DSC/e:
Data Science Center
Eindhoven

Smart processes for the IoT

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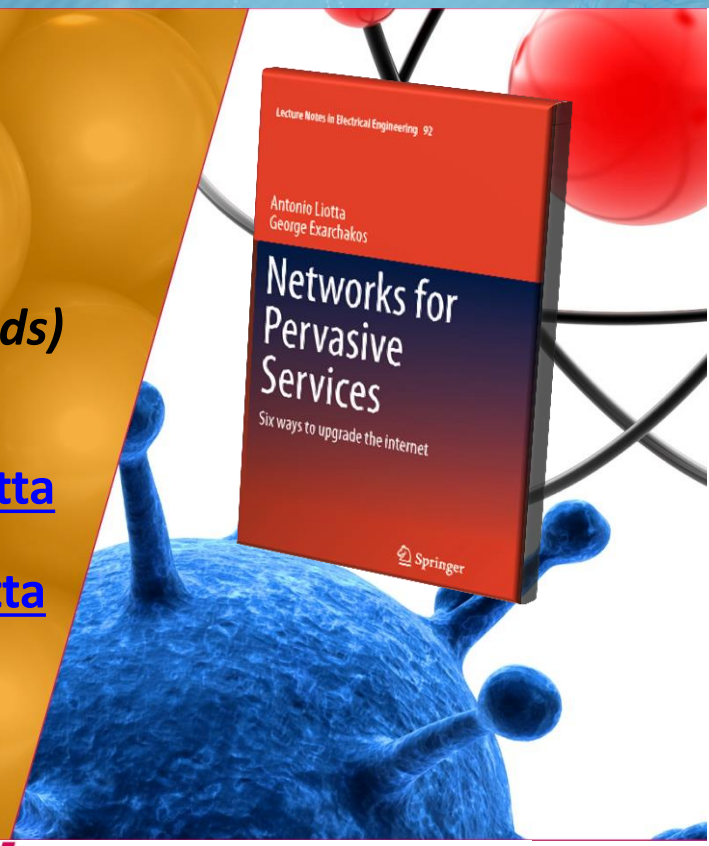

CNSM 2014 Distinguished Experts Panel: Managing our Networked Life: From Smart Devices to Social Networks

Rio de Janeiro, 20 November 2014

TU/e Technische Universiteit Eindhoven University of Technology

Eindhoven Institute for Research on ICT

Smart Communication Networks Lab: embedded within several virtual organizations

NIRICT

3TU.CeDICT

TU/e Technische Universiteit Eindhoven University of Technology

EIRICT
Eindhoven Institute for Research on ICT

CWTe
Centre for Wireless Technology Eindhoven

TU/e Technische Universiteit Eindhoven University of Technology

Intelligent Lighting Institute

DSC/e:
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Evolution of ICT
(will the IoT crush IT?)

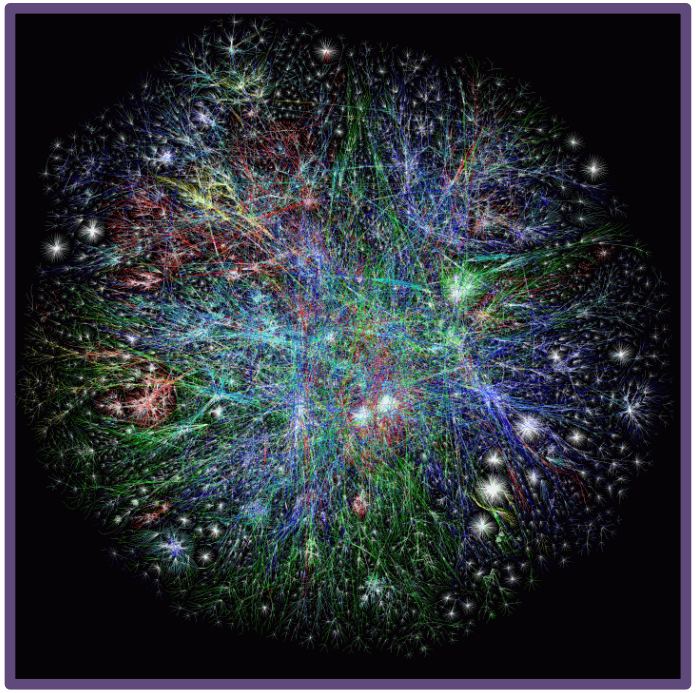
High-density wireless
(how to overcome physical transmission limits?)

Applications
(how can networks adjust?)

Big-data problem
(which data is relevant?)

The IoT is a “complex network”

- Properties of whole can’t be inferred from properties of individual parts
- Individual components interact nonlinearly, leading to emergent behavior
- Constantly evolving and unfolding over time



The future Internet will be comparatively as complex as other complex ‘natural’ networks

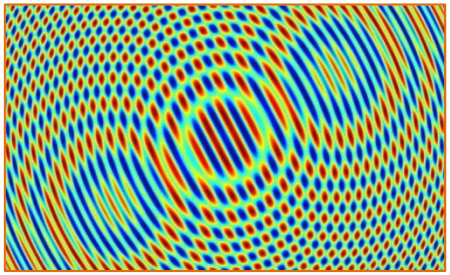
Idea: treat complex networks as a distributed big-data, prediction problem

≈ 1tn 'things' (*)

>> 1tn reliable connections

Extreme (varied) mobility

>> hard-to-anticipate dynamics



Extreme density

>> unprecedented interference

Hidden features

>> emergent behavior

(*) **Forecasts by CISCO, the Trillion Sensor Summit, etc.**

My controversial IEEE Spectrum paper

The COGNITIVE NET Is Coming

The Internet will break down without new biologically inspired routing

By Antonio Liotta

Illustrations by L-Dopa

PERHAPS AS EARLY AS THE END OF THIS DECADE, our refrigerators will e-mail us grocery lists. Our doctors will update our prescriptions using data beamed from tiny monitors attached to our bodies. And our alarm clocks will tell our curtains when to open and our coffeemakers when to start the morning brew.

By 2020, according to forecasts from Cisco Systems, the global Internet will consist of 50 billion connected tags, televisions, cars, kitchen appliances, surveillance cameras, smartphones, utility meters, and whatnot. This is the Internet of Things, and what an idyllic concept it is.

But here's the harsh reality: Without a radical overhaul to its underpinnings, such a massive, variable network will likely create more problems than it proposes to solve. The reason? Today's Internet just isn't equipped to manage the kind of traffic that billions more nodes and diverse applications will surely bring.

In fact, it's already struggling to cope with the data being generated by ever-more-popular online activities, including video streaming, voice conferencing, and social gaming. Major Internet service providers around the world are now reporting global latencies greater than 120 milliseconds, which is about as much as a Voice over Internet Protocol connection can handle. Just imagine how slowly traffic would move if console gamers and cable television watchers, who now consume hundreds of exabytes of data offline, suddenly migrated to cloud-based services.

The problem is not simply one of volume. Network operators will always be able to add capacity by transmitting data more efficiently and by rolling out more cables

26 | AUG 2013 | NORTH AMERICAN | SPECTRUM.IEEE.ORG

"Junk thoughts with no practical sense"

Anonymous blogger

A. Liotta, **The Cognitive Net is Coming**, IEEE Spectrum, Vol.50(8), pp.26-31, August 2013, IEEE http://bit.ly/spectrum_LIOTTA

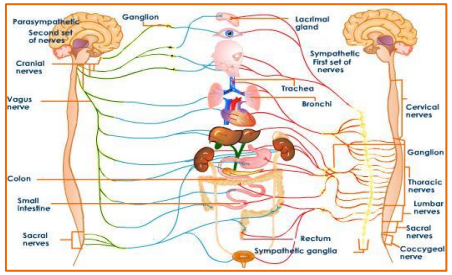
A tricky question about the IoT self-management: where to process the huge amount of data involved

Where?	**In-node**	**Co-operative**	**In-cloud**
Techniques?	**Light ML**	**Swarm, transfer learn.**	**Data mining**
Data fusion?	**Homog. data**	**Standardized data**	**Heterog. data**
Safety?	**safe**	**vulnerable**	**Company-owed**
Management?	**self**	**distributed**	**Orchestration**

Computational intelligence to address complex-network problems

Swarm intelligence & Gossip

(pursue global properties through simple local mechanisms)



Autonomic computing

(coordinated response in face of extreme perturbations)

Machine Learning

(adapt to unpredicted conditions)

Data Mining

(detect global patterns among appl., data, control and mgmt planes)

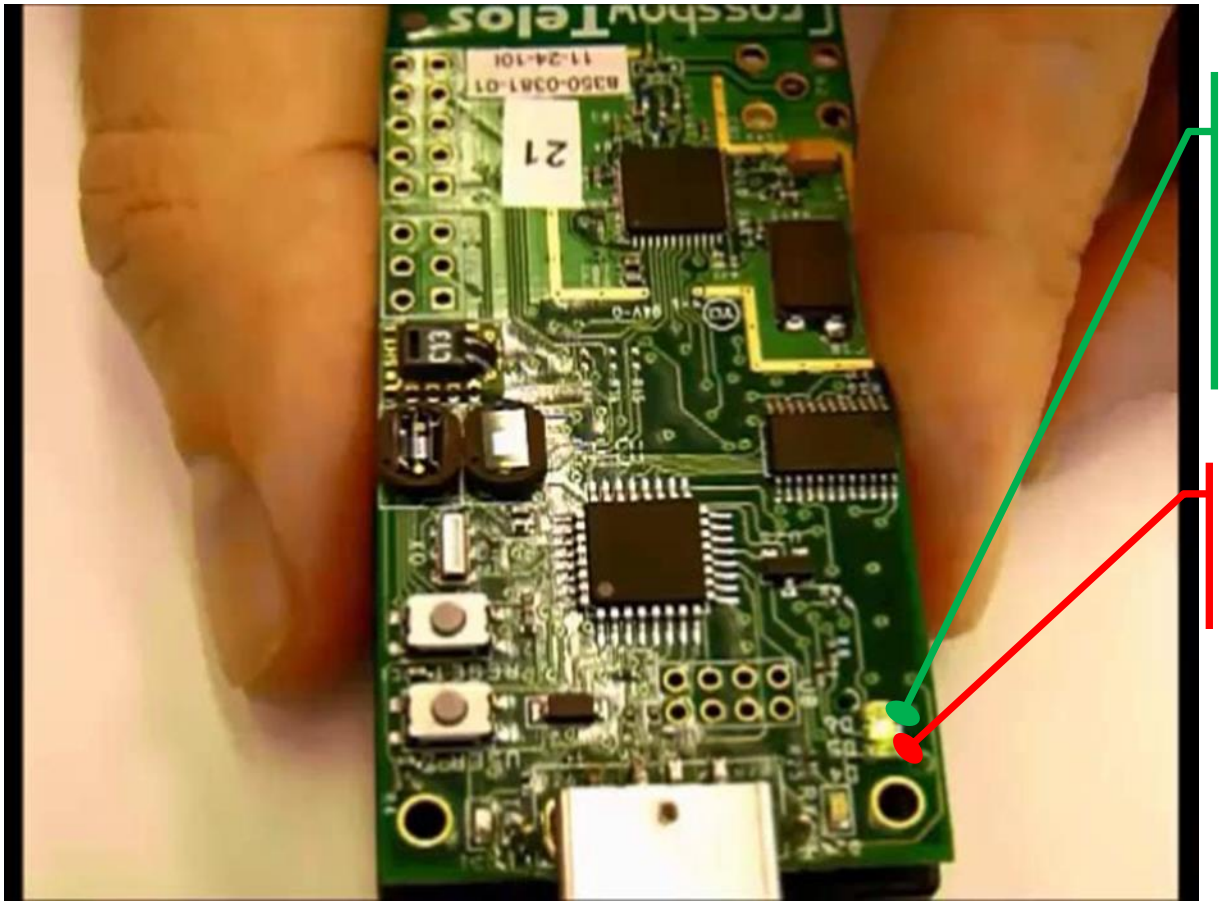
Smart sensors can learn when to fire anomalies

This sensor is learning a ‘tapping’ pattern. Soon to learn how to **trade-off spectrum**, **energy** and **bandwidth** based local view

Light sensor 10Kbyte RAM

Detection of non-specified anomalies

Self-learning based on local info



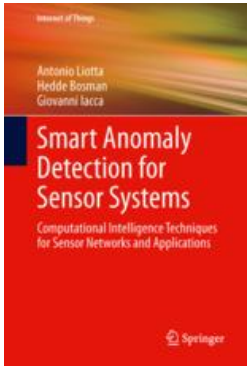
H.H.W.J. Bosman, G. Iacca, H.J. Wortche, A. Liotta, **Online Fusion of Incremental Learning for Wireless Sensor Networks**, in proc. of IEEE ICDM 2014 Workshop on Data Mining in Networks (DaMNet), December 14, 2014, Shenzhen, China (IEEE).

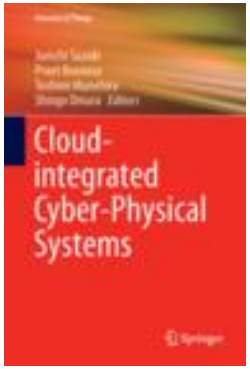
Check out the Springer Series on IoT

http://www.springer.com/series/11636

Internet of Things

Technology, Communications and Computing
Series editors: Giancarlo Fortino, Antonio Liotta





Contact me if you have a proposal in mind
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Check out these specialist workshops

CogMan

The IEEE/IFIP IM Workshop on Cognitive Network Management, Ottawa, 11-15 May 2015

Antonio Liotta, Eindhoven University of Technology, NL

Steven Latré, University of Antwerp – iMinds, Belgium

Giuseppe Di Fatta, University of Reading, UK

Paper submission due: 15 December 2014

http://www.cogman.org/

IEEE ICDM International Workshop on Data Mining in Networks
Shenzhen, China, December 14, 2014

Giuseppe Di Fatta, University of Reading, UK

Antonio Liotta, Eindhoven University of Technology, NL

http://damnet.reading.ac.uk/

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- D.C. Mocanu, G. Exarchakos, A. Liotta, **Node Centrality Awareness via Swarming Effects**, proc. of the IEEE International Conference on Systems, Man, and Cybernetics, San Diego, USA, 5-8 October 2014 (IEEE).
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- A.K. Gopalakrishna, T. Ozcelebi, A. Liotta, J. Lukkien, **Statistical Inference for Intelligent Lighting: A**
- **Pilot Study**, proc. of the 8th International Symposium on Intelligent Distributed Computing, Madrid, Spain, 3-5 September 2014 (Springer) http://dx.doi.org/10.1007/978-3-319-10422-5_3

Some open questions

- How to miniaturize Data Mining
- How to distribute Data Mining
- How heterogeneous DM can help pushing the physical boundaries of wireless transmission
- Whether/How to handle non-deterministic (learning-capable) networks
- How to build dependable IoT networks
- How to strike a balance between privacy and cooperative architectures
- Energy efficiency vs the prospects of having to ‘distribute’ 1 Gwatt to power the IoT in 2020

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