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Semainaire “Objects connectés industriels, M2M, réseaux”

June 12th, 2014

IoT et Smart Cities: comment passer à l’échelle

Paolo Medagliani (paolo.medagliani@thalesgroup.com)

Agenda

- IRIS and smart cities
- Overview on smart cities
- Technical contributions for going large-scale with actual IoT solutions
- Concluding remarks

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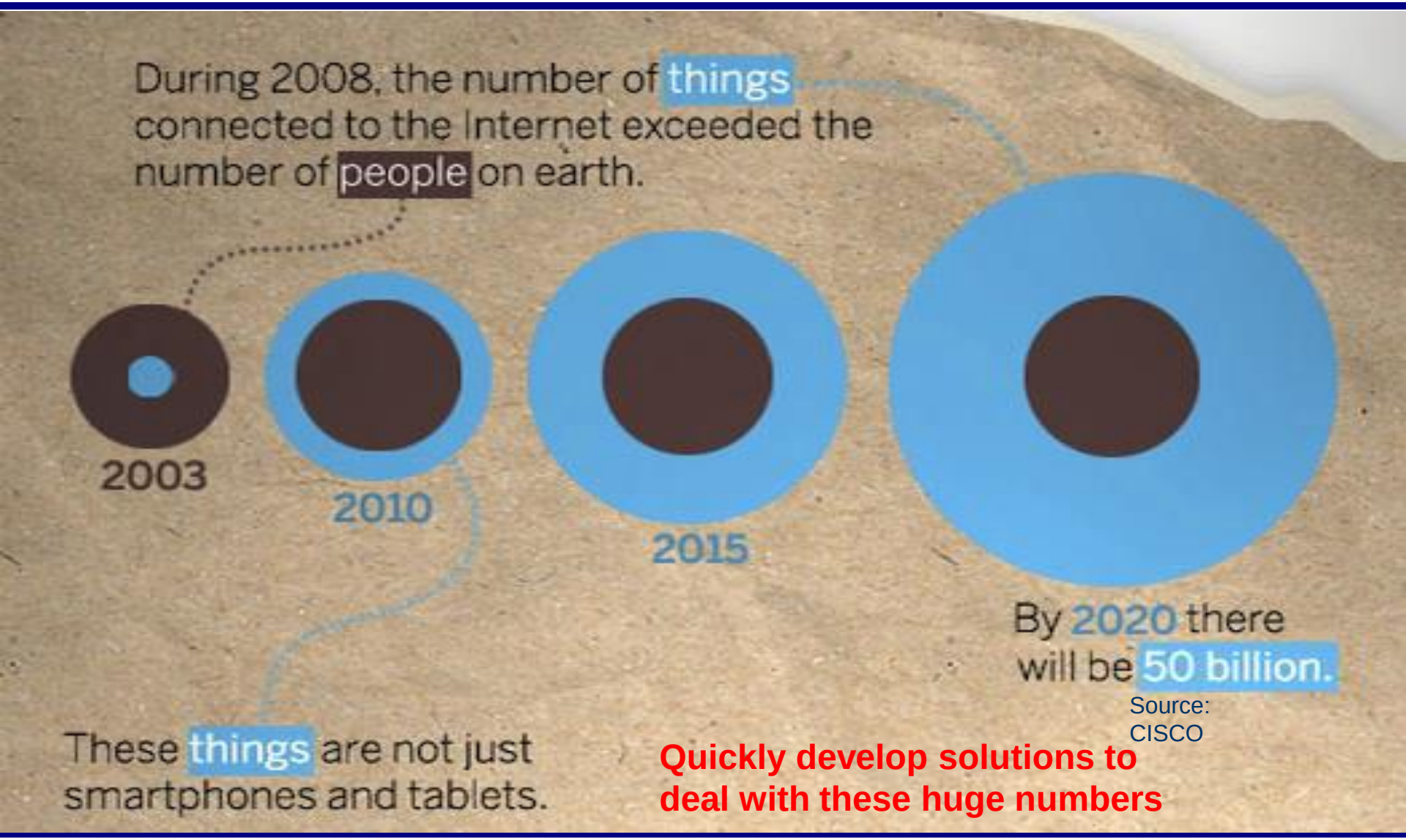
IRIS Consortium

- All IP Networks for the Future Internet of Smart Objects
- Financed by the ANR
- KO in January 2012 (duration of 3 years + 1 year extension)
- Partners
  - Thales Communications & Security (coordinator)
  - ST Microelectronics
  - Sen.se
  - Grenoble Institute of Technology
  - University of Paris 6, LIP6 Laboratory
  - Conectus, Icube Laboratory

IoT is growing fast



Source: CISCO

Quickly develop solutions to deal with these huge numbers

Behind the Smart Cities

Challenges: optimize business processes

Natural disasters threats

Transport systems

Utilities

Public safety

Opportunities

Security

Data networking

Smart metering

Big data

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How Smart cities are classically structured?

Command Center & Information System

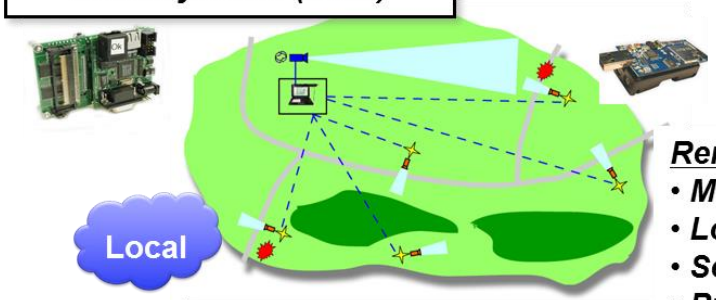
C4I systems

- *Cartography (Widget view on charts, Incident logs, Video streaming)*
- *Device management*
- *Deployment assistance*
- *External data integration*
- *Data intensive processing*

Global

Connected devices

Local systems (WSN)



Local

Deployable/Small Sensors

Remote devices

- *Multi-hop ad hoc network*
- *Low power operations*
- *Self-configuration*
- *Push & Pub-sub communication*

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Where do we stand now?

Consortium and organizations for standardization

- IETF and oneM2M, IPSO are pushing towards the definition of
  - A system architecture
  - Some standards for Wireless Sensor Networks

Some “isolated” solutions

- Actually some solutions need for a gateway that translates data between the Internet and the internal protocols

Web for data exchange

- Web is the solution for interoperability and data exchange between remote entities

Need for new business models

- Data collected must be made available to other entities to create new services

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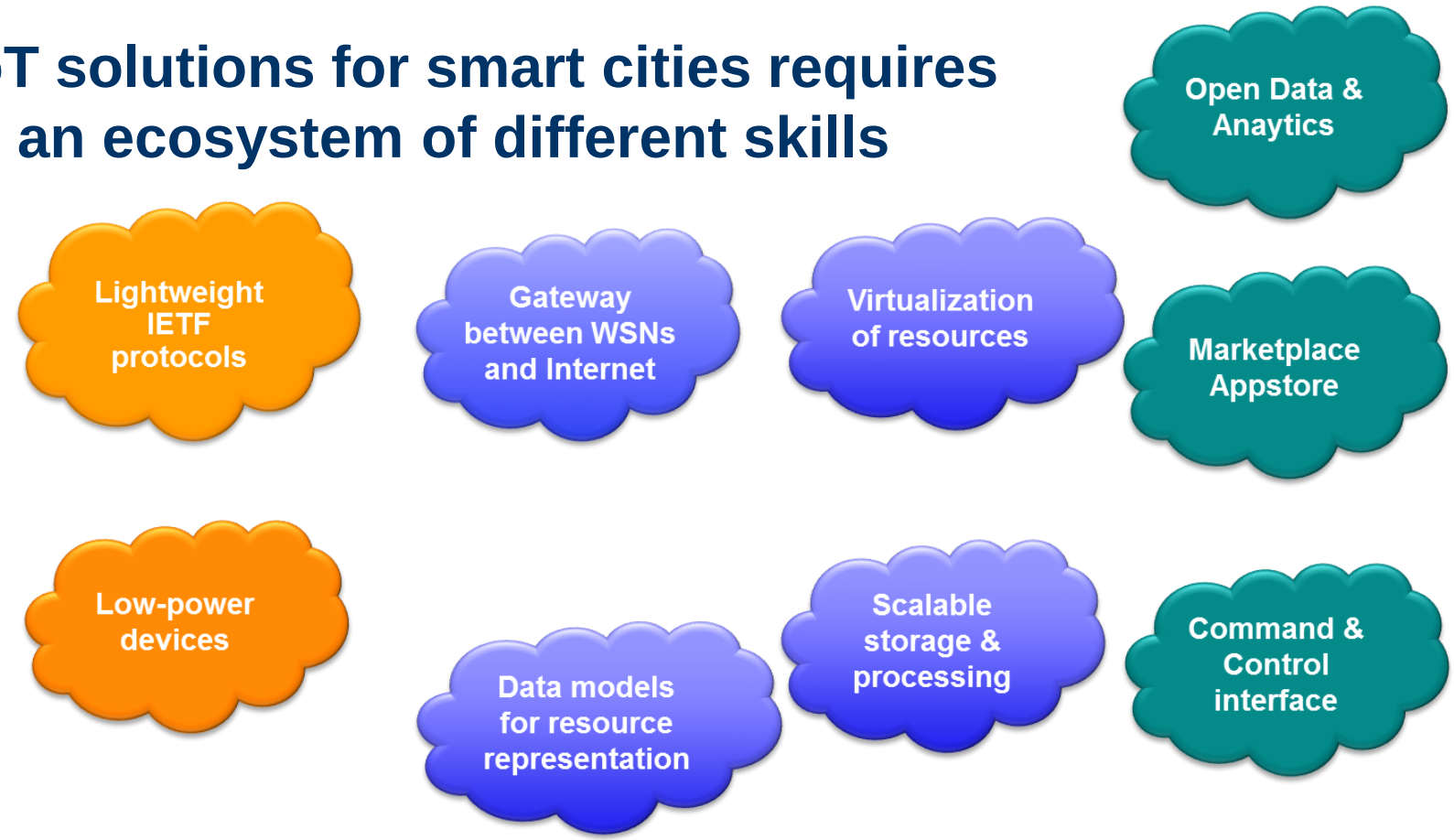
Smart cities as an ecosystem

IoT solutions for smart cities requires an ecosystem of different skills



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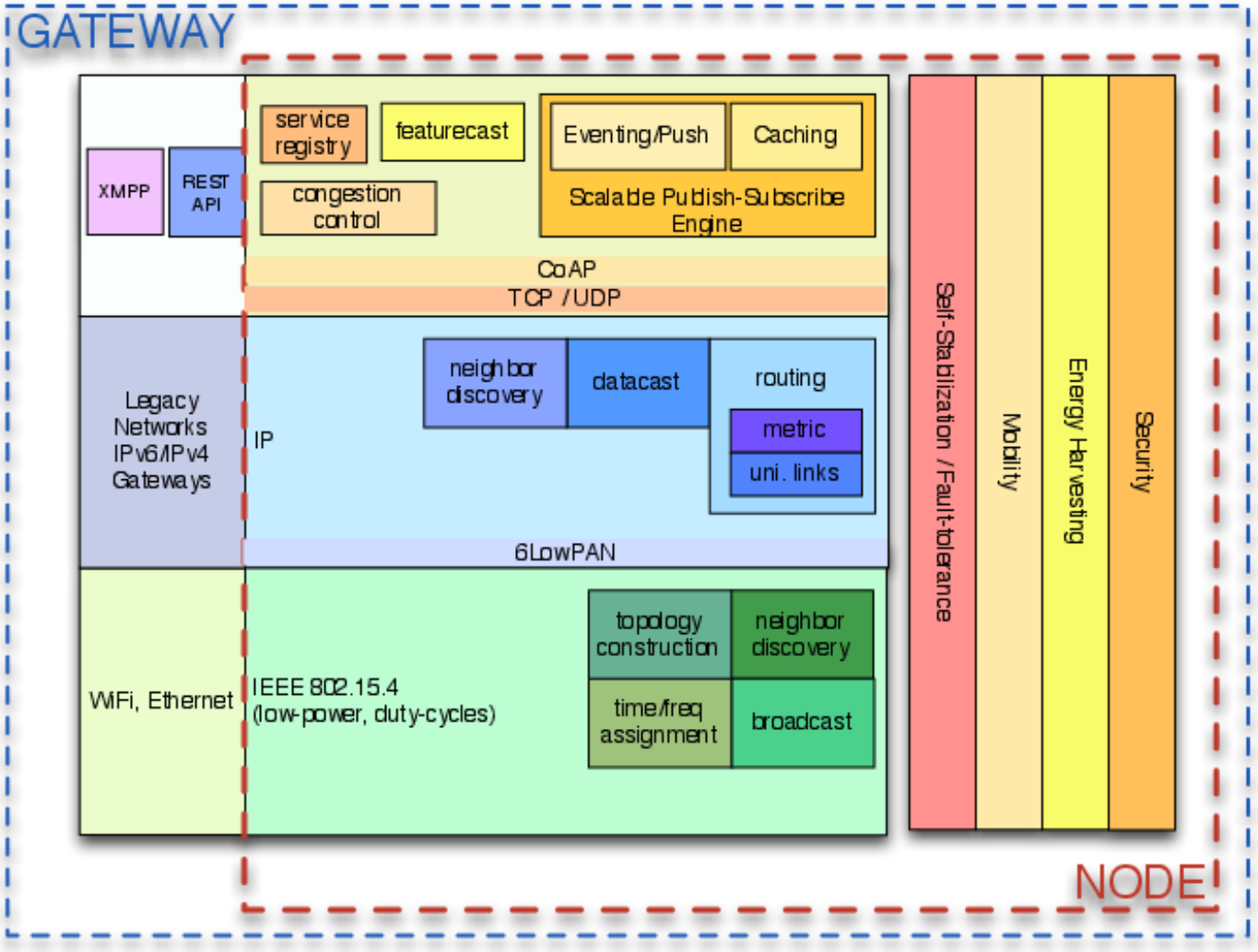
Node architecture for Smart Cities …



Impact on:

- Energy efficiency
- Delay
- End-to-end data transfer

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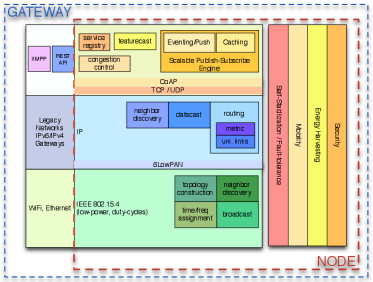
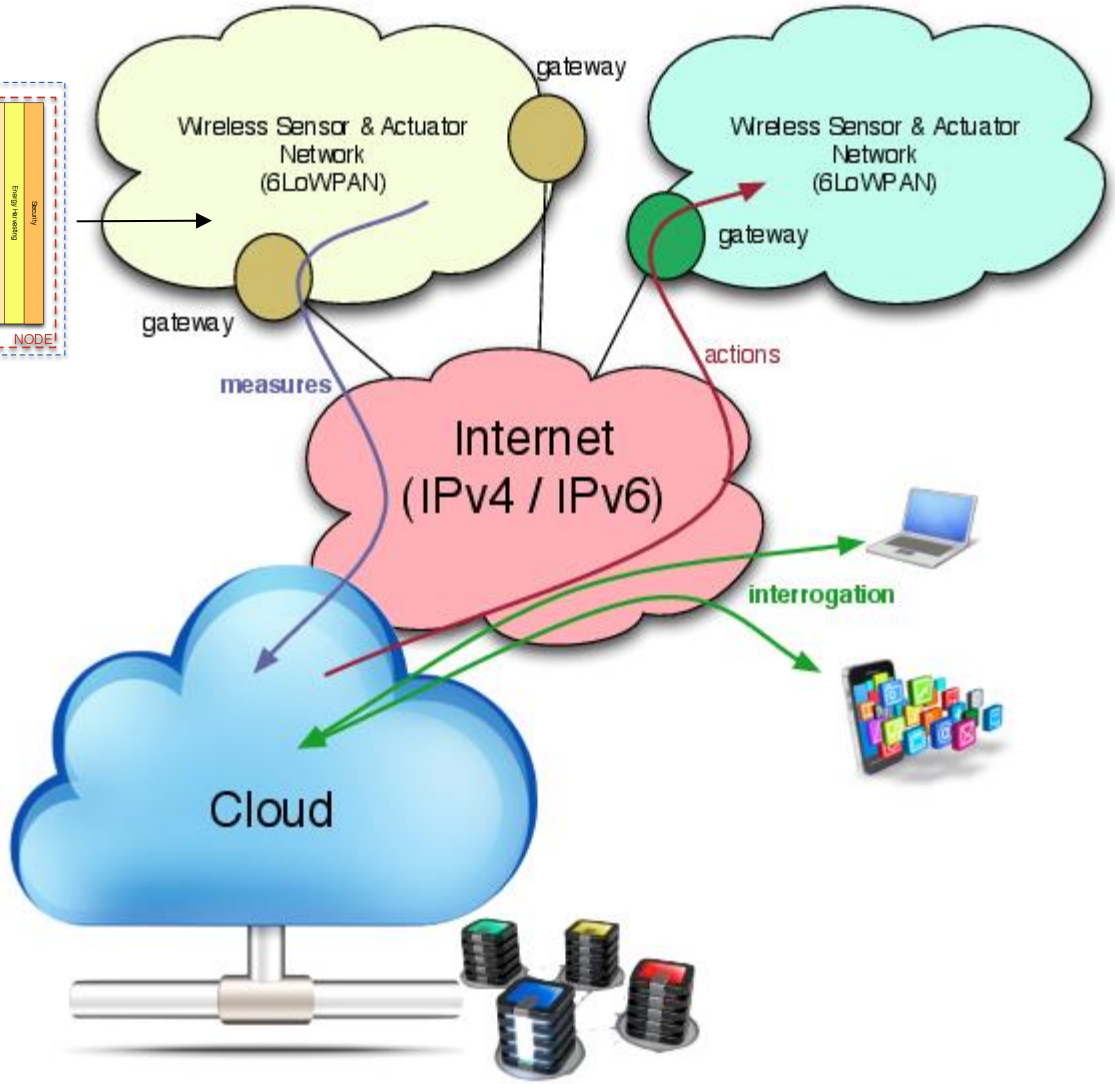
… and system architecture





Impact on:

- Resource location
- Resource availability
- Applications provisioning

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Technical needs for Smart Cities

- Security
  - Prevention against cyber attacks, confidentiality, integrity
- Large-scale information management
  - How to reuse data? How to locate resources?
- Resilience and fault tolerance
  - In case of problems, system must auto-reconfigure to provide service continuity
- Interaction between Internet and constrained devices
  - Different paradigm and different type of approach
- Standardization
  - Having standardized solutions open the interoperability with existing systems

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A lot of unsolved question marks

Research on top of
- Hardware
- MAC and routing protocols
- Data aggregation
- Service discovery and location
- Data provisioning

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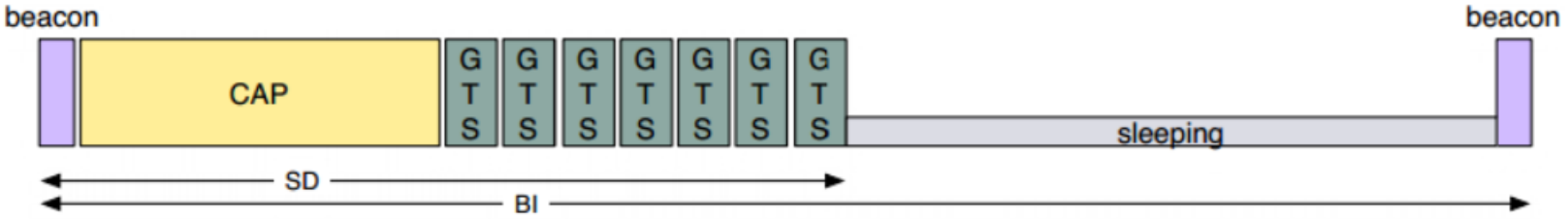
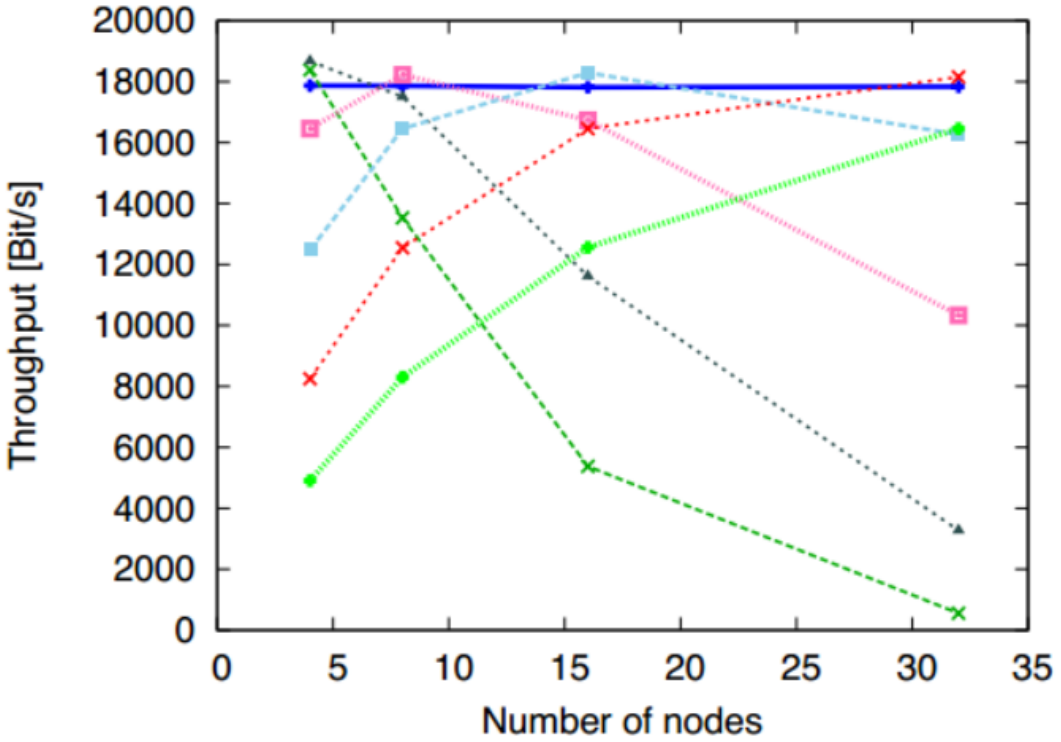
Beaconed 802.15.4



- Problem: self-adaptation
  - parameters of IEEE 802.15.4
  - nb of CCA, retransmissions → simple
- The Backoff Exponent depends on
  - Traffic intensity
  - Number of contenders
- Self-adaptive method
  - model “a la” idle sense
  - Heuristic
    - Periodic and Poisson traffic
    - Each coordinators computes and pushes the optimal value



Nazim Abdeddaim, Fabrice Theoleyre, Martin Heusse, Andrzej Duda: Adaptive IEEE 802.15.4 MAC for Throughput and Energy Optimization. DCOSS 2013: 223-230

IPv6 Routing Protocol for Low-power and Lossy Networks

- Creates a Destination-Oriented Direct Acyclic Graph (DODAG)
- Optimized for multipoint to point traffic flow

Periodic transmission of DODAG Information Object (DIO)

- Broadcasted by the root
- Trickle timer to adapt the transmission frequency

Objective function for the determination of the rank in the DODAG tree

- LQI: link quality indicator
- ETX: expected transmission count
- MinHop: minimum number of hop between source and destination

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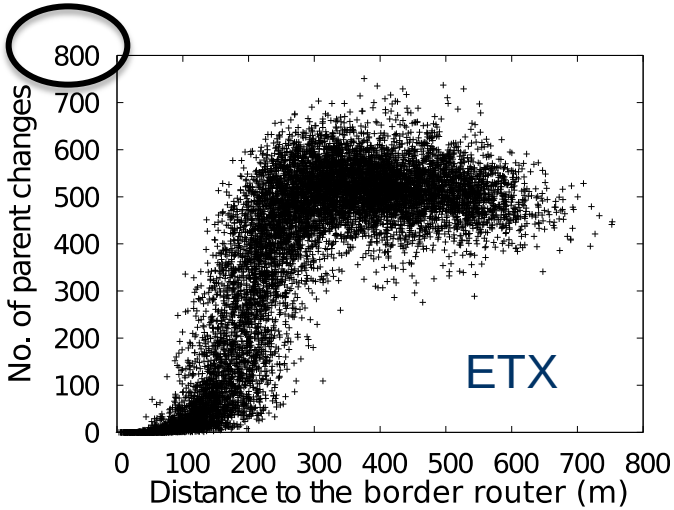
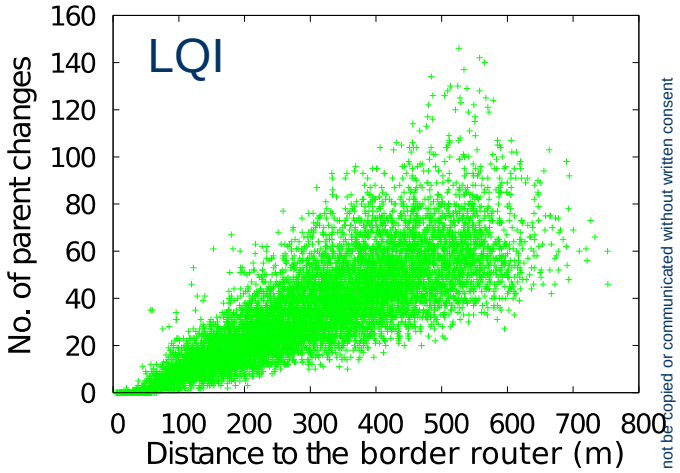
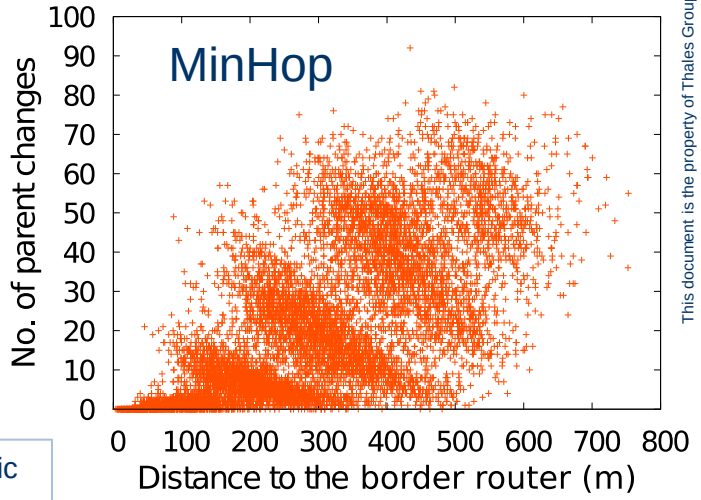
Scaling RPL

- Strong correlation between Packet Delivery Ratio and distance
  - Minhop performs poorly (as expected)





- The metric deeply impacts the stability (ETX → worse instability)
- Limited scalability
- Next: efficiency AND stability
  - Statistical estimator
  - Stabilizing mechanisms



Oana Iova, Fabrice Theoleyre, Thomas Noël: Stability and efficiency of RPL under realistic conditions in Wireless Sensor Networks. PIMRC 2013: 2098-2102

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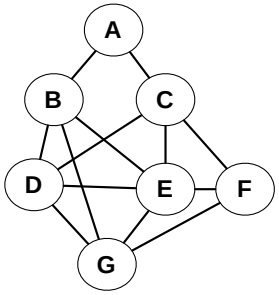
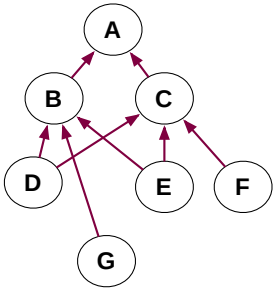
Topology control

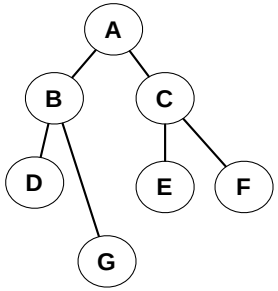
- IEEE 802.15.4, 2 modes
  - meshed but no energy savings
  - Low duty-cycle but a tree
- RPL : a DAG
  - Over a tree → no redundancy



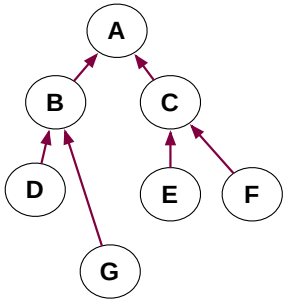
IEEE 802.15.4 non-beacon



RPL + IEEE 802.15.4 non-beacon

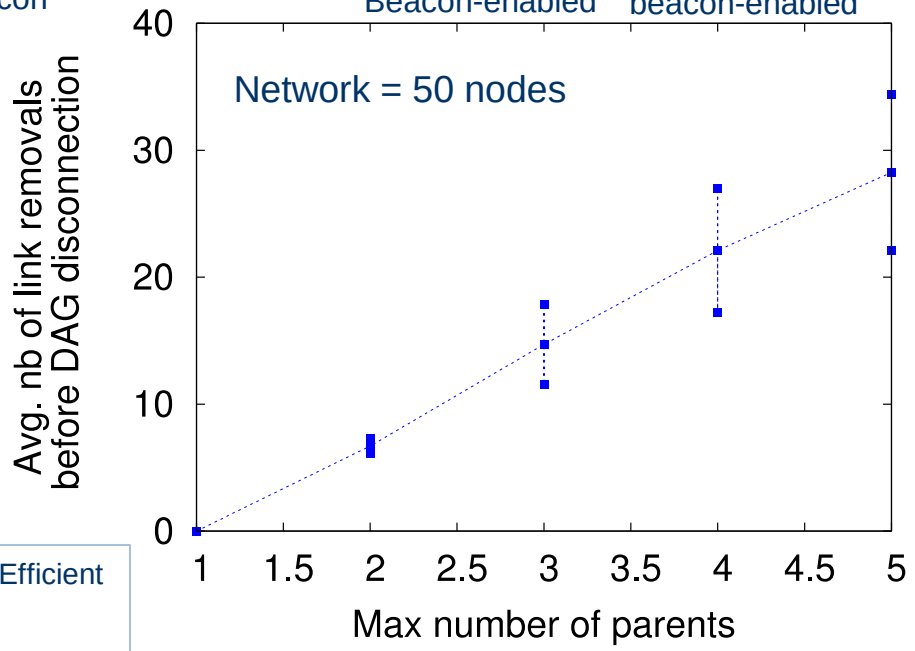


IEEE 802.15.4 Beacon-enabled



RPL + IEEE 802.15.4 beacon-enabled

- Proposed to create cluster-DAG
  - Several parents to follow
  - Scheduling appropriately the active periods to avoid overlaps
  - Larger throughput, larger reliability
- Multipath
  - Delay-aware forwarding
  - Deadline is close → choose an expensive parent with a quick forwarding
  - Deadline is far → saves energy



Bogdan Pavkovic, Andrzej Duda, Won-Joo Hwang, Fabrice Theoleyre: Efficient Topology Construction for RPL over IEEE 802.15.4 in Wireless Sensor Networks, Ad Hoc Networks, 2013

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Virtualization

- Suitable for large-scale reuse of available data
- Actually available solutions for virtualization of data
  - Reuse of existing data for different applications
  - Minimize communications with the constrained WSNs

- What if we want to improve the QoS of the system?
  - Virtualization of sensor node resources?

- OPEN POINT!!!

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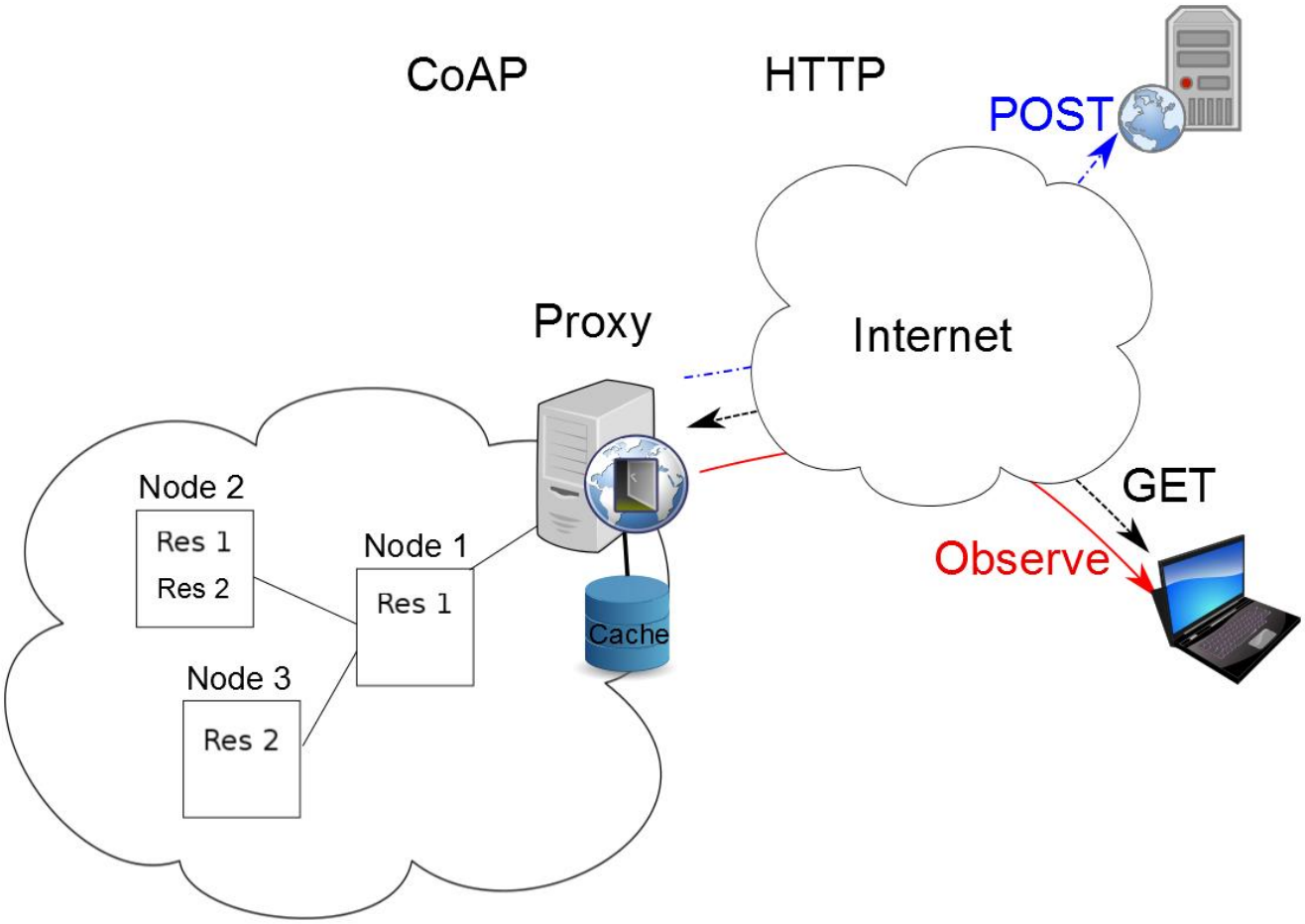
Caching



Rémy Leone, Paolo Medagliani, Jérémie Leguay: Optimizing QoS in Wireless Sensors Networks using a Caching Platform, Sensornets 2013, February 2013, Barcelone, Spain

Caching

- Separation of Internet and constrained networks
  - Communications with the WSNs can be limited through the use of a cache
  - Possibility of adapting caching lifetime to meet QoS requirements
  - For internal servers, the subscriber is only the proxy which hides
- Management of CoAP GET and OBSERVE
- Publication on remote webservers through REST APIs
- Translation between HTTP and CoAP protocols

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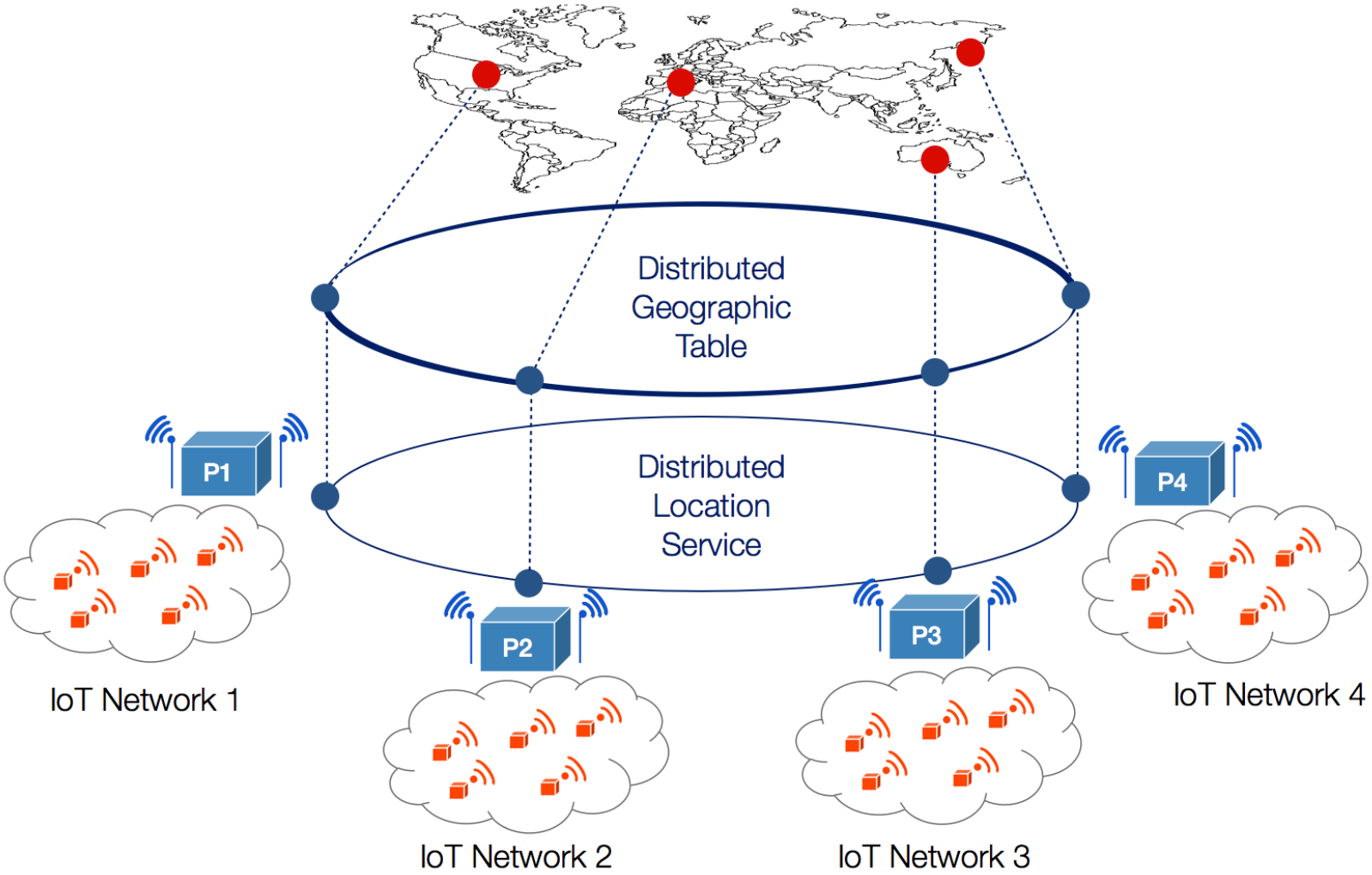
Large scale service discovery



Simone Cirani, Luca Davoli, Gianluigi Ferrari, Rémy Léone, Paolo Medagliani, Marco Picone, and Luca Veltri:
A Scalable and Self-Configuring Architecture for Service Discovery in the Internet of Things, IEEE Internet of Things Journal. SUBMITTED

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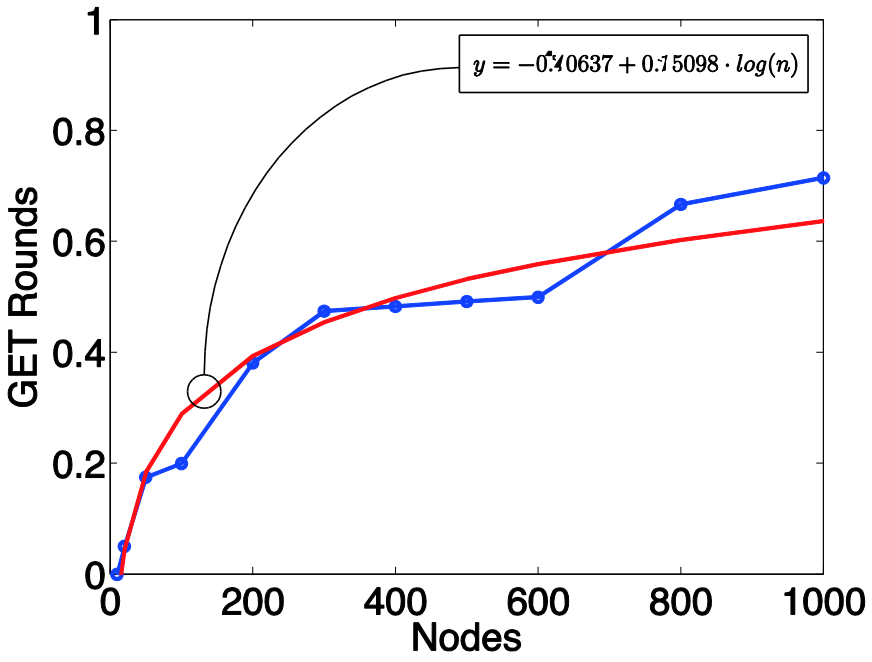
Large scale service discovery

- The use of DHT reduces the complexity of location services
- Two overlays for geographic resolution and location service
- Peers correspond to WSN gateways
  - Interaction through GET, PUT, and JOIN primitives
  - GWs have the complete knowledge of WSNs
- Strong uncorrelation between local constrained WSNs and Internet
- Architecture inherently scalable



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Cloud

- Interaction with local gateways/nodes through REST APIs
- Periodic poll of data and punctual reading of data if required
- Need for real-time large-scale messaging systems
- Aggregation of user-defined sources of data to
  - Personalize applications
  - Create profiles of use

- Actual solutions are still lacking of usability and the sufficient generality

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Conclusions

- Smart cities are still an open research direction
- Suitable solutions are going to be developed to address the problems of scalability and resilience
- Interaction between several protocols and specific strategies to face problems of data management in constrained environments
- Applications must be specifically designed to flexibly handle huge amounts of data

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