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Internet of Things Program

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Topics

- Motivation
- IoT program overview
- IoT program challenges
- Selected program activities
- Program achievements

[Background] Ok, but what is IoT?

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- **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, …***

[Categorization] What can you do with Things ? DIGILE | INTERNET OF 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

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- **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
  - …

[Forecast] Market Predictions 2010 – 2020

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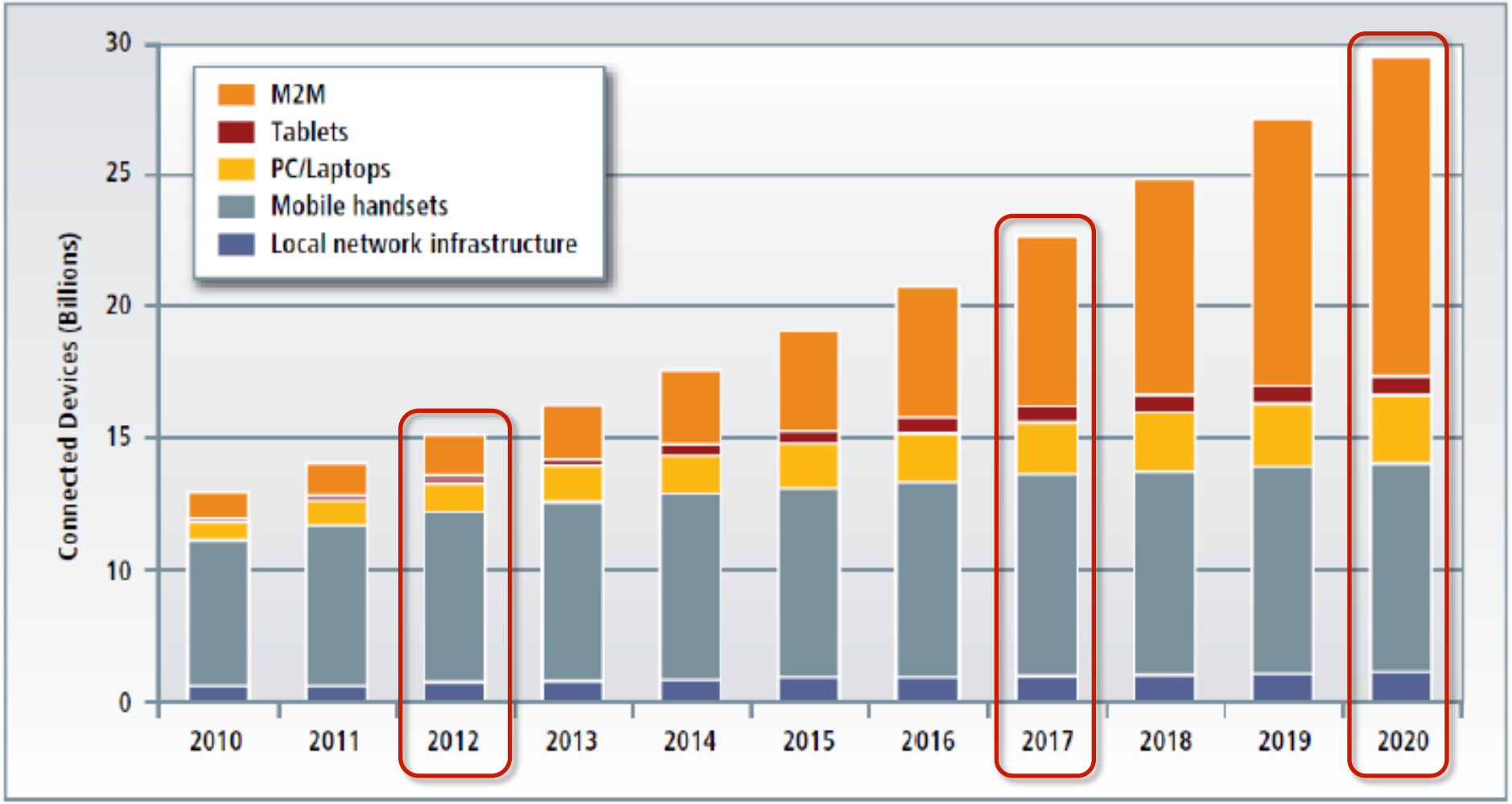
- **Prediction of connected devices worldwide**
  - Amount of connected devices in billions



[Forecast] Market Predictions 2010 – 2020

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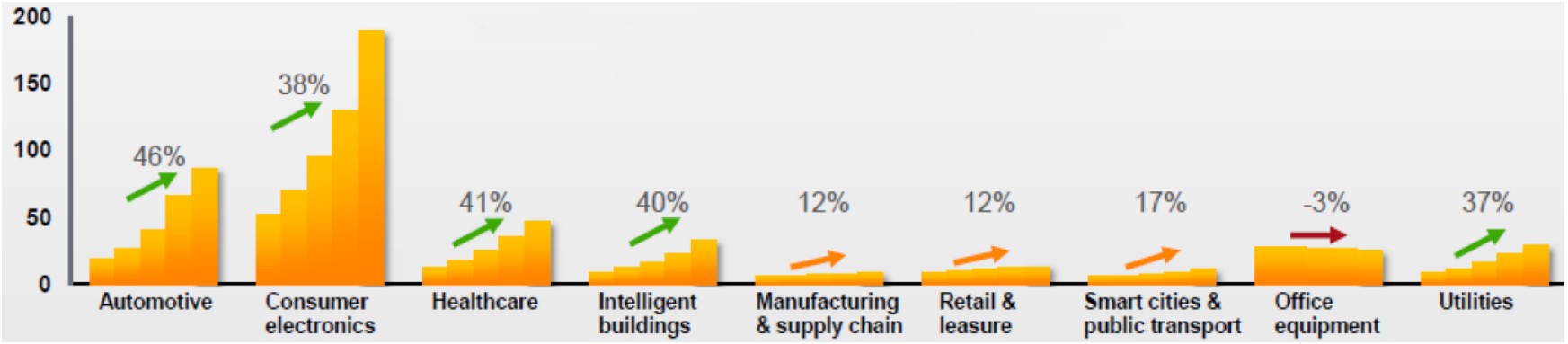
- **How about the revenues?**
  - M2M communication generates more than 700 billion EUR in revenues by 2020
  - M2M market is expected to be the largest submarket within IoT market
  - Some verticals with possible double-digit growth in the upcoming years
  - Most prospective verticals in terms of the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

IoT Program Overview

[Overview] Setup

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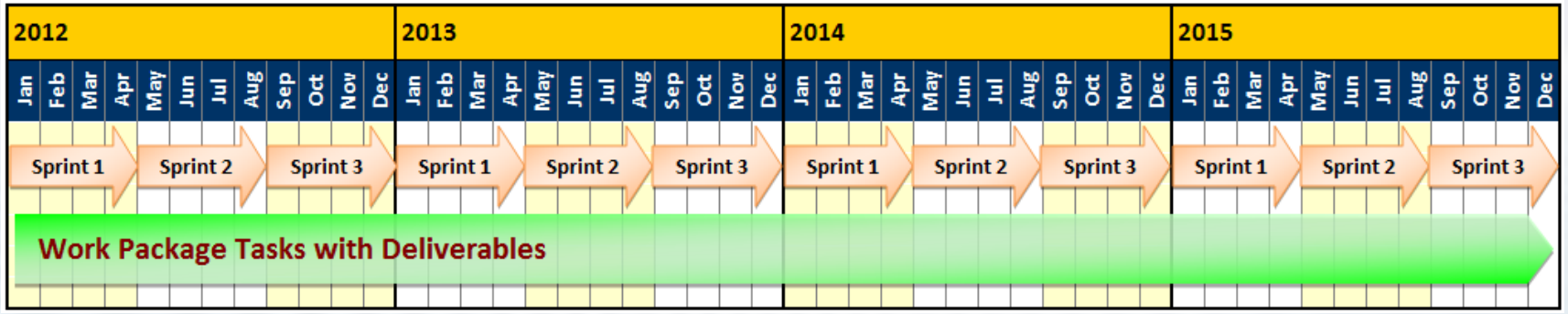
- 4-year-program
- Subsidized by the Finnish government
- Program started Q1/2012
- Program ends Q4/2015



- 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

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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

[Overview] Vision

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IoT Program Challenges

[Challenges] Program Challenges and Goals

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- **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

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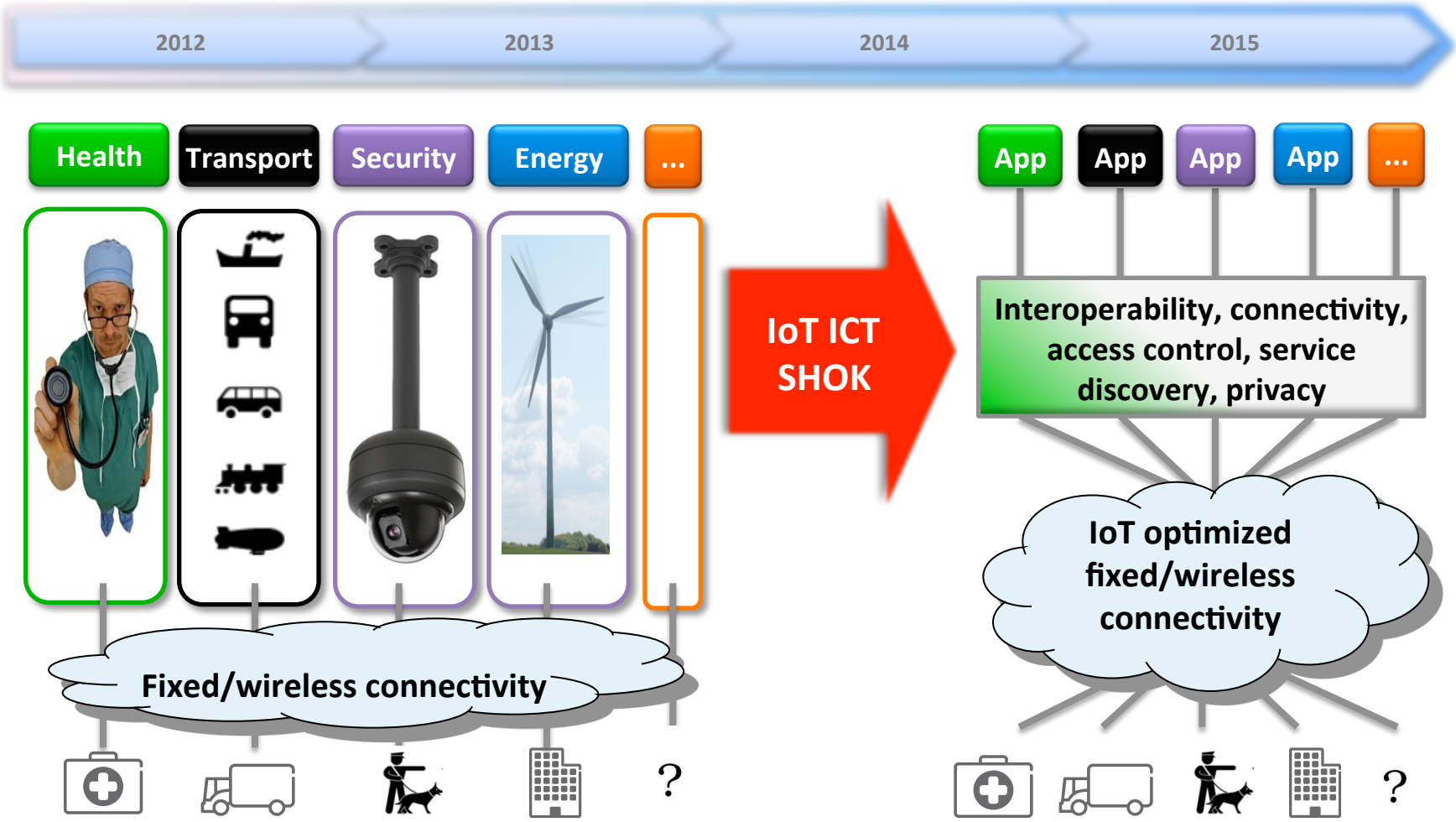

Within 4 years the foundations for new horizontal solutions shall exist!
Goal is to move from silos towards horizontal solutions.

Program Activities

Technical view to IoT

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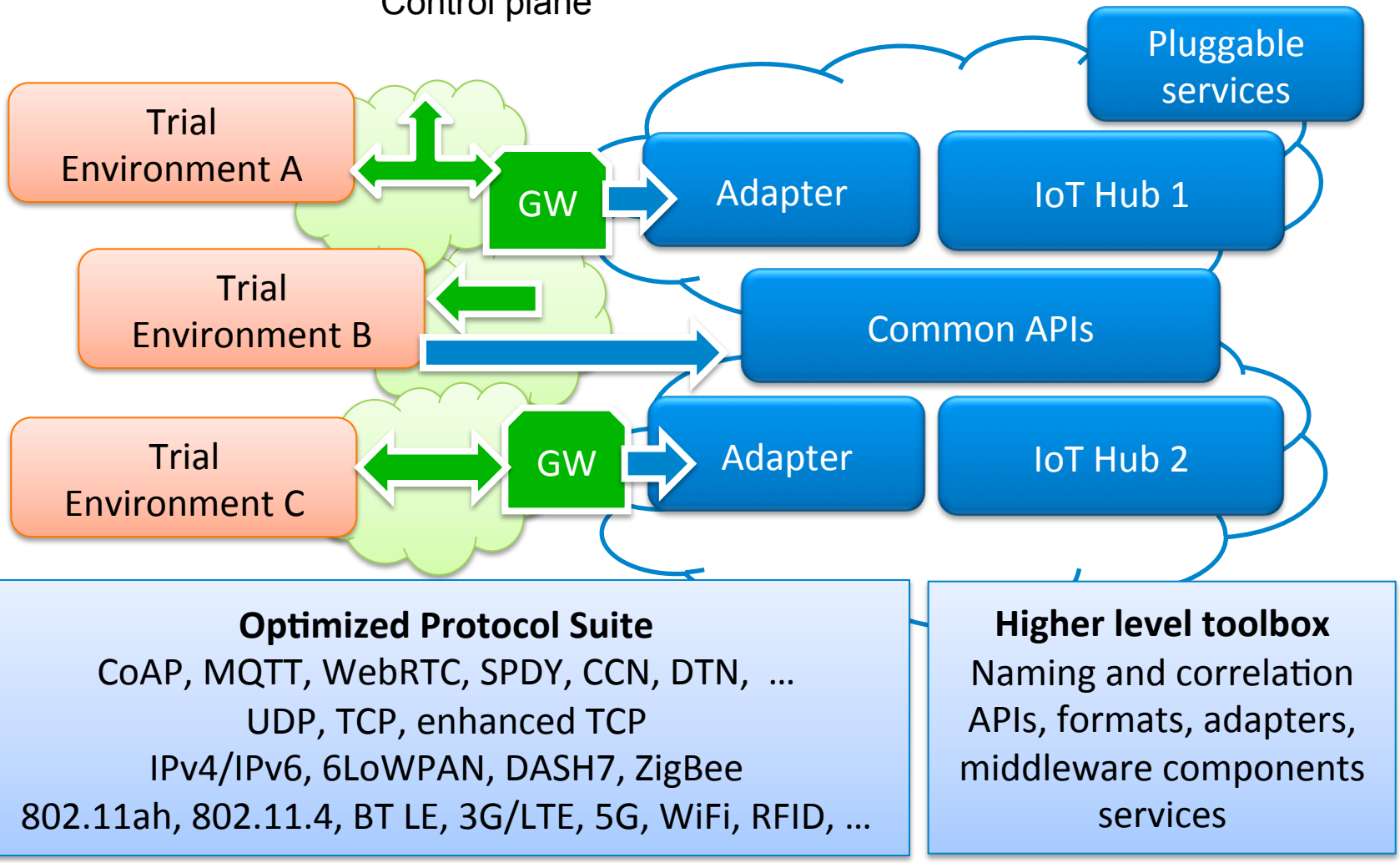

[Activities] Teams

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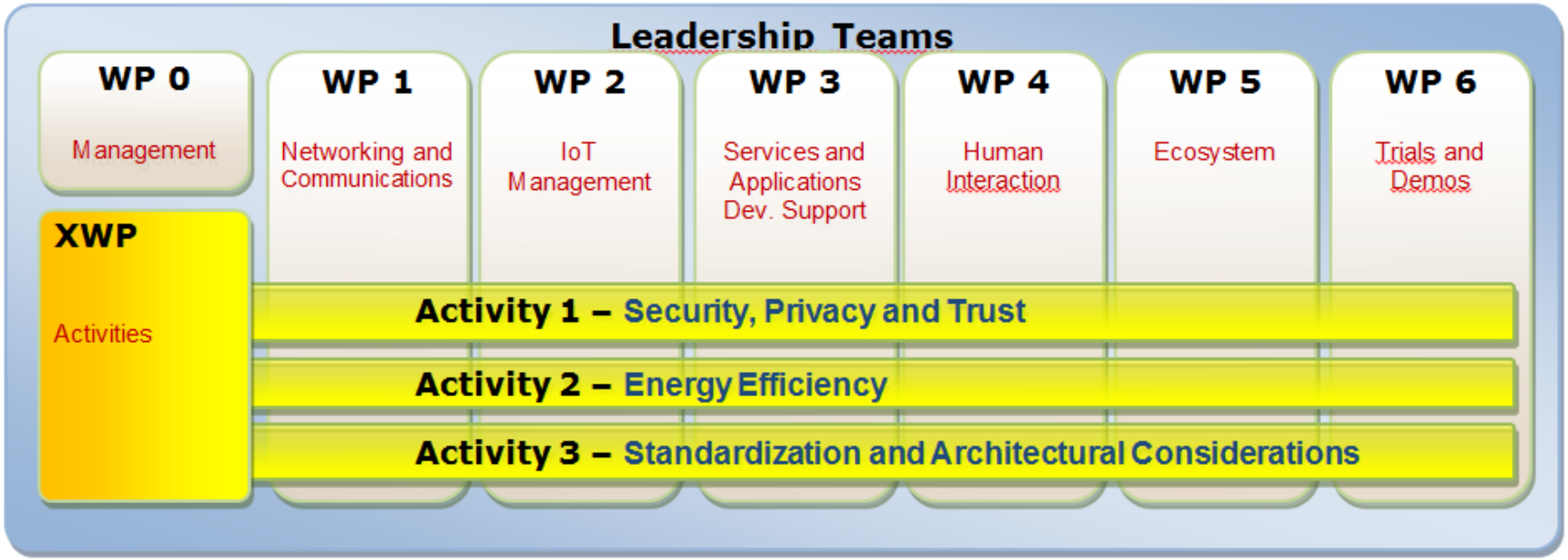

[Activities] Task Overview

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- **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

[Selected Achievements] Publications

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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:*
- *IEEE Communications, IEEE Transactions on Mobile Computing, IEEE SECON, ACM SIGCOMM workshop on Mobile Cloud Computing, IEEE Globecom workshop on IoT, ACM ExtremeCom, …*
- *Significant contributions to IETF CoAP and HOMENET, IEEE 802.11ah, 3GPP LTE, …*

[Achievements 2012] Research and Prototypes

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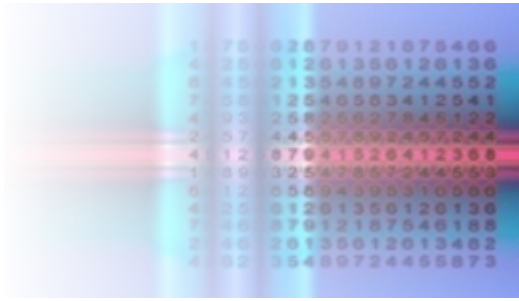
- Evaluation of cryptographic libraries and algorithms
- Feedback to COAP resource directory and mirror proxy drafts at the IETF
- Research and prototypes for low-power, low-cost sensor networking design for snow environments



- 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

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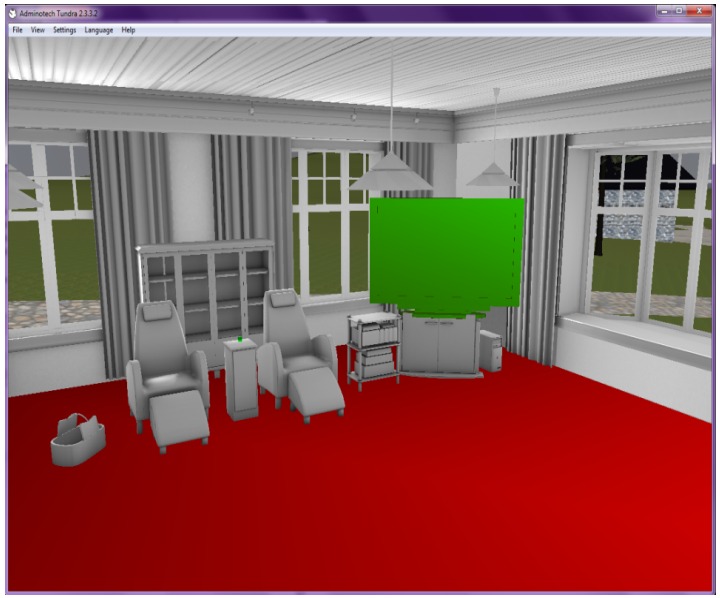
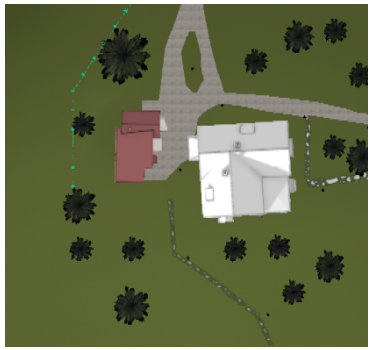
- General 3D visualization prototype of IoT



- 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

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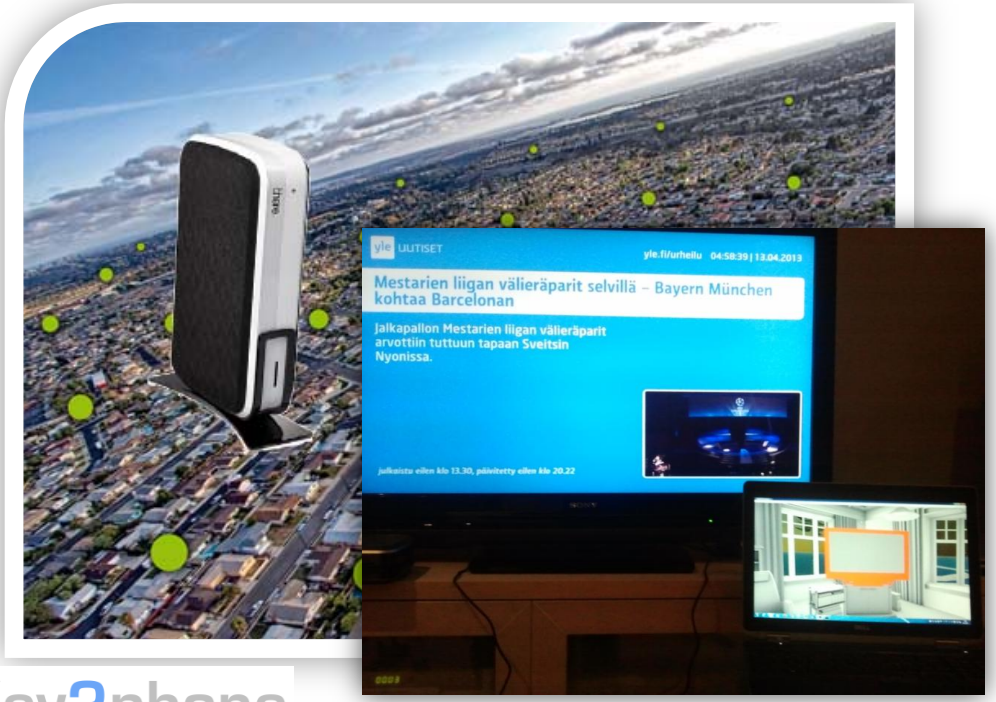
- **There Gate – Finwe Key2phone – Interoperability**

- 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

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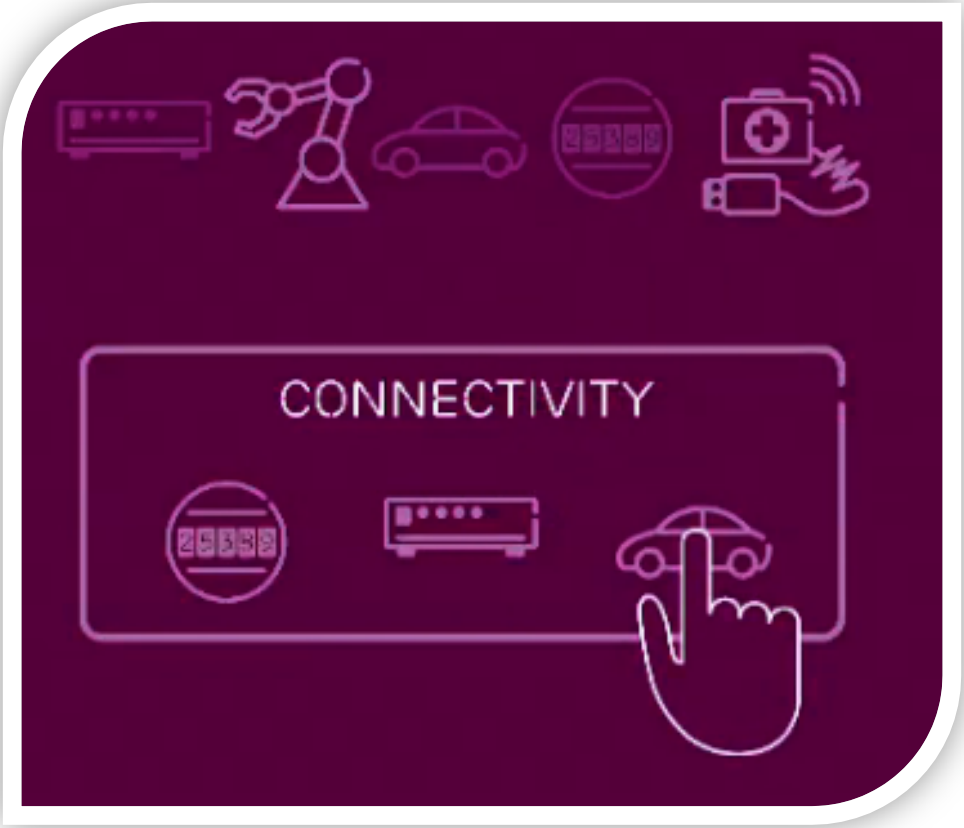
- **Ericsson Device Connection Platform**

- 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

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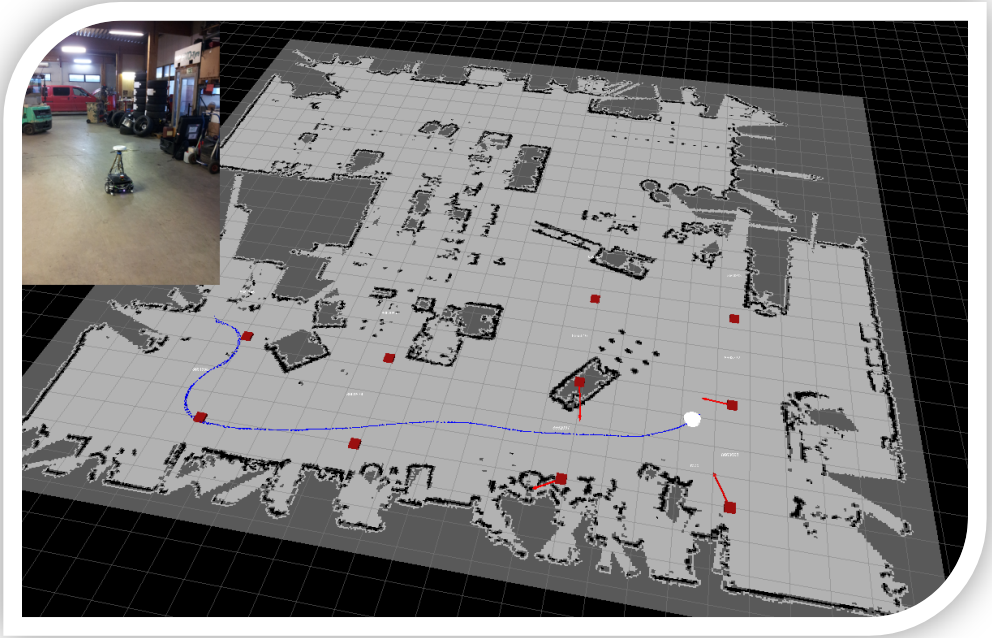
- Implementation of a positioning pilot in a warehouse environment to evaluate the applicability of High Accuracy Indoor Positioning (HAIP) to track the location of vehicles such as mobile robots or forklifts.
- A mobile robot equipped with HAIP beacon estimates the location of stationary tags. The location 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.

[Achievements 2012] SOTA: The State of the Art Report

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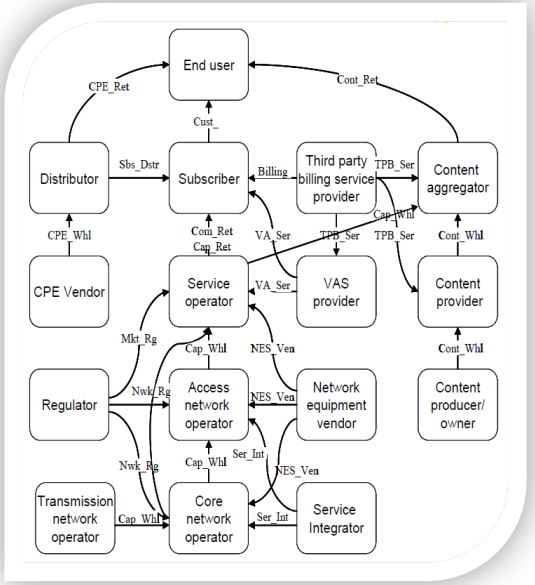
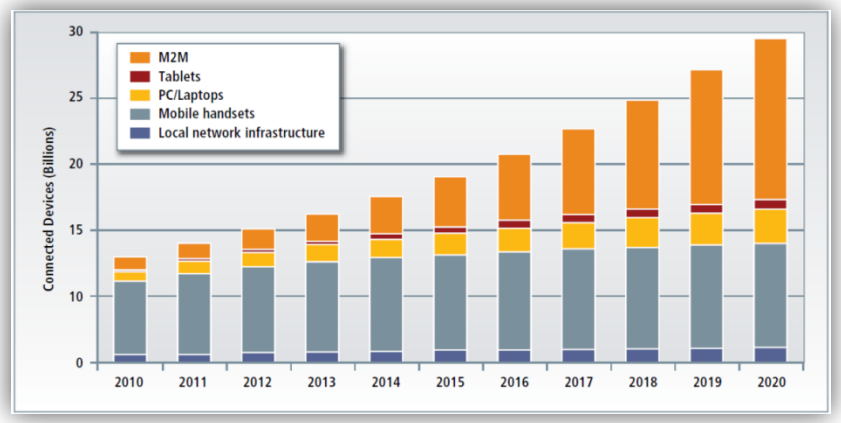
- The report analyzes IoT market segments, their size and growth.
- It summarizes the development of radio-frequency identification (RFID), machine-to-machine (M2M) communication and machine-type communication (MTC), wireless sensor and actuator networks (WSAN), ubiquitous computing, web-of-things (WoT) 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.



Typical roles in telecommunications business and their relationships

- 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).



Number of connected devices

[Achievements 2012] Towards an Intelligent Traffic System „The ITS Pilot"

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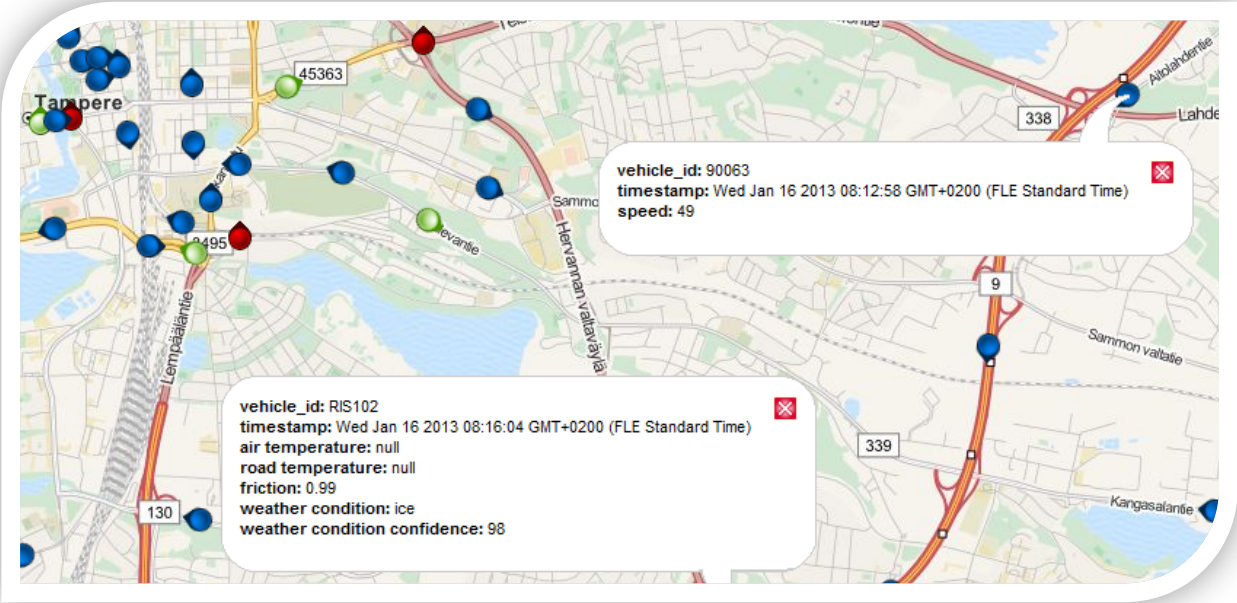
- Various pilot vehicles were connected to a regional test bed in Tampere.
- In this pilot intelligent vehicles communicate via IEEE 802.11p WiFi, cellular LTE/3G and other possible radio channels.
- The current pilot user interface can display:



→ taxis (blue dots) collecting traffic information,
→ buses (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.

Thank you!

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