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The Standards-based IoT Research Ecosystem

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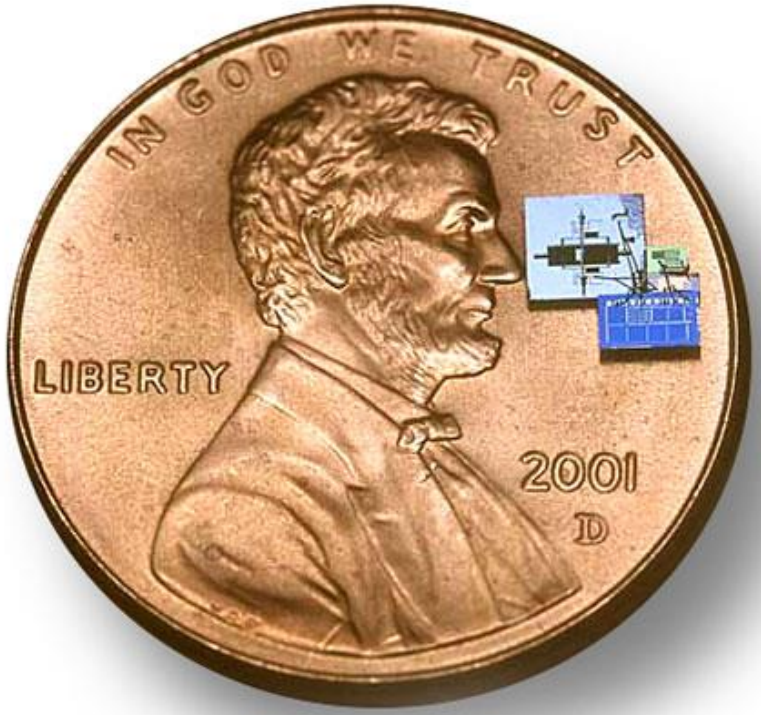
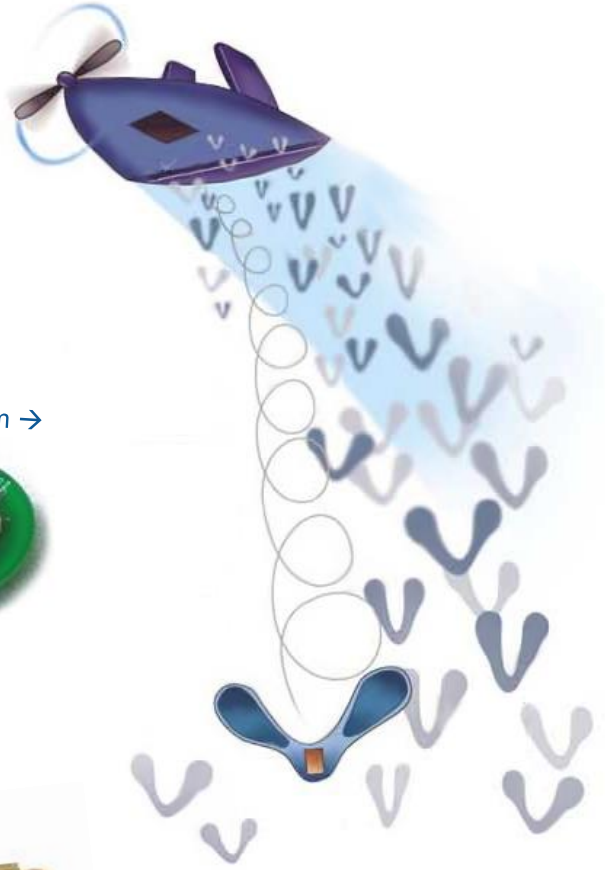
IRTF Thing-to-Thing Research Group
Dallas, TX, USA

Saturday, 21 Mar 2015

Wireless Sensor Networks





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First Proposals for Low-power IP

- A. Dunkels. *Full TCP/IP for 8-bit Architectures*.
  In Proceedings MobiSys, San Francisco, CA, USA, **2003**

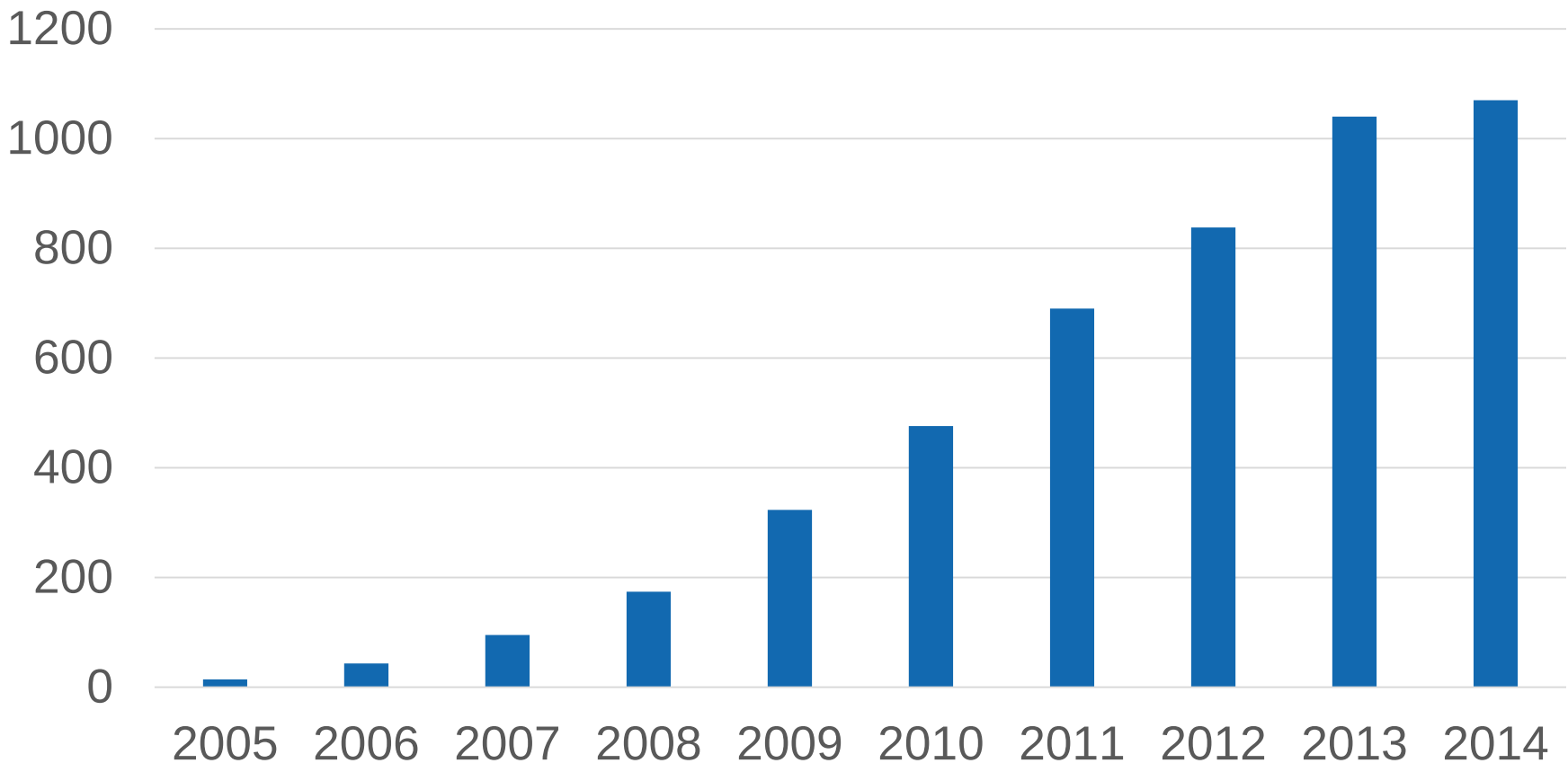
- Z. Shelby, P. Mahonen, J. Riihijarvi, O. Raivio, and P. Huuskonen. *NanoIP: The Zen of Embedded Networking*.
  In Proceedings ICC, Anchorage, AK, USA, **2003**

6LoWPAN Efforts Officially Started in 2005

- IETF 6LoWPAN Working Group Charter, **2005**
- RFC 4944: Initial 6LoWPAN Standard, **2007**
- J. Hui and D. Culler. *IP is Dead, Long Live IP for Wireless Sensor Networks*.
  In Proceedings SenSys, Raleigh, NC, USA, **2008**
- RFC 6282: Header Compression Update, **2011**
- RFC 6775: Neighbor Discovery Update, **2012**

Papers on 6LoWPAN per Year

Source: Google Scholar “6LoWPAN” (in English without patents and citations)



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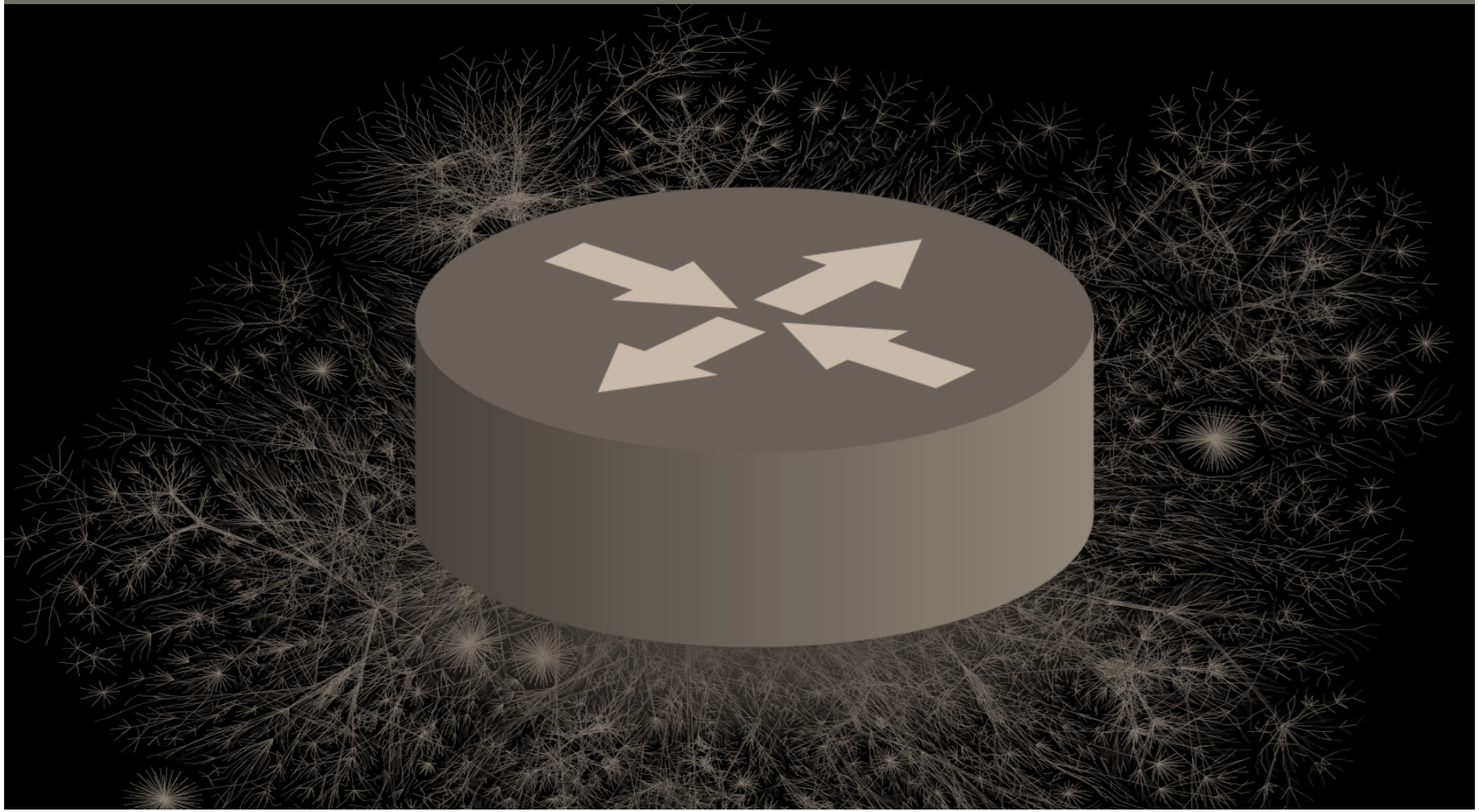
Routing



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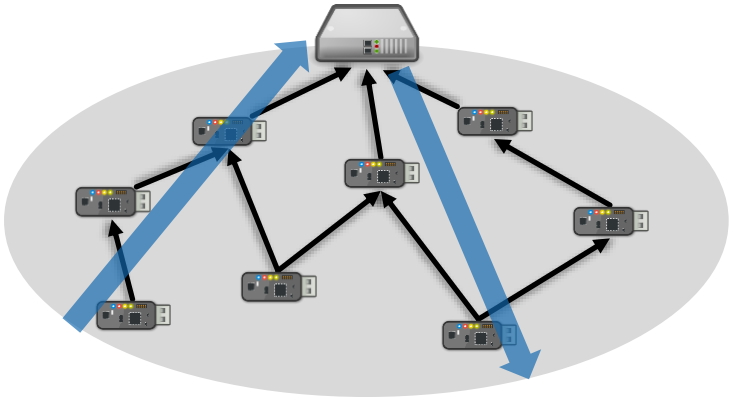
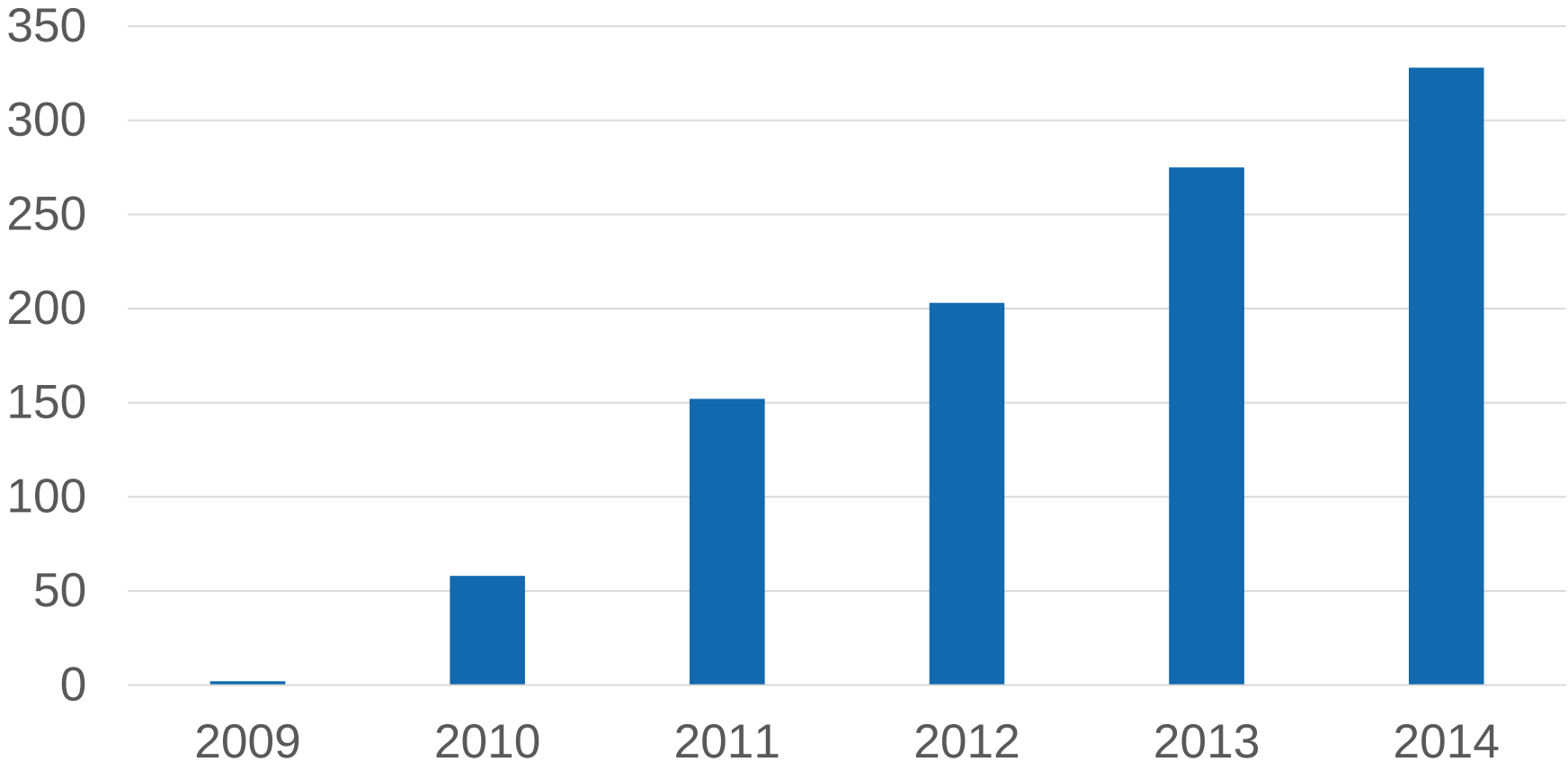
Collection Tree Protocol

- R. Fonseca, O. Gnawali, K. Jamieson, S. Kim, P. Levis, and A. Woo. *The Collection Tree Protocol (CTP)*. TinyOS Enhancement Proposal 123, **2006**
- O. Gnawali, R. Fonseca, K. Jamieson, D. Moss, and P. Levis. *Collection Tree Protocol*.
  In Proceedings SenSys, Berkeley, CA, USA, **2009**
- RFC 6550: RPL, **2012**



Papers on RPL per Year

Source: Google Scholar “Routing Protocol for Low Power and Lossy Networks”



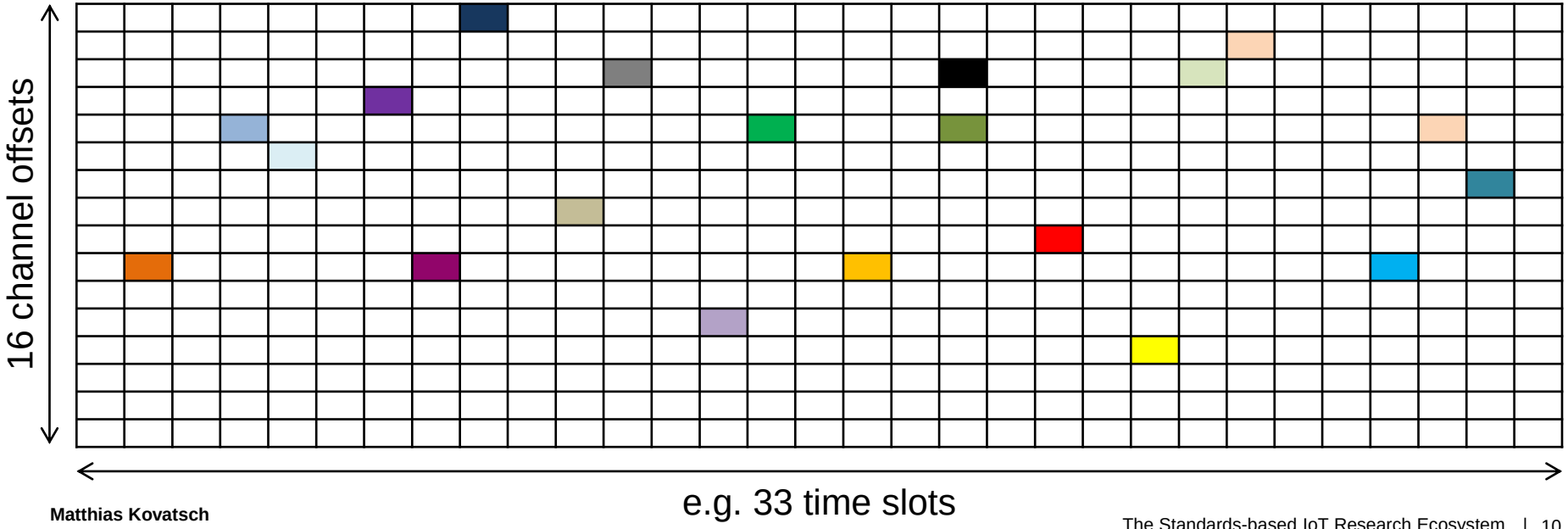
e.g., Opportunistic RPL

- S. Duquennoy, O. Landsiedel, and T. Voigt. *Let the Tree Bloom: Scalable Opportunistic Routing with ORPL*.
  In Proceedings SenSys, Rome, Italy, **2013**

99.5% packet delivery ratio
0.48% duty cycle
0.47 s latency

e.g., OpenWSN Project

- Determenistic networking
- Robustness, latency, energy consumption
- Time Synchronized Channel Hopping (TSCH)



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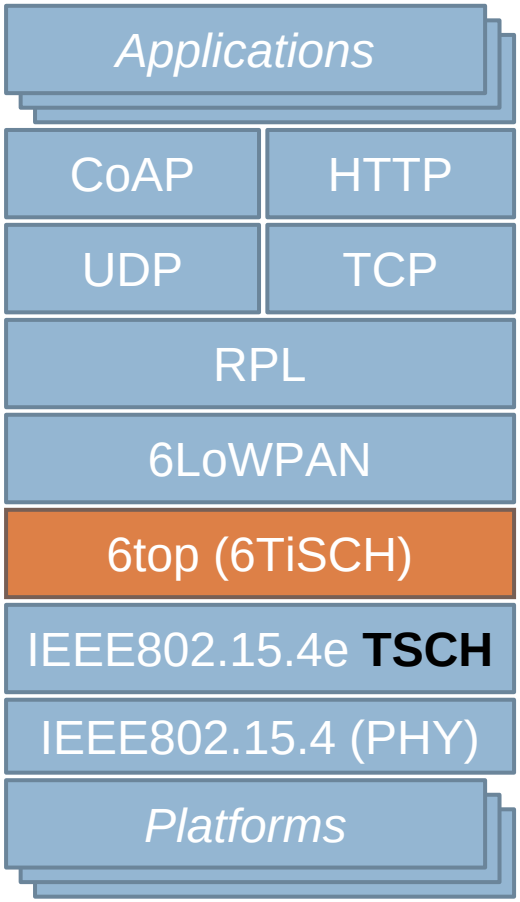
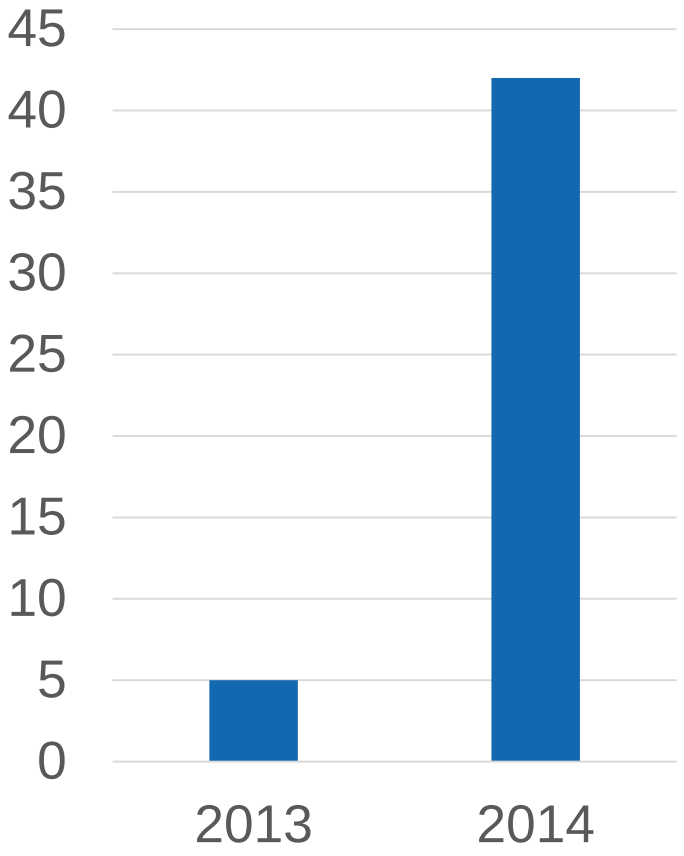
6TiSCH Working Group Established in 2014

Source: Google Scholar “6TiSCH”



IETF

IEEE



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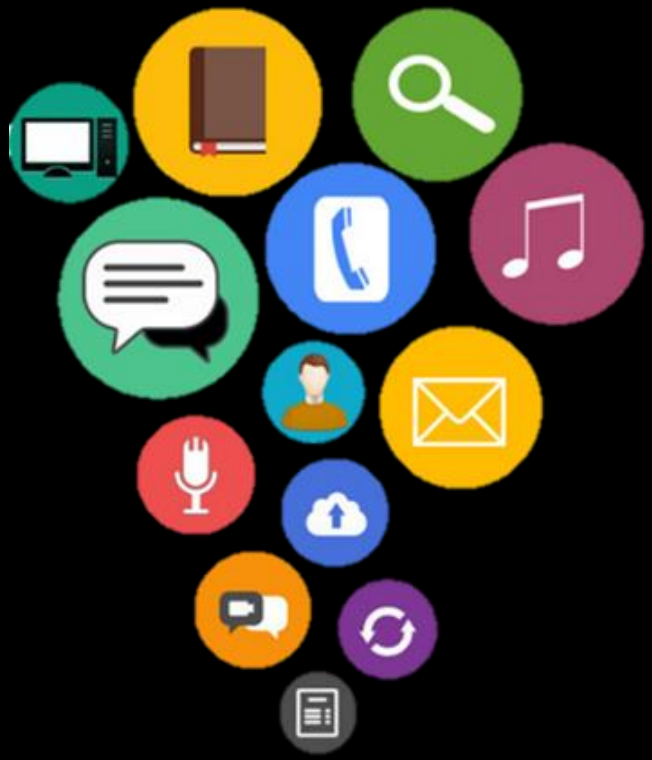
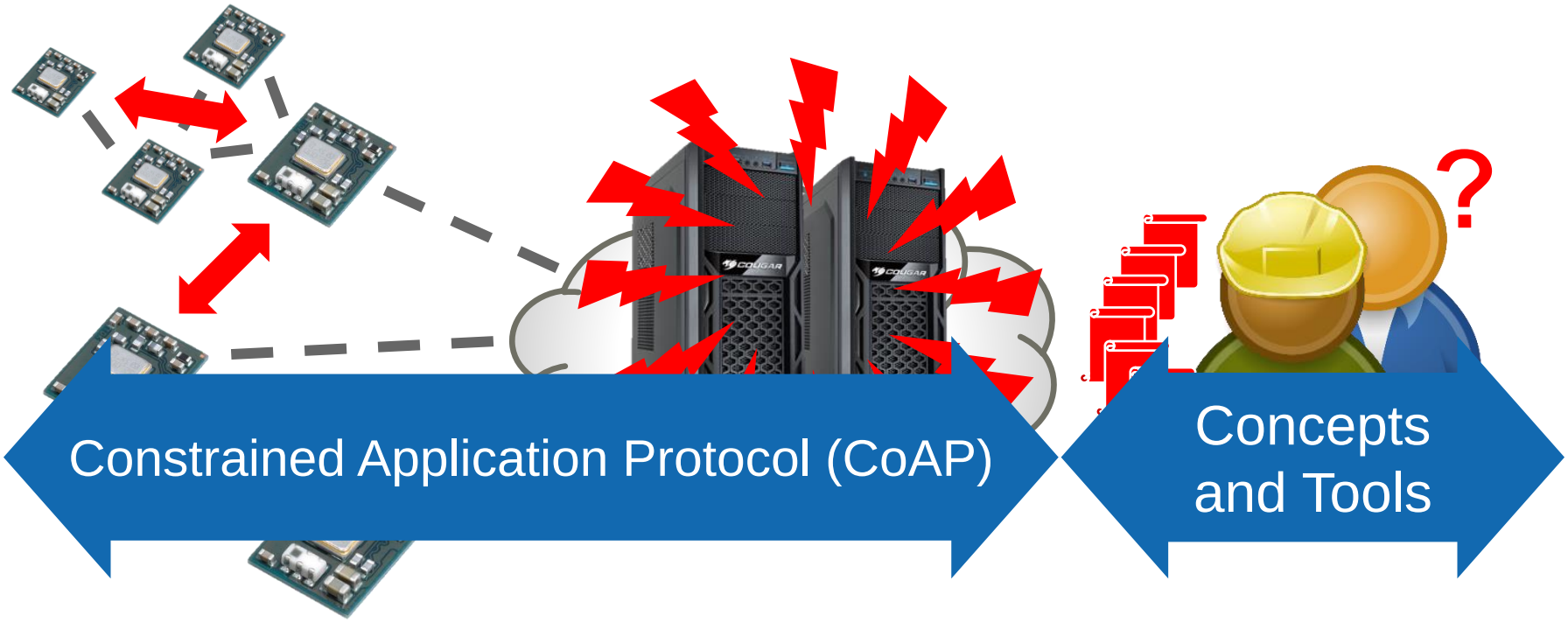
Application Layer



CoAP Evaluation and Running Code



Resource-constrained Devices

IoT Cloud Services

Humans in the Loop

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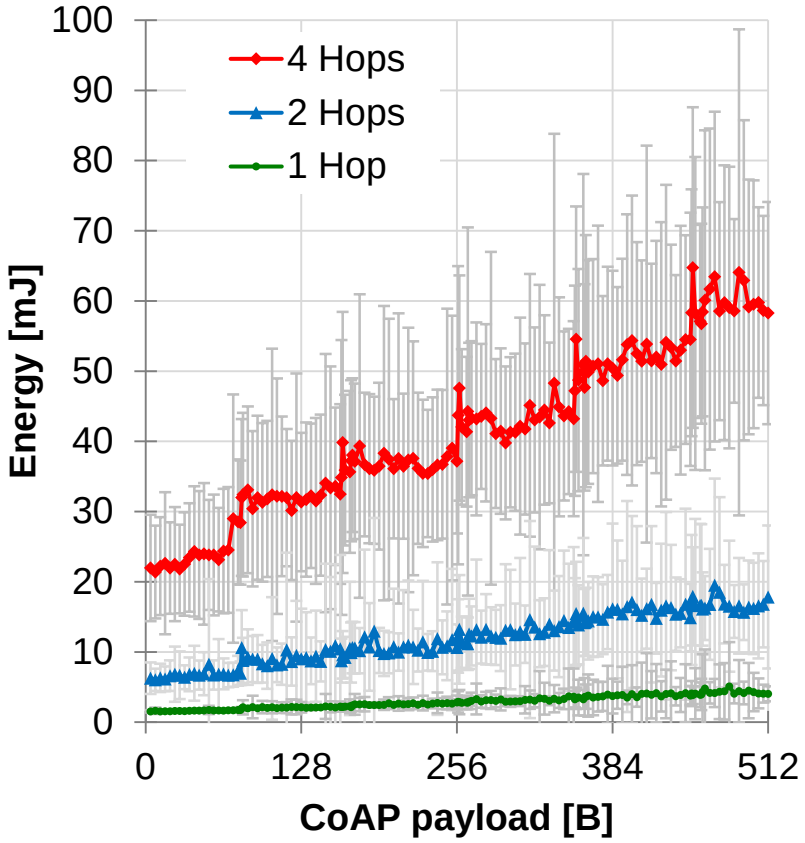
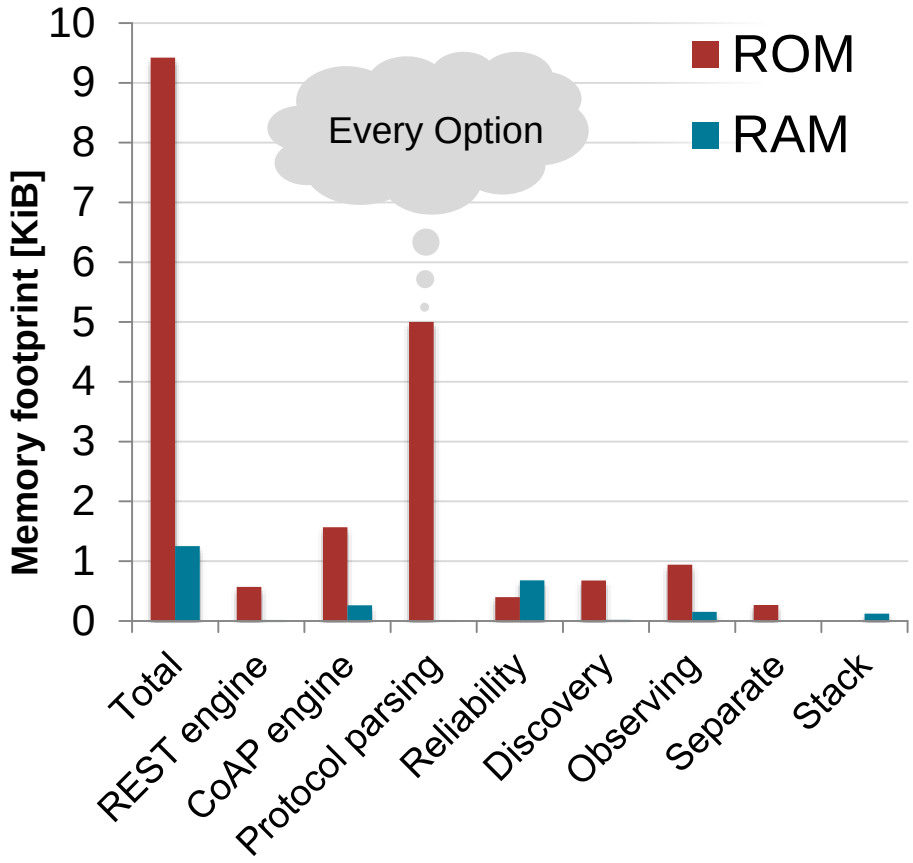
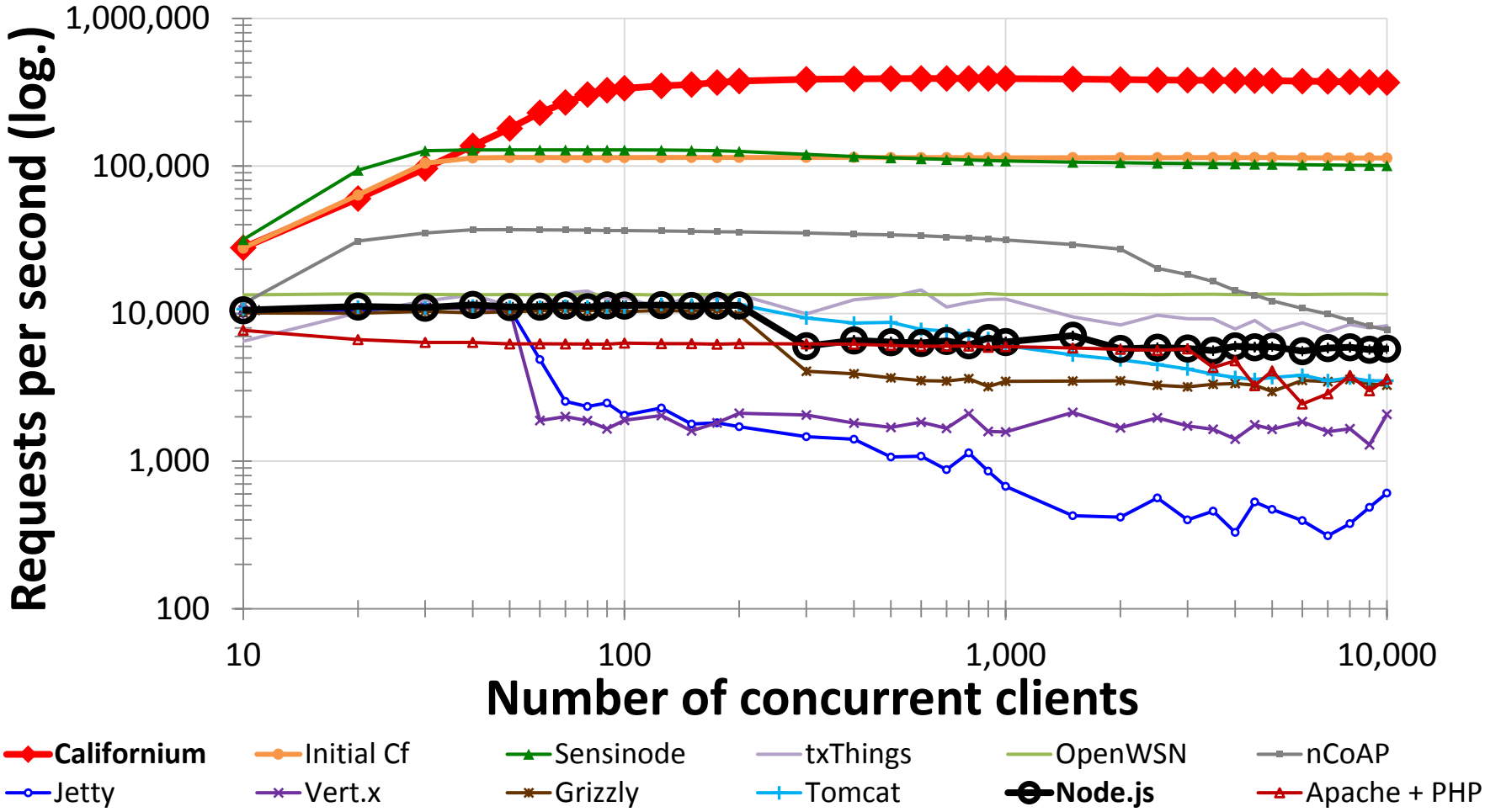
Energy Efficiency and Memory Footprint (Erbium)



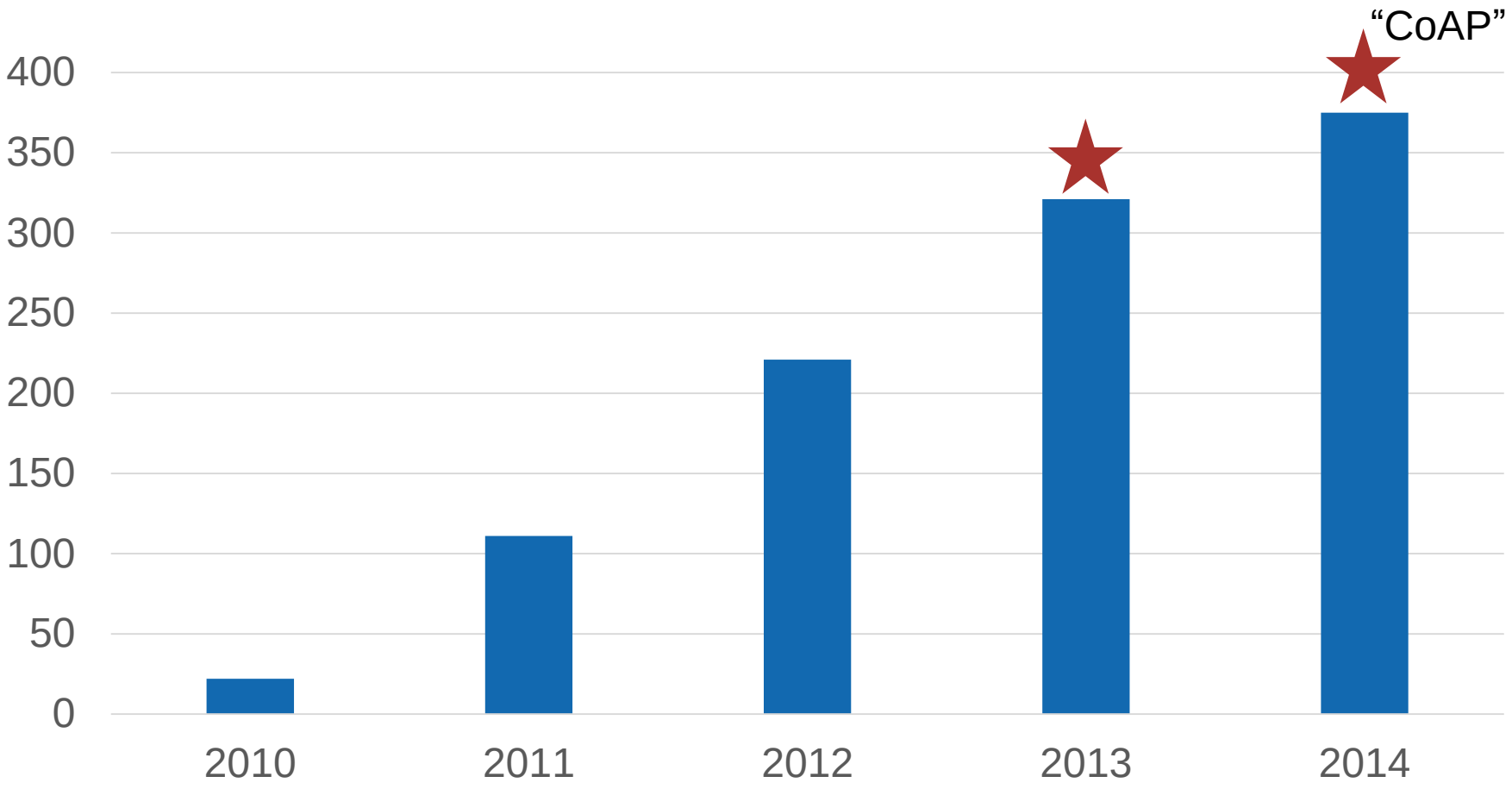


Service Backend Architectures (Californium)



Papers on CoAP per Year

Source: Google Scholar “Constrained Application Protocol”



e.g., Convergence in Building Automation

- Bovet, G. and Hennebert, J. *Offering Web-of-Things Connectivity to Building Networks*. In Proceedings WoT, Zurich, Switzerland, 2013

- Jung, M., Raich, P., and Kastner, W. *The relevance and impact of IPv6 multicasting for Wireless Sensor and Actuator Networks based on 6LoWPAN and constrained RESTful environments*. In Proceedings IoT, Cambridge, MA, USA, 2014

e.g., Health Care

- Bui, N., and Zorzi, M. *Health Care Applications: A Solution Based on the Internet of Things*. In Proceedings ISABEL, Barcelona, Spain, 2011

- Santos, D. F., Perkusich, A., and Almeida, H. O. *Standard-based and Distributed Health Information Sharing for mHealth IoT Systems*. In Proceedings HealthCom, Natal, Brazil, 2014

e.g., Service Discovery

- Butt, T. A., Phillips, I., Guan, L., and Oikonomou, G. *Adaptive and Context-aware Service Discovery for the Internet of Things*. In Internet of Things, Smart Spaces, and Next Generation Networking (pp. 36-47). Springer Berlin Heidelberg, 2013

- Ruta, M., Scioscia, F., Pinto, A., Di Sciascio, E., Gramegna, F., Ieva, S. and Loseto, G. *Resource Annotation, Dissemination and Discovery in the Semantic Web of Things: A CoAP-Based Framework*. In Proceedings iThings/CPSCom, 2013

WoT Workshop & W3C

Meanwhile, in a galaxy not that far away…

- A. Katasonov, M. Palviainen: *Towards Ontology-Driven Development of Applications for Smart Environments*, 2010
- C. Seitz et al.: *Embedding Semantic Product Memories in the Web of Things*, 2010
- M. Boussard et al.: *Providing User Support in Web-of-Things Enabled Smart Spaces*, 2011
- C. Fortuna et al.: *Towards Building a Global Oracle: a Physical Mashup Using Artificial Intelligence Technology*, 2012
- S. Mayer, G. Basler: *Semantic Metadata to Support Device Interaction in Smart Environments*, 2013
- A. Miclaus et al.: Semantic Web Based Context-Adaptable Generation of Product Specific Documentation, 2014

Semantic Web Best Practices
http://www.w3.org/2001/sw/BestPractices/SE/ODA/

OWL Profiles
http://www.w3.org/TR/owl2-profiles/

XML Linking Language
http://www.w3.org/TR/xlink/

JSON-LD
http://www.w3.org/TR/2014/REC-json-ld-20140116/

W3C Vocabularies
e.g., WGS84 Geo Positioning

SPARQL
http://www.w3.org/TR/sparql11-overview/

WoT Workshop & OGC

Meanwhile, in a galaxy not that far away…

- OGC: Sensor Web Enablement DWG
  - OpenGIS Sensor Model Language (SensorML)
  - Sensor Observation Schema & Service
  - Sensor Alert Service
  - Sensor Planning Service

- A. Broering, T. Foerster, S. Jirka: *Interaction Patterns for Bridging the Gap between Sensor Networks and the Sensor Web*, 2010

- M. Blackstock and R. Lea: *Toward Interoperability in a Web of Things*, 2013

Standards-based Research: Challenges

Challenges

(…) in a rapidly evolving area such as the WoT, **premature standardization would risk killing innovation**.

Equally, [the community] will **need to seek some degree of interoperability** if it is to offer developers more than simple islands of things (…)

Toward Interoperability in a Web of Things (M. Blackstock and R. Lea), 2013

Challenges

- IoT / WoT / CPS / M2M hype in industry and research
  - Emergence of more and more *de facto "standards"*
  - How can standards organizations **keep pace** with the development?
- WoT space is huge. IoT space is HUGE
  - Do standards organizations **want too much**?
  - Can/Should they focus stronger?

Standards-based Research

- Example: W3C Social WG and Activity Streams (AS)
  - AS 1.0 … rather informal guidelines

    http://activitystrea.ms/specs/json/1.0/
  - AS 2.0 … in flux?
    - Core model RDF-based?
    - Which extensions are allowed?

    http://www.w3.org/TR/activitystreams-core/

Standards-based Research

- Ideally
  - Quick core standard
  - Extension model / registry

- Plus also consider the backchannel: How can **contributing back to standards** be encouraged for academia and industry?

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Questions?

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https://github.com/mkovatsc/

http://people.inf.ethz.ch/mkovatsc/