DIGILE | INTERNET OF THINGS

R&D Activities and Progress Around IoT in Finland

Wilhelm Rauss
Focus Area Director
IoT Program

The 6th conference on Internet of Things and Smart Spaces
What’s happening around the world?

IoT related initiatives in Finland
  - Ubicom Program overview
  - Spearhead Program overview
  - IoT Program overview
    - Background information
    - An attempt to categorize IoT
    - IoT program challenges
    - Selected program activities
    - Program achievements
    - IoT forecast 2010-2020
First (Internet of) Things first: What’s happening around the globe?
German Telekom and French Medria Technologies introduced an M2M solution to monitor cows in real time.

**Products "HeatPhone" and "VelPhone"**

- The **HeatPhone** notifies farmers when cows are ready to conceive so they can improve their herds’ reproduction rate.
- The **VelPhone** warns farmers when cows are about to calf.
- Farmers install a data collector in the stable or in the pasture. Sensors fitted to or in the cows then relay the animals’ vital data to this data collector.
- SMS messages update the farmers.
Samsung is selling a smart Ceramic Oven MC368GAAW5A with smart induction cooktop.

- Programmable and accessible over Android devices
- Cooktop recognizes cookware size, shape and position to deliver heat without boundaries
Two Holiday Inn hotels are testing smart phones as room keys in the US.

- Guests receive before arrival a link for unlocking their room.
- iPhone, Android and Blackberry smartphone applications are used as room keys.
- No need to check-in.
vitaliSHOE developed a smart wearable Insole Gait Analyzing System for Automated Mobility Assessment for elderly people.

- Falls among the older population are one of the most common causes for injuries, frailty and for morbidity. Fall incidents have various reasons and are often related to decreased mobility.
- Sensors determine fall risk indicators in older people’s gait and body movements.
- Emergency services can be alerted automatically.
Limmex developed an emergency watch. Users can request assistance at the push of a button. Press a button and the emergency watch will set up a telephone call.

Hyetis Crossbow connects via Bluetooth, WLAN and NFC with smartphones.

Sony SmartWatch 2 connects via Bluetooth or NFC to a smartphone oder tablet.

Samsung Galaxy Gear with dual core processor makes phone calls, plays games and sends e-mails.
Electrolux, Ericsson join to connect homes

October 15, 2013
Web posted at: 1:12 p.m. EDT (1712 GMT)

by Terho Uimonen

STOCKHOLM (IDG) -- Appliance maker Electrolux and L.M. Ericsson Telephone have announced a new joint venture that aims to deliver its first wired appliances for use in networked homes within one year. The companies said they intend to create a "plug-and-use" infrastructure, allowing household appliances to become networked and connected to the Internet.

Scheduled to start operations this month, the yet-to-be-named company will be owned 50-50 by the two Sweden-based electronics makers, the companies said in a statement. Initially, the partners plan to invest 70 million krona (US$8.6 million) in the venture.

Android Appliances at CES 2013
LG Smart Fridge
This is another "probably" Android smart appliance from LG. Like the Hisense fridge, it's capable of tracking the freshness of your food, delivering recipes and monitoring its energy usage. But this one's a lot more American than the Chinese-only Hisense product.
Welcome to the “Internet of Things,” where even lights aren’t hacker safe

Malware attacks on Internet-connected Philips Hue lights cause blackouts.

by Dan Goodin - Aug 14, 2013, 2:25am +0300

Malware attacks on Internet-connected Philips Hue lights cause blackouts

Japanese Smart Toilet Vulnerable to Hackers

Hackers can take over control of the Satis luxury toilet.

By Stephanie Mlot - August 6, 2013 11:58am EST

Swiss vendor “Saia-Burgess” updates 200,000 of its industrial control systems (heating power plants, major data centers, a prison and a stadium).

“c’t” deckt Sicherheitslücken in Industrieanlagen auf

02.05.2013

Das Internet der Dinge birgt zum Teil gefährliche Sicherheitslücken.
A hacker took over a baby monitor in a home in the US city of Houston, Texas, to spy on a 2-year-old girl, to broadcast obscenities at the child, to swivel the camera so as to watch her shocked parents as they came in, and to then call the parents insulting names.

Ever wanted to ring the bells of a church? For some time that was possible online in Beckum, Germany.

Back to the roots…

Russia orders typewriters to prevent data leaks

The Telegraph reports that the Federal Guard Service (FSO) has placed an order for 20 German-made electric typewriters. The FSO is an agency tasked with Russian communications and President Vladimir Putin's safety.
IoT Related Initiatives in Finland
Ubicom Program Overview
Duration: 2007-2013
Total Budget: 300+ M€
Subprojects: around 380

Research topics

- Ubiquitous computing
- Ambient intelligence
- Internet of Things
- Cyber Physical Systems
- Pervasive computing
- Real World Internet
- Web Squared
Ubicom research projects and pilots

- **Ubiquitous weather services**  
  Finnish Meteorological Institute; various companies

- **Real time monitoring with sensor network fusion**  
  Univ. of Oulu; Ostrobotnia Univ. of Applied Sciences

- **Integrated Ubiquitous Services**  
  VTT Technical Research Centre of Finland

- **Semantic Ubicom services**  
  Helsinki Univ. of Technology

- **Service-based monitoring for industrial ambients**  
  SAMIA; Tampere University of Technology

- **Web-based Service Platform Architecture for Context-aware Mobile Services**  
  VTT Technical Research Centre of Finland

- **Wireless Sensor Networks Field Pilots**  
  Tampere University of Technology

- **Skiing and snow research environment**  
  Univ. of Oulu and Jyväskylä; VTT

- **ShipSensorNet - Ships as a sensor network for observing ice field properties**  
  VTT Technical Research Centre of Finland

- **Mobile media containing value adding services**  
  University of Oulu, MediaTeam Oulu
• Ambient intelligence based on sound, speech and multisensor interaction  
  Tampere University of Technology
• Nomadic Use of a Plant Model  
  VTT Technical Research Centre of Finland
• UbiLife  
  University of Oulu
• Forum Virium Helsinki / Ubiquitous Helsinki  
  VTT Technical Research Centre of Finland
• Personalised Ubiservices in Public Spaces Technology  
  Helsinki University, Helsinki Institute for Information Technology
• Adaptive and energy efficient light control  
  VTT; University of Oulu
• Homecare robot development  
  Tampere University of Technology
• Broadcast information platform  
  Metropolia University of Applied Sciences
• Traffic & logistics multiservice platform SUNTIO2  
  VTT; various companies
• Embedded ICT in new factory pilot applications  
  Central Ostrobothnia Univ. of Applied Sciences; University of Oulu
• Ubiquitous computing in news media  
  Univeristy of Jyväskylä, Tampere and Turku
Spearhead Program Overview
Spearhead Program

Technical Research Centre of Finland

Duration: 2013 – 2016
Yearly Budget: 13 M€ - 20 M€
Subprojects: around 60
Participants: around 150

Research topics

- Global asset management
- Condition-based maintenance of equipment
- Smart Lighting
  - Lights for our well-being
  - Energy control
  - Task based optimal lighting
  - Lighting as a service
  - autonomously reacting nodes
Pedestrian Streetlamp of AthLEDics project

Results:
• 18% - 44% energy savings
• 40% decreased power consumption using presence detection.
• 45% decreased power consumption in snowy circumstances.
• 62% decreased power consumption in the morning due to sunrise (30 min)

Condition-based maintenance of equipment

Wishlist:
• Optimization of production
• Maintenance before breakdown
• Spare part availability
• Smart product life cycle
• Maintenance as an automated service
• …
IoT Program
Overview
[Overview] Setup

- 4-year-program
- Subsidized by the Finnish government
- Program started Q1/2012
- Program ends Q4/2015

**IoT Program**

- Agile Teams
- 3 sprints per year
- More than 250 experts involved
- Estimated program budget (4 years): 50 - 60 million €
- More than 35 consortium partners from industry and research organizations
Overview IoT Program Partners 2012/2013

Big companies
- Elektrobit
- Ericsson
- Finnpark
- F-Secure
- Intel
- Metso
- Nokia
- Polar Electro
- Renesas Mobile
- TeliaSonera

SMEs
- 4G-Service
- Arch Red
- Componentality
- Cybercube
- Finnet Group
- Finwe
- FRUCT
- Laturi
- Mattersoft
- Mikkelin Puhelin
- Mobisoft
- Refecor
- There Corporation

Research Organizations
- Aalto University
- Laurea University of Applied Sciences
- Tampere University of Technology
- University of Helsinki
- University of Jyväskylä
- University of Oulu
- University of Tampere
- VTT Technical Research Centre of Finland
Background Information
Ok, but what is IoT?

What are we actually trying to build?
- A world of heterogeneous things with identities
- Things may have physical and virtual attributes
- Things that are seamlessly and securely integrated into the Internet infrastructure using standard communication protocols

Some of the key technologies
- Radio-frequency identification (RFID)
- Machine-to-machine communication (M2M)
- Wireless sensor and actuator networks (WSAN)
- Ubiquitous computing (UbiComp)
- Web of Things (WoT)

Protocols and standards
- Protocols & standards from traditional Internet & telecommunication fields: WiFi and Bluetooth, Ethernet, 3G and LTE, HTTP, …
- Protocols & standards specifically tailored for things being connected: ZigBee, Z-Wave, 6LoWPAN, RPL, CoAP, …
So let’s connect everything?

Ericsson:

“In the networked society everything that will benefit from a connection will be connected.

The vision is not about connecting things per se but what will happen in society when everybody and everything is connected.”

Urban population is growing fast with many challenges:

› Water
› Energy
› Transportation
› Pollution
› Urban divides
› Public safety
› Health
› Corruption
› Housing
› Jobs

...
An Attempt to Categorize IoT
[Categorization] What can you do with Things?

• One way to categorize IoT
  – The variety of IoT technologies could be conventionally categorized as follows: Tagging of things, sensing of things and embedding of things

• Some of the key challenges
  – The IoT field is still relatively young
  – Development is still dominated silos
  – Incompatible technologies with relatively limited marked penetration
  – Missing standards and legal regulations for: Interoperability, connectivity, access control, service discovery, privacy
  – Need of energy-efficiency
[Categorization] IoT Sectors

- **IoT sectors in a nutshell**
  - Intelligent environments
  - Natural resources and sustainable economy
  - Vitality of people

- **Revenue generation through**
  - IoT applications and service providers
  - IoT platform providers and integrators
  - Telecom operators
  - Software and hardware vendors
  - …

- **Example verticals**
  - Consumer electronics
  - Automotive industry
  - Healthcare sector
  - Smart home suppliers
  - Farming industry
  - Security sector
  - …
[Categorization] Potential Areas of Cooperation

INTELLIGENT ENVIRONMENTS

- Built environment innovations - RYM
  - Metal products and mechanical engineering - FIMECC
  - Energy and the environment - CLEEN
  - ICT industry and services - DIGILE

NATURAL RESOURCES AND SUSTAINABLE ECONOMY

- Forest cluster
  - Health and wellbeing - SalWe

VITALITY OF PEOPLE

- Intelligent services and service platforms
  - Information delivery platforms
  - Entertainment
  - Infotainment

- Elderly care
- Food safety
- Emergency services
- Media and games

- Smart cities
- Safety
- Education
- Mobility, transport and safe traffic
- Information delivery platforms
- Nanotechnology
- Arctic research
- New energy
- Clean tech
- Shipping industry and sea cluster
- Food safety
- Agriculture
- Emergency services
- Media and games

- Intelligent services and service platforms
- Information delivery platforms
- Entertainment
- Infotainment
- Elderly care
- Food safety
- Emergency services
- Media and games
IoT Program Challenges
Program Challenges and Goals

- **Establishing a competitive IoT ecosystem**
  - New revenue models for participating companies in the emerging IoT market.
  - Local ecosystem formed for proof of concept, initial market, and critical mass for international business.
  - Solutions for establishing and sustaining global IoT ecosystems.
  - Develop generic horizontal solutions that can be used across verticals.

- **Creating IoT business enablers**
  - Generate IoT product concepts and prototypes and test them in real-life environments.
  - Supply critical components for IoT proliferation (such as gateway/border router to connect IoT with Internet).

- **Improving Finland’s global IoT visibility**
  - Demonstrate Finnish cutting-edge IoT technology in pilots and prototypes.
  - Impact recognition of Finnish research partners as top-level institutions in IoT domain, high-impact publications.

- **Impacting IoT technology evolution and standardization**
  - Significantly influence IoT standards at IETF, 3GPP, IEEE, W3C, and other relevant forums.
  - Bring IoT technology to pilot implementations (prototypes, showcases, testbeds etc.).
[Challenges] **The Way from Silos to Platforms**

Within 4 years the foundations for new horizontal solutions shall exist!

Goal is to move from silos towards horizontal solutions.
Program Activities
[Activities] Teams

**Leadership Teams**

- **WP 0**: Management
- **WP 1**: Networking and Communications
- **WP 2**: IoT Management
- **WP 3**: Services and Applications Dev. Support
- **WP 4**: Human Interaction
- **WP 5**: Ecosystem
- **WP 6**: Trials and Demos

**XWP**

Activities

- **Activity 1** – Security, Privacy and Trust
- **Activity 2** – Energy Efficiency
- **Activity 3** – Standardization and Architectural Considerations
[Activities] Task Overview

• WP1: Networking and Communications
  – 1.1 Radio technologies
  – 1.2 Networking
  – 1.3 Security, privacy and trust

• WP2: IoT Management
  – 2.1 Adaptive Security
  – 2.2 Network configuration and management
  – 2.3 Enterprise Service Portal

• WP3: Services & Applications Dev. Support
  – 3.1 Integration with Web (task of year 2012)
  – 3.2 IoT data analysis and visualization
  – 3.3 Integration with Social Web
  – 3.4 Collaborative data gathering and analysis
  – 3.5 Data dissemination
  – 3.6 Flow based platform for IoT devices
  – 3.7 End-to-end data transport
  – 3.8 IoT applicability for mHealth and e-Tourism
  – 3.9 Platforms supporting new applications & services

• WP4: Human Interaction
  – 4.1 Co-creation & validation of IoT UI’s
  – 4.2 Interactive environmental aware IoT services
  – 4.3 Usable security for IoT services
  – 4.4 Visualization of IoT services and devices

• WP5: IoT Ecosystem
  – 5.1 IoT Evolution and Diffusion
  – 5.2 IoT value networks vs. technical architectures and platforms
  – 5.3 Business models of IoT firms

• WP6: Trials and Demos
  – 6.1 Home automation pilot in apartment buildings
  – 6.2 Secure and automatic IoT service provisioning
  – 6.3 Communications in Mines
  – 6.4 IoT for Intelligent Traffic System
  – 6.5 New Battery Management System
  – 6.6 Device Connection Platform Test Bed

• XWP – Cross-WP issues
  – 7.1 Security, Privacy and Trust (SPT)
  – 7.2 Energy efficiency issues
  – 7.3 Standardization and architecture issues
Selected Program Achievements
By 2017 the Finnish ICT industry is a recognized leader in the IoT domain due to its expertise in standards, software, devices, and business models integrating various vertical industry segments.

- The program has published or submitted around 70 scientific articles including:
  - Significant contributions to IETF CoAP and HOMENET, IEEE 802.11ah, 3GPP LTE, ...
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<td>Overview of User-centred Quality Assurance Methodologies for Anti-phishing Software and Phishing-resistant Systems</td>
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<td>Modeling Energy Consumption of Data Transmission over Wi-Fi</td>
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<td>On Mobile Vehicular LTE Relay Node Suitability for the Internet of Things</td>
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<td>Delayed Key Exchange for Constrained Applications</td>
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<td>Efficient Small Data Access for Machine-Type Communications in LTE</td>
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<td>A Storage Infrastructure for Heterogeneous and Multimedia Data in the Internet of Things</td>
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<td>Machine-to-Machine Communication with LTE with Reduced Device Energy Consumption</td>
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<td>Impact of MTC on Energy and Delay Performance of Random-Access Channel in LTE-Advanced</td>
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<td>Robust Gravity Component Estimation from Accelerometer Measurements</td>
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<td>Comparing the cost-efficiency of CoAP and HTTP in Web-of-Things applications</td>
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<td>IEEE 802.11ah - An Enabling Technology for Massive Power-Efficient Machine-to-Machine Applications</td>
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<td>Real-Time Traffic Control for Multihomed Devices</td>
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<td>Accelerometer-Based Transportation Mode - Detection on Smartphones</td>
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<td>Combining Sensor Networks with Social Networks by XMPP</td>
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[Selected Achievements] Publications

35 Reciprocal Learning for Cognitive Medium Access
Sensor Integration underlying Cellular Networks through
MC-CDMA and Mobile Sink
36 Techno-economic Feasibility of Multipath Protocols in
Mobile Internet of Things Applications
Techno-economic feasibility analysis of Internet protocols,
Framework and tools
37 Analysis of PDCCH performance for M2M traffic in LTE
Maximizing Timely Content Advertising in Delay Tolerant
Networks
Method for Context-Aware Hot Swapping of Smart-M3
Mobile Agents Based on Dataflow Network Model
Design Challenges of Smart Spaces Deployment in the
Internet of Things
Improving Energy Efficiency in Green Femtocell Networks;
A Hierarchical Reinforcement Learning Framework
IPv6 Addressing Strategies for IoT
39 Link Adaptation Performance Evaluation in IEEE 802.11ah
Throughput performance comparison between IEEE
802.11ah and ZigBee
Extending Monitoring and Accounting Infrastructure
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41 IPv6 Addressing Strategies for IoT
42 3GPP LTE Traffic Offloading onto WiFi Direct
43 Towards Risk-Driven Security Measurement in Android
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Models: State of the Art Report
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Performance comparison between Slotted IEEE 802.15.4 and IEEE
802.11ah in IoT based applications

50 Control, Management, and Off-Load of Real-Time Traffic
for Multihomed Devices
Identification and Authentication for Location Dependent
Contents Delivery
51 Requirements of Secure WSN-MCN Edge Router
52 Business Model Opportunities for the Web of Things
53 Enabling Energy-Aware Collaborative Mobile Data Offloading
for Smartphones
54 Video transmission over IEEE 802.11p - real-world
measurements
55 Distributed Emulation of Heterogeneous Networks and Devices
Deployment of Smart Spaces in Internet of Things - Overview of
the Design Challenges
57 Computing the Retransmission Timeout in CoAP
58 Intelligent Mobile Tourist Guide - Context-Based Approach and
Implementation
59 Transforming SenML Data to Semantic Representations
Towards Risk-Driven Security Measurement in Android
Smartphone Platforms
Internet-of-Things Market, Value Networks, and Business
Models: State of the Art Report
Bundling frames to save energy while streaming video from
LTE mobile device
Stabilizing Multi-Channel Slotted Aloha for Machine-Type
Communications
Energy-Efficient Operation of a Mobile User in a Multi-Tier
Cellular Network
Performance Analysis of Uplink Coordinated Multi-Point
Reception in Heterogeneous LTE Deployment
IoT for Intelligent Traffic System
Real-time event-based information collection from street parking
[Achievements 2012] Research and Prototypes

- Evaluation of cryptographic libraries and algorithms
- Feedback to COAP resource directory and mirror proxy drafts at the IETF
- Research and prototypes for low-power, low-cost sensor networking design for snow environments

- State-of-the-art review of M2M communications in the LTE-context from traffic point of view
- Literature review related to security and energy efficiency of various resources-constrained networks

- World's first implementation of IETF HOMENET technology; a routed network that configures the routing protocols, network prefixes, router advertisements, DNS, and even NAT64 automatically
[Achievements 2012] Research and Prototypes

• General 3D visualization prototype of IoT

  • Sensor data values are mapped to attributes of 3D objects
  • Objects can change their color, opacity, size, velocity etc.
  • Current prototype changes colour of objects
  • Data read directly from providers to 3D visualization
  • Implementation includes a map and a single 3D house
  • Prototype uses power consumption data from There’s sensors
  • Lock status data available from Finwe

• Possibility to move in a 3D environment using a map of the world

• 3D objects are updated based on real data from sensors
  Current prototype has still limited functionality
[Selected Achievements] Ecosystem seeds

• An example use case from the IoT program (Renesas Mobile)
[Selected Achievements] Ecosystem seeds

• There Gate – Finwe Key2phone – Interoperability

• ThereGate™ is designed to help households use energy more intelligently and reap the benefits of things like smart metering.

• As an example the power consumption of watching TV is measured and delivered via ThereGate to the visualisation server.

• Compatibility with partner components, like Finwe’s Key2phone™ - Mobile Access Solution
[Selected Achievements] **Ecosystem seeds**

- **Ericsson Device Connection Platform**
  - DCP is a cloud service enabling operators to offer connectivity management to enterprise customers.
  - DCP is a dedicated M2M platform to handle connectivity management, subscription management and allows for automation of the business processes between the operator and enterprises.
  - The platform supports enterprises’ business critical communication for a high number of devices and applications in a wide range of industry verticals efficiently.
[Achievements 2012] High Definition Positioning in New Service Domains

- Implementation of a positioning pilot in a warehouse environment to evaluate the applicability of High Accuracy Indoor Positioning (HAIP) to track the location of vehicles such as mobile robots or forklifts.

- A mobile robot equipped with HAIP beacon estimates the location of stationary tags. The location accuracy is illustrated by red error vectors pointing from the true tag locations (red boxes) to the estimated locations.

- The work includes a feasibility study of the new positioning approach where the vehicle location is estimated by installing the HAIP tags to the ceiling of the warehouse and the HAIP beacon to the vehicle.

- Required software components were installed to integrate HAIP to mobile robots running Robot Operating System (ROS).

- Two mesh networks routing protocols were tested.
Security Analysis: Adaptive Security and Privacy in IoT

- IoT encompasses an ever-growing list of connected devices, which – if unsecured – pose a threat to utilized networks.
- With security and privacy mechanisms and networking standards we can ensure security of nodes, their data, and the networks in which they participate, as well as appropriate preservation of end-user privacy.
- IoT security and privacy issues were elaborated.
- Techniques supporting better security effectiveness of IoT environments, such as risk-driven security objectives, security control, security metrics development and adaptive security management are presented.
- Appropriate security effectiveness and efficiency metrics are utilized in the development of better security solutions.
- The background of authentication, authorization and identity management was elaborated.

Example overall structure of an IoT environment [ISO/IEC FDIS 29180], USN = Ubiquitous Sensor Network, SCM = Supply Chain Management, NGN = Next Generation Network
The report analyzes IoT market segments, their size and growth.

It summarizes the development of radio-frequency identification (RFID), machine-to-machine (M2M) communication and machine-type communication (MTC), wireless sensor and actuator networks (WSAN), ubiquitous computing, web-of-things (WoT) etc.

Domain-specific applications and their specific requirements for automotive/transportation applications, digital home and consumer electronics, automated meter reading, residential security and various healthcare solutions were elaborated.

The report gives a detailed comparison of wireless protocols (NW topology, range, frequency, interoperability, layers, data rates, ...) 

It analyzes IoT ecosystems: the role of platforms, standards and open interfaces and gives examples of IoT ecosystem cores.

Business models of IoT firms are described (technical perspective vs. business perspective).
Various pilot vehicles were connected to a regional test bed in Tampere.

In this pilot intelligent vehicles communicate via IEEE 802.11p WiFi, cellular LTE/3G and other possible radio channels.

The current pilot user interface can display:

- taxis (blue dots) collecting traffic information,
- busses (green dots if they are on time or red dots if they are delayed)
- a road weather station (brown)
- additional meta information

In addition, two sensor equipped cars (Nissan and BMW) provide even more sensor data than the taxis.

The ITS pilot will undergo testing and further development during 2013. A mobile version of the application will be developed.
IoT Report Regarding an Energy-efficient IoT Security Architecture

• The study describes generic security and privacy threats of IoT environments (lower-level threats, cross-level threats and privacy threats).

• State-of-the-art of the security issues of IoT associated with energy consumption and energy efficiency are addressed.

• Authentication, Authorization and Identity Management is described.

• The study lists a large number of security threat types (Cloning of things, malicious substitution of things, eavesdropping attacks, man-in-the-middle attacks, firmware replacement attacks and many others)

• The Energy vs. security and privacy analysis focuses on security issues associated with energy consumption. Primarily it concerns numerous encryption algorithms and key distribution and management issues.

• Moreover, the document describes what kind of security issues are being considered in 3GPP (3rd Generation Partnership Project) in the context of Internet of Things.
IoT Forecast 2010-2020

• Prediction of connected devices worldwide
  – Amount of connected devices in billions

• How about the revenues?
  – M2M communication generates more than 700 billion EUR in revenues by 2020
  – M2M market is expected to be the largest submarket within IoT market
  – Some verticals with possible double-digit growth in the upcoming years
    – Most prospective verticals in terms of the growth rate and revenues are:
      o **Consumer electronics** (revenue opportunity $B445)
      o **Automotive** (revenue opportunity $B202)
      o **Healthcare** (revenue opportunity $B97)
      o **Intelligent buildings and utilities** (revenue opportunity $B36)

• Expected revenue growth in different M2M vertical segments

Global revenue forecast 2011-2015 (Machina, M2M Global Forecast & Analysis)
Thank you!

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