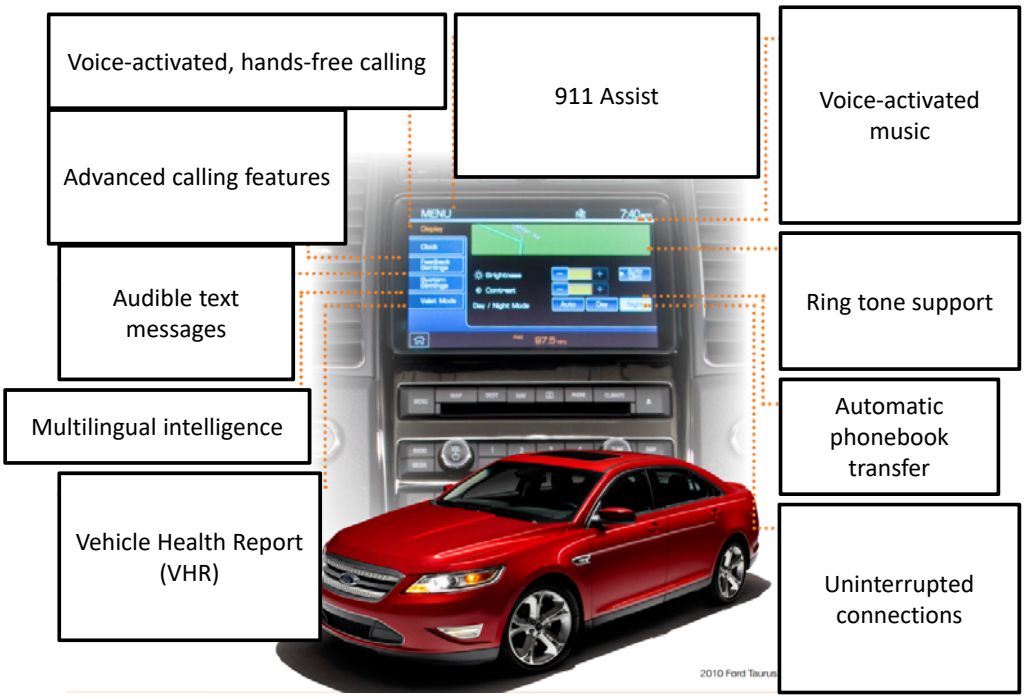
Technology

- Ford uses Microsoft software to read information from user's smartphone while he/she is driving.
- Sync uses user's phone's wireless to connect with outside.
- With Sync, the user are in the middle of an in-car web of communication between he/she, his/her cell phone and his/her Ford Sync head-unit via Bluetooth

How SYNC Emergency Assistance Works



SYNC Features



Features(1/4)

- Voice-activated, hands-free calling
  - Press the “Push to Talk” button on the steering wheel, and then say the name of the person that user wish to call. SYNC automatically will connect with the names in the mobile phone’s contact list.
- Advanced calling features
  - SYNC includes the same features offered on mobile phones, including caller ID, call waiting, conference calling, a caller log, contact list, signal strength icon, and a phone battery charge icon – all conveniently located on the radio’s display screen.

Features(2/4)

- Audible text messages
  - When paired to capable Bluetooth-enabled phone, SYNC will convert text messages from your phone to audio and read them out loud. User can choose to reply from any of 20 predefined responses.
- Multilingual intelligence
  - SYNC is fluent in English, French and Spanish
- Vehicle Health Report
  - To create a health report, SYNC will gather relevant information from the major vehicle control modules and send it to Ford via the customer’s mobile phone. The information automatically is analyzed by Ford, a report is created and notification is sent via text message or e-mail, based on customer preference

Features(3/4)

- 911 Assist
  - When a phone is properly paired, turned on and connected to SYNC- which is designed to happen every time the driver enters the vehicle with his or her cell phone – the system will be ready to assist in placing a call directly to a local 911 emergency operator should an air bag-deploying accident occur
- Voice-activated music
  - SYNC's advanced voice recognition technology means when you are ready to use your phone or digital music player, just speak simple voice commands

Features(4/4)

- Ring tone support
  - SYNC will play personal ring tones for supported phones. If you have configured unique ring tones to identify specific callers, SYNC automatically will play those, too.
- Automatic phonebook transfer
  - SYNC automatically and wirelessly will transfer all the names and numbers in a mobile phonebook
- Uninterrupted connections
  - No need to hang up in the middle of a cell phone call as you enter your vehicle. Simple touch the Telephone Button on the steering wheel, and SYNC instantly will connect to a Bluetooth phone.

GM OnStar versus Ford SYNC

- OnStar has a phone built-in to user's vehicle so user can leave his/her cell phone at home; Sync is a voice-activated bridge between user and user's smartphone while driving
- OnStar gives customers live support with navigation and emergency assistance while with Ford the only thing standing-by is Sync software
- OnStar system comes with built-in GPS capability so in the event of a crash, operators at GM are notified and already know user's exact location. But Sync relies on user's cell phone, if it doesn't have GPS capabilities, the user can only depend on 911 to triangulate the location.

Summary

- Six key IoT/M2M applications are covered in this unit. Major issues exist on each application.
  1. Industrial Automation: Integration of OT (Operation Technology) and IT (Information Technology). Will require cross disciplinary collaboration and expertise.
  2. Smart Grid: Huge investment required to upgrade the existing power grid. However, will be revolutionary in terms of energy management.
  3. eHealth: Liability issues. However, increasingly important due to aging population.
  4. Smart Home: Lack of a unified standard for all home applications. Nevertheless, one of the most promising applications in the near term.
  5. Smart City: There are multiple roles, actors and engagement thus it involves very large scope and complexity.
  6. Connected Car: GM and FORD have achieved good success. However, more applications are required to create momentum.