

Deployment, Test and Validation of Sensor Networks

Jan Beutel

Computer Engineering and Networks Lab, ETH Zurich



Wireless Sensor Networks

Visions

1991

1996

1999

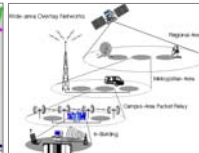
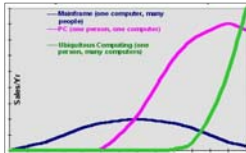
2000

2001

2003

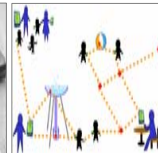
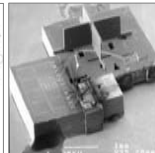
2004

Ubiquitous
Vision



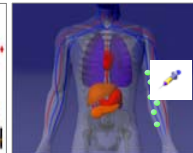
Wireless
Overlay

Smart Dust



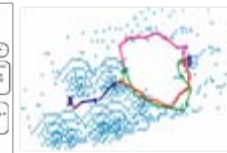
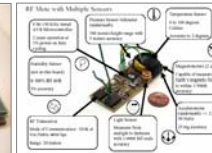
PicoRadio

Directed
Diffusion



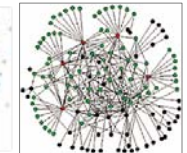
Paintable
Computing

COTS Dust



Terminodes

Scale Free
Networks



Applications

2000

2001

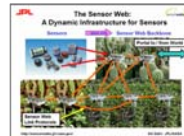
2003

2004

Argo



Military Surveillance



Sensor Webs



Duck Island

James Reserve



ZebraNet

Shooter Localization



Wireless Sensor Networks

Visions

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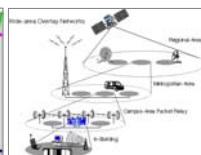
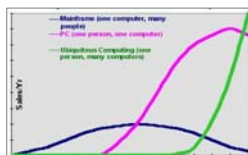
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2001

2003

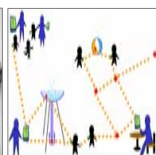
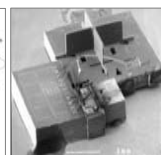
2004

Ubiquitous Vision

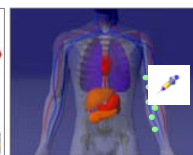


Wireless Overlay

Smart Dust

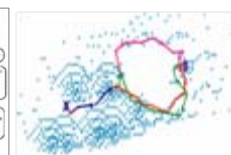
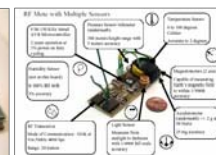


Directed Diffusion



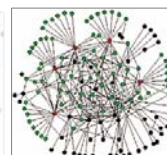
Paintable Computing

COTS Dust



Terminodes

Scale Free Networks



Applications

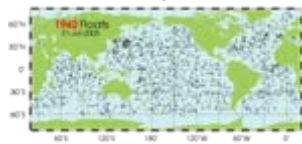
2000

2001

2003

2004

Argo



Military Surveillance

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Shooter Localization



Sensor Webs



Duck Island



ZebraNet

Prototypes, Experiments and Research Demos

WSN Community

Wireless Sensor Networks

Visions

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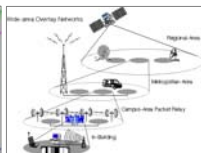
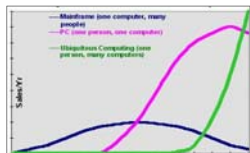
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2001

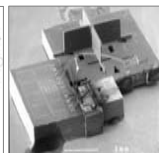
2003

2004

Ubiquitous
Vision



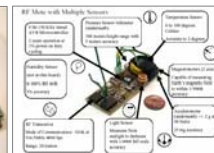
Smart Dust



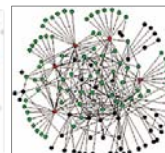
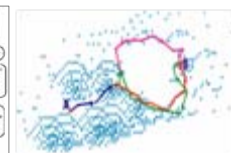
Directed
Diffusion



COTS Dust



Scale Free
Networks



Wireless
Overlay

**Other
People**

PicoRadio

Paintable
Computing

Terminodes

WSN Community

Applications

2000

2001

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James Reserve

Shooter Localization

**Production
Applications**



**Prototypes, Experiments
and Research Demos**

Sensor Webs

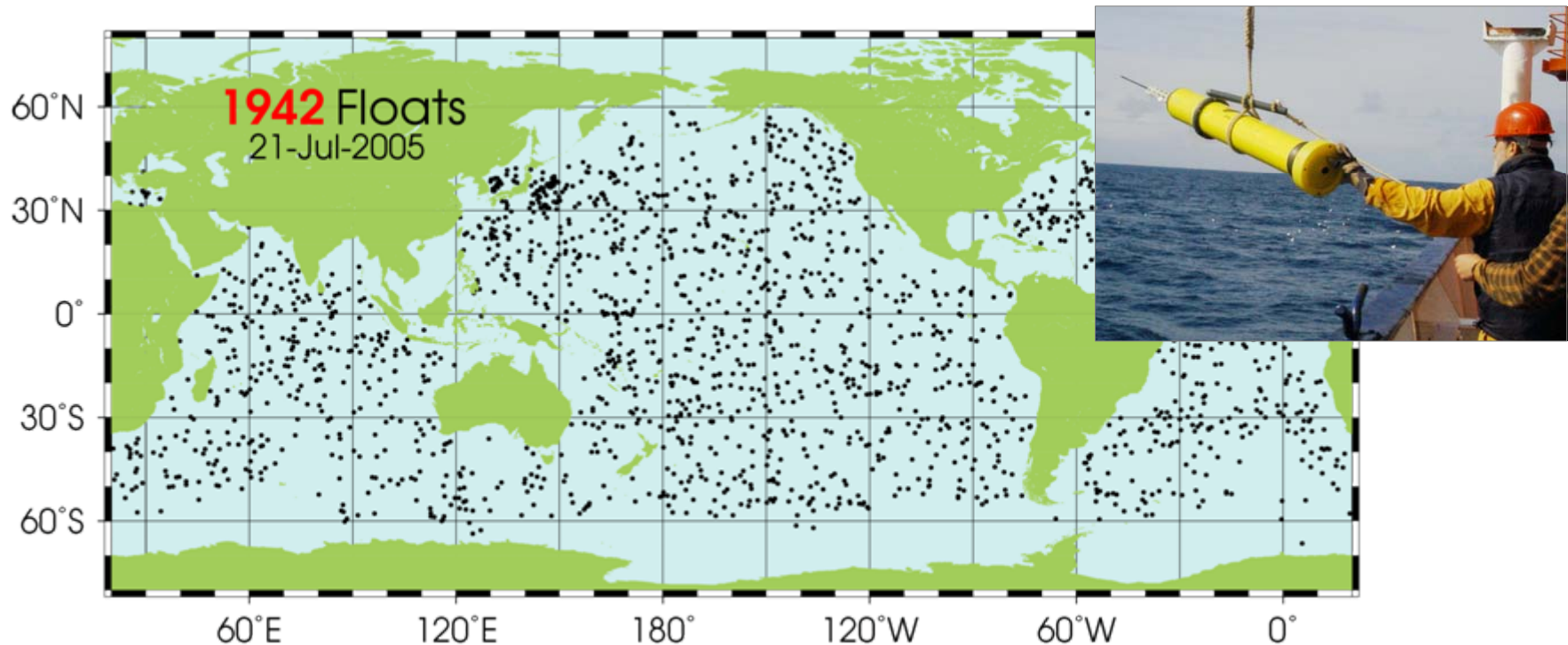
Duck Island

ZebraNet

Argo – Global Ocean Observation Strategy

Global array of temperature/salinity profiling floats

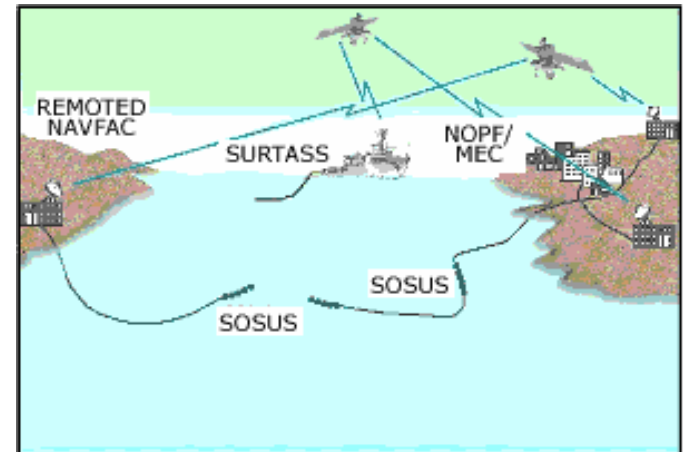
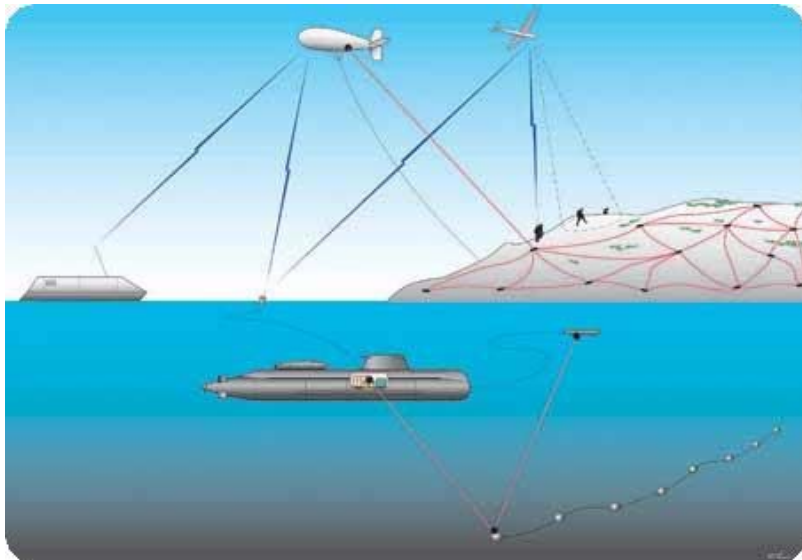
- Satellite data relay to data centers on shore
- Operational since 2000
- Developed and maintained mainly by oceanographers



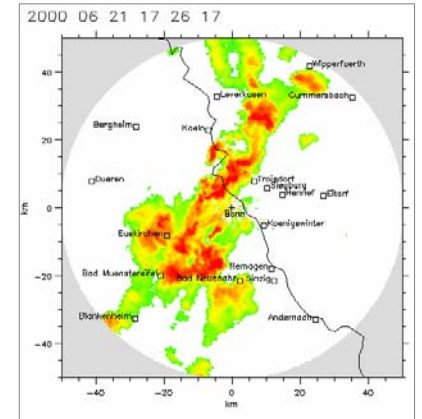
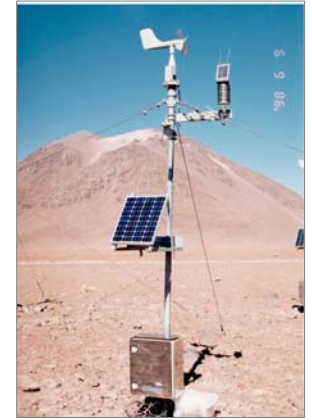
Anti-Submarine Surveillance

Distributed acoustic monitoring and surveillance

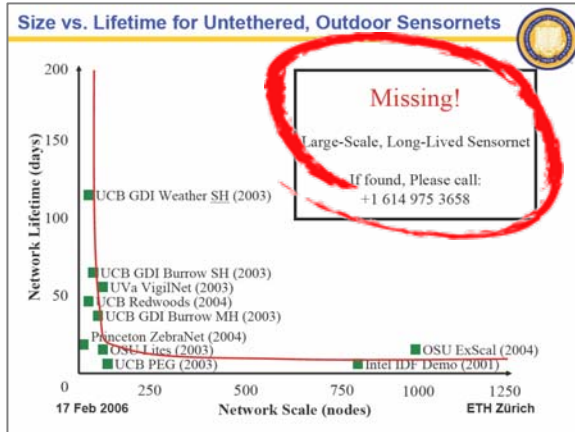
- Advanced signal processing
- Mostly wireline and analog
- Fixed installations and mobile units
- Military development since the cold war



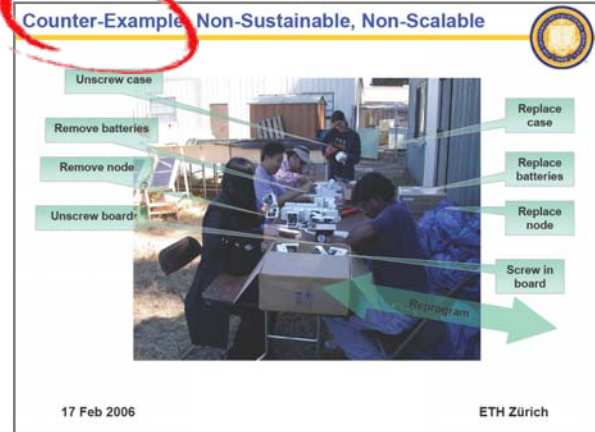
Globally Networked Weather Stations



“Proof-of-Concept” Deployment Experience



[Prabal Dutta, UC Berkeley]

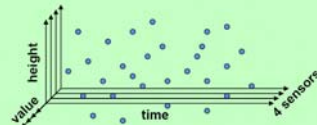


[Prabal Dutta, UC Berkeley]

We got 820,700
49% yield

Data Overview
33 motes
44 days
288 samples/day
4 sensors
1,672,704 points

Still more than we knew how to handle!



[Gilmann Tolle, UC Berkeley]

Murphy's law: everything that can go wrong will go wrong

March 1st [Field test 1]

- Gateway casing does not fit
- melted DC/DC converter
- TNodes antennas fall off
- incorrect wiring of Sensirion sensor



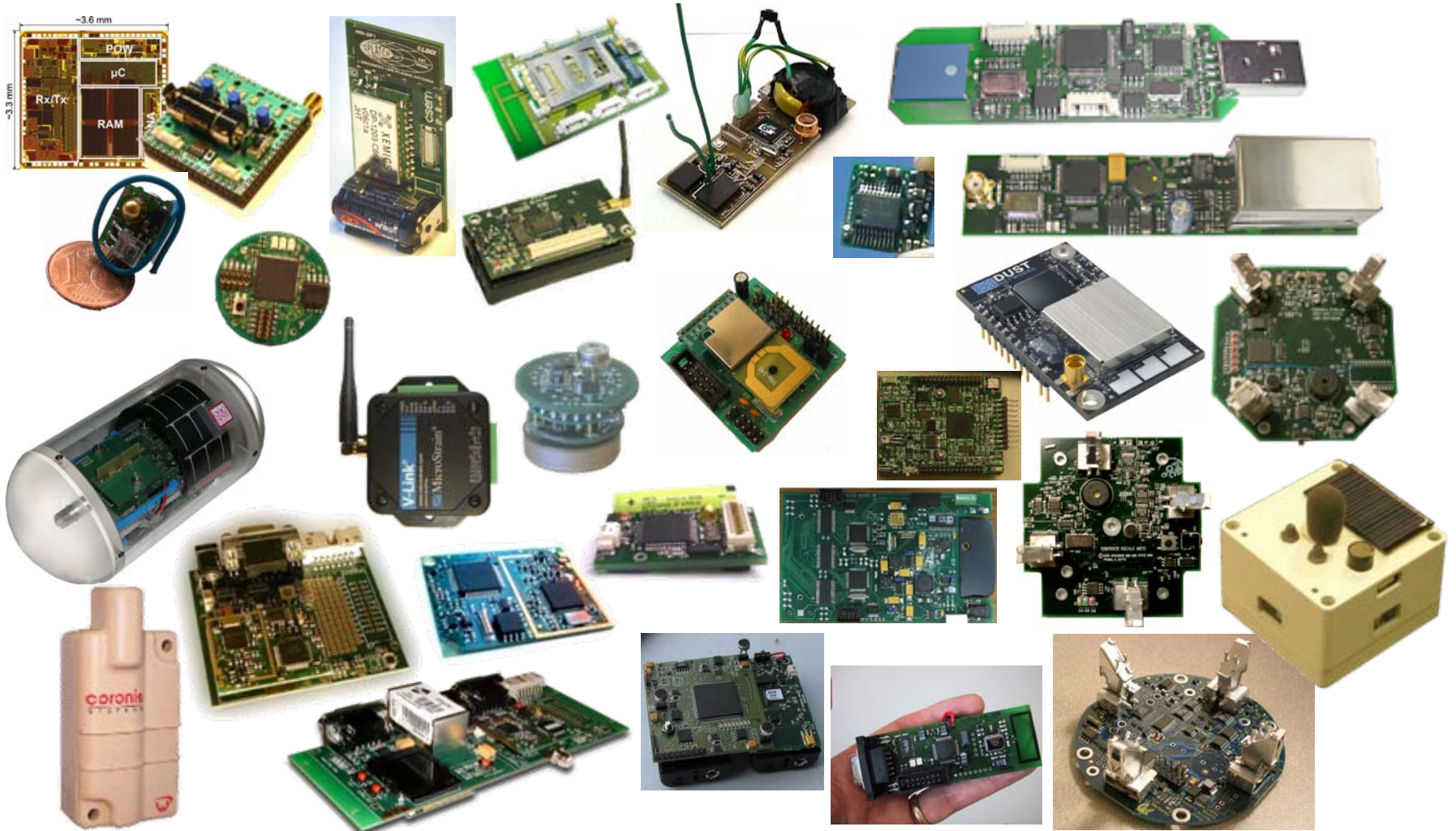
May 4th [Field test 2]

- untested T-MAC version (no development tree!)
- T-MAC loses synch (never use unsigned!)
- debugging nightmare (LEDs off, low data rate)

Summer School, Delft, September 1st, 2005

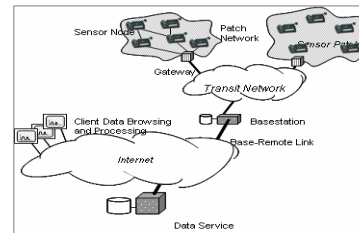
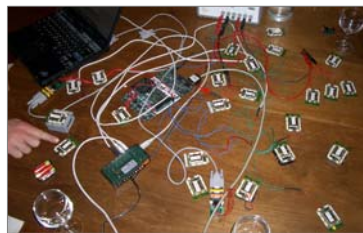
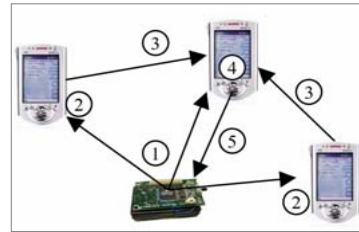
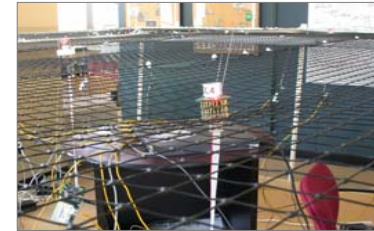
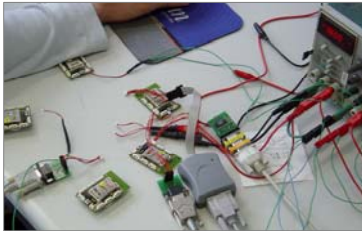
[Koen Langendoen, TU Delft]

More Wireless Sensor Network Systems...



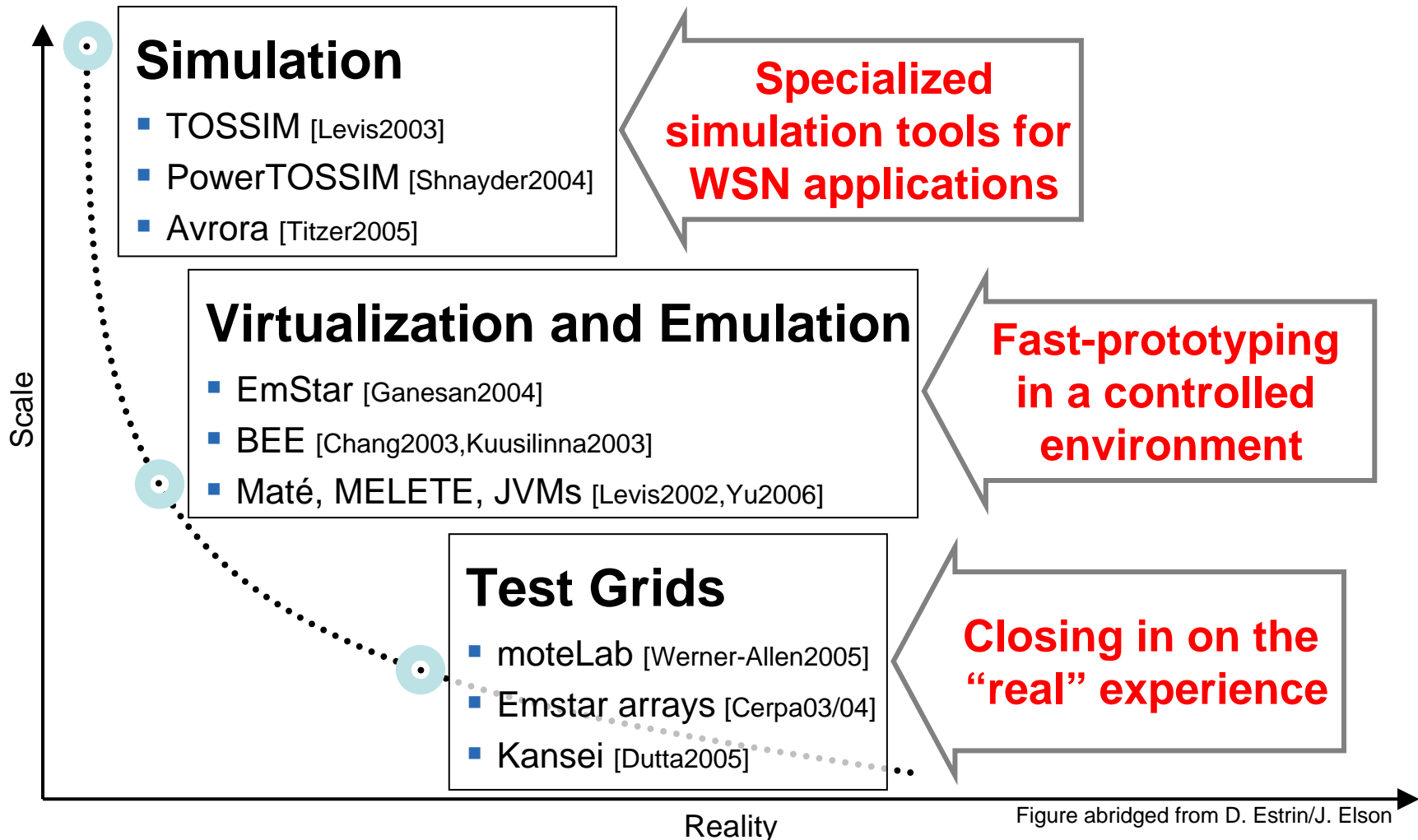
WSN Development Reality

It is hard to deploy anywhere beyond 10-20 nodes today.

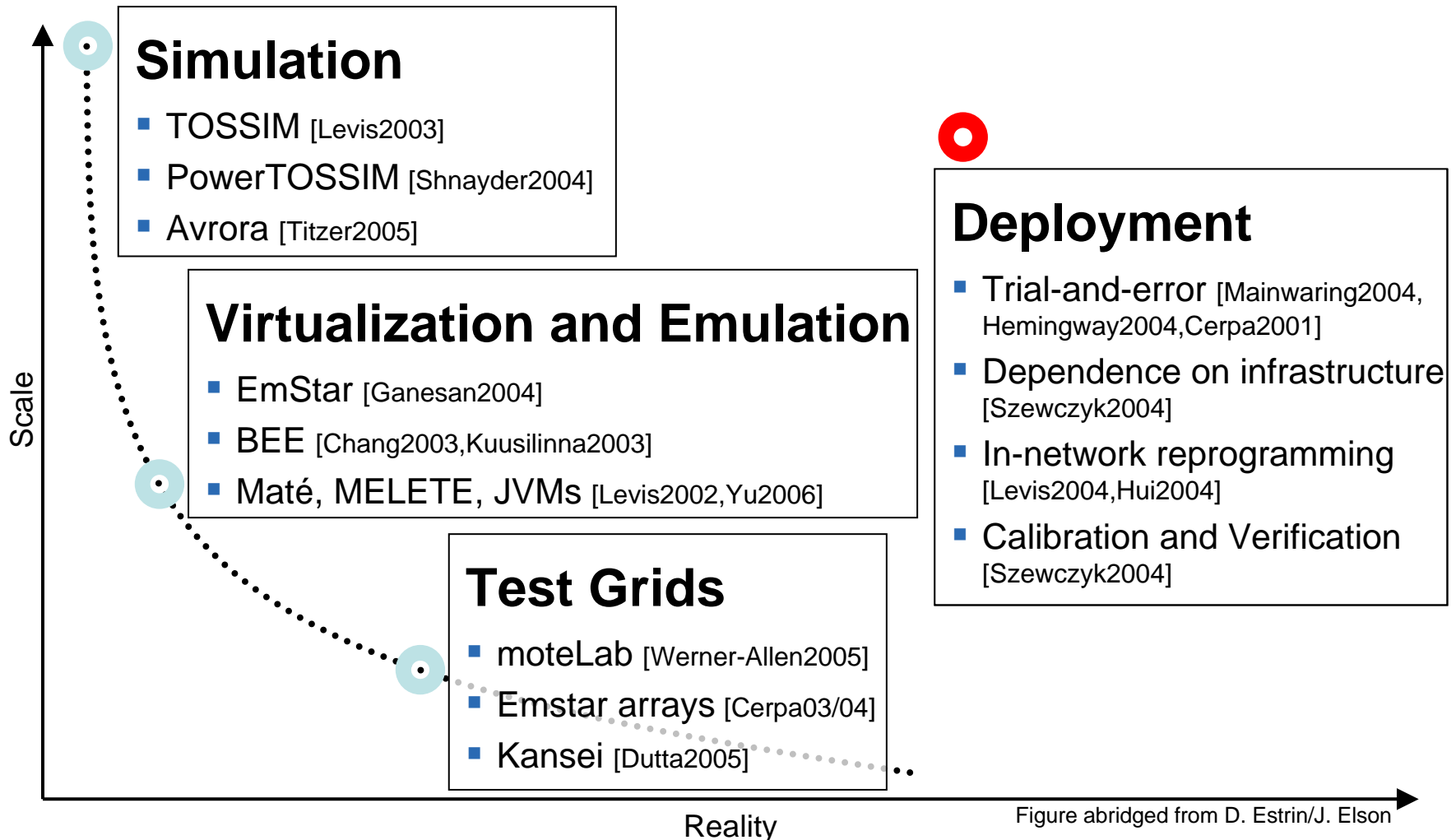


Coordinated methods and tools are missing today.

Today's WSN Design and Development



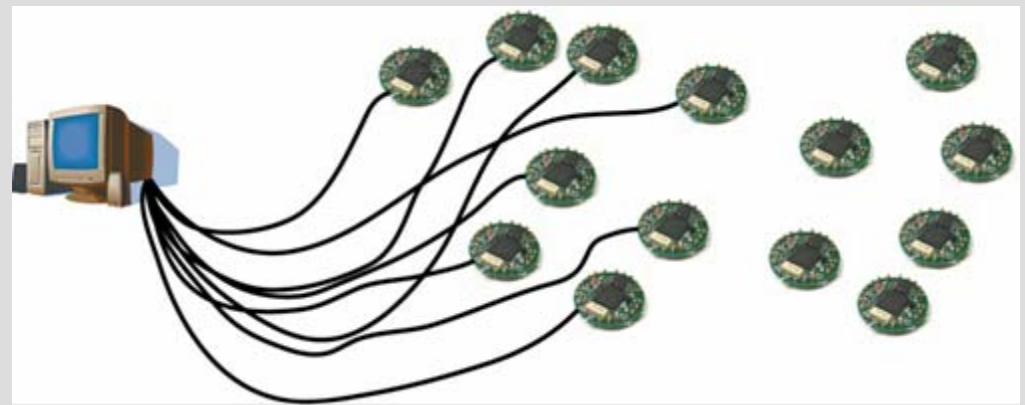
Today's WSN Design and Development



From Proof-of-concept to Real-world WSNs

Traditional test grid

- Wired
- Immobile
- Not scalable

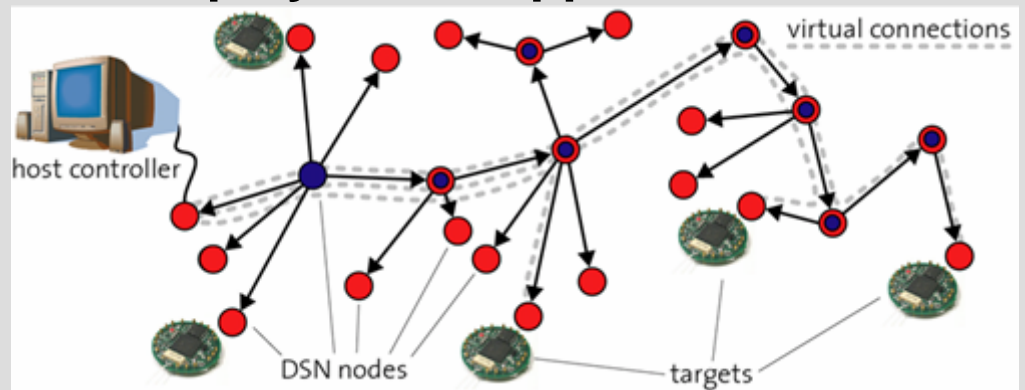


In-network tools

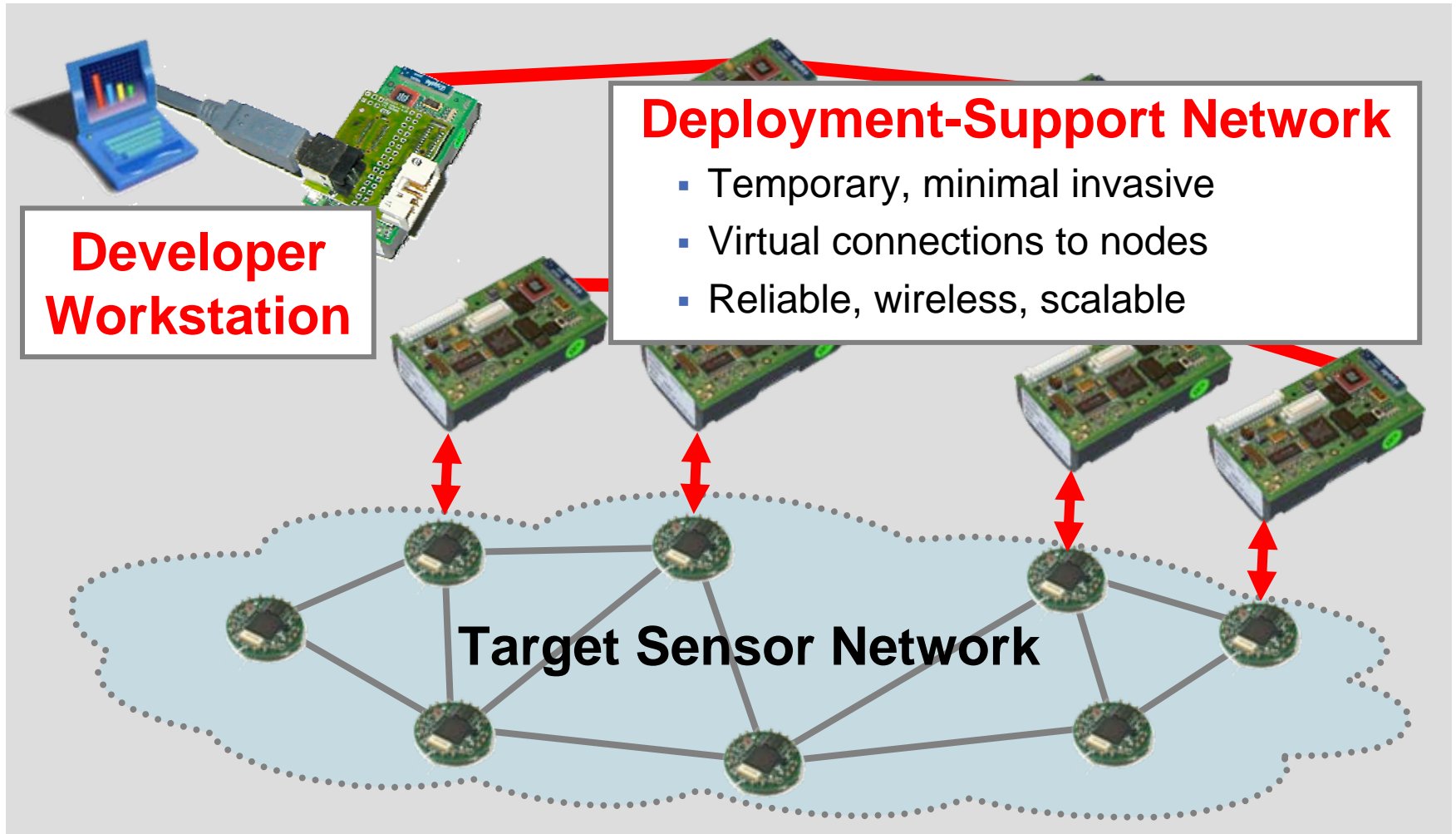
- Limiting, unreliable

**Self-organizing
backbone network
with
deployment-support
services**

Deployment-Support Network



Next-Generation Deployment-Support

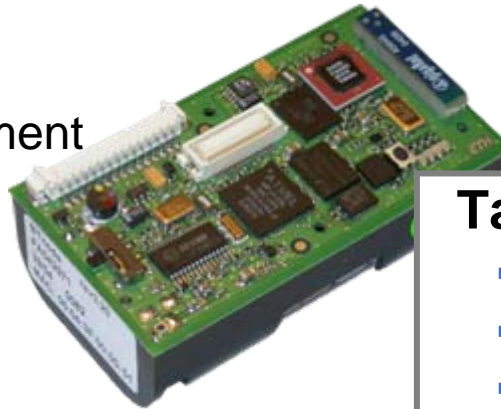


JAWS – Application Partitioning

JAWS Application

- Topology Control
- Connection Management
- Data Transport
- Caching
- Node Management

Codesize 100 kB



Target Adapter

4 kB

- Target Control
- Programming
- Logging

WSN Target Application

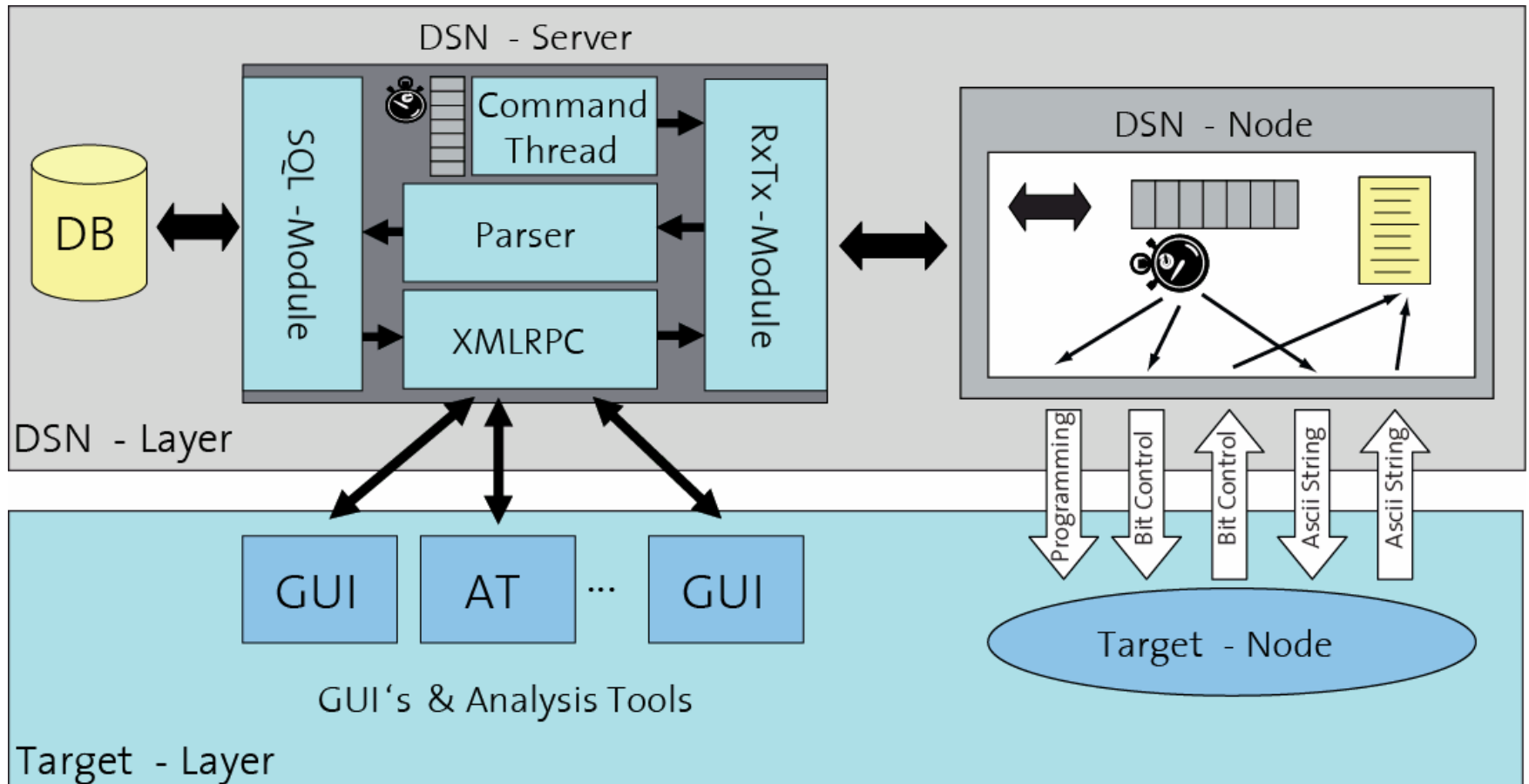


Monitor

2 kB

- Threads/IRQs
- High level context

JAWS – DSN Architecture Details



JAWS – Sensor Network Monitoring Toolkit

A suite of services based on the JAWS deployment-support network

- Remote logging and event detection
- BTnut OS tracing facility
- Long-term logging and analysis
- Remote programming
- Generic DSN access
- Power and status monitoring
- Coordinated fault injection

Target Sensor Network

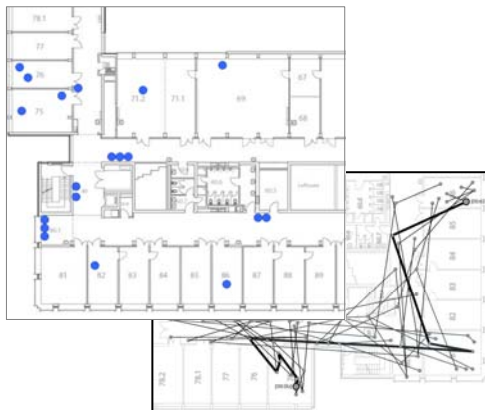


The diagram illustrates the JAWS toolkit's interaction with a target sensor network. A central laptop icon represents the monitoring station. A network of sensor nodes is shown, with a red arrow pointing from a sensor node to a detailed view of a sensor board. A red double-headed arrow indicates communication between a sensor node and a central hub.

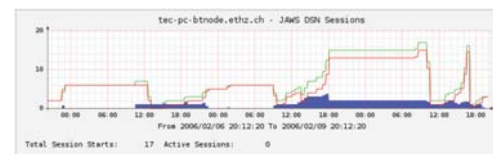
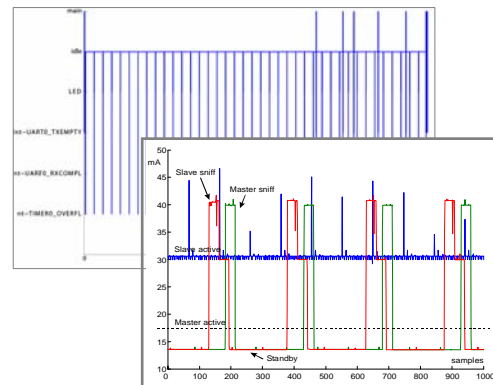
JAWS Application – Fire Sensor Networks

KTI Cooperation: CSEM – Siemens – TIK

Test Setup



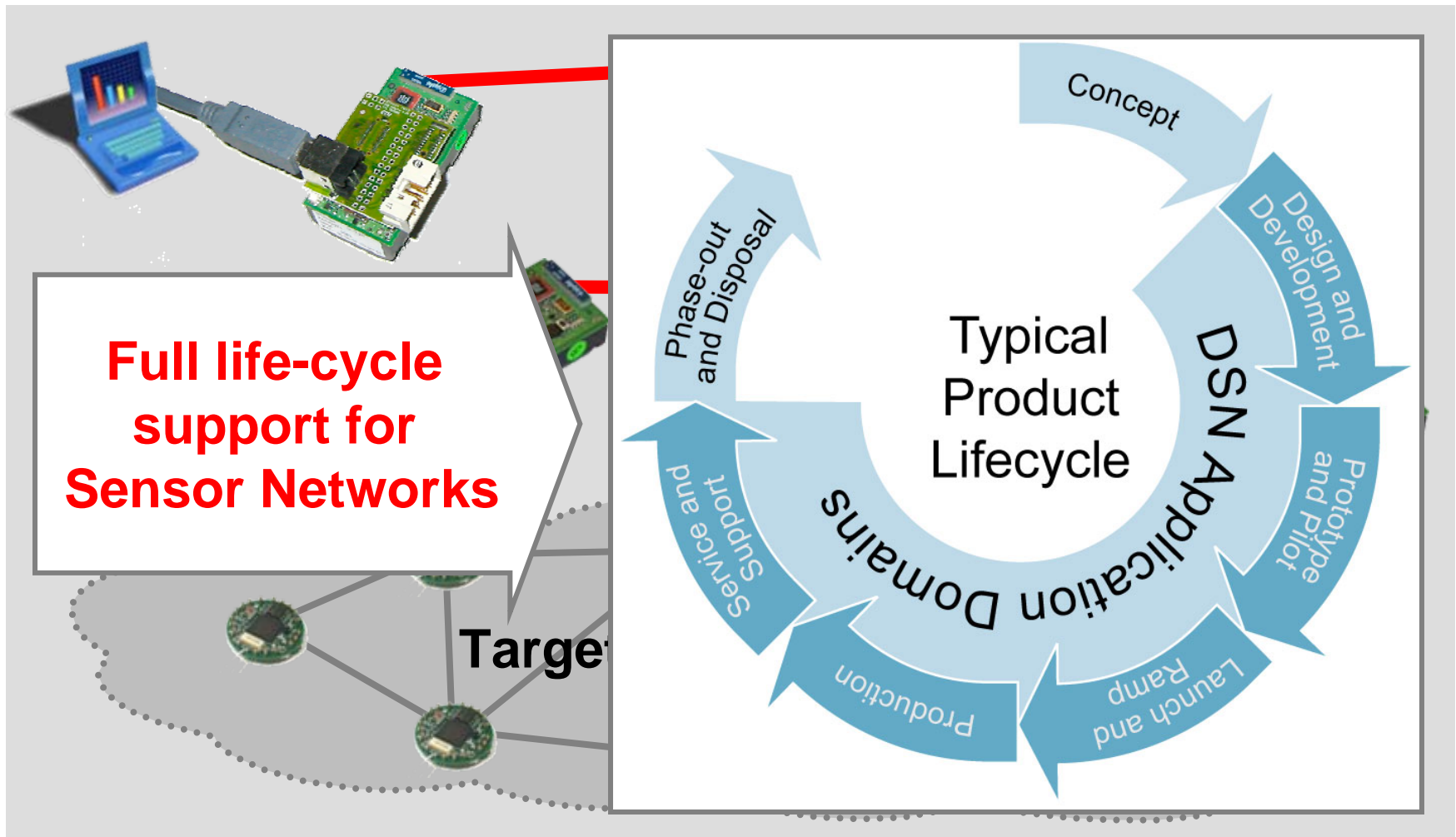
Development & Analysis



Field Testing



Deployment-Support – Closing the Loop...



Acknowledgements

BTnode Core Team

- Oliver Kasten, Marc Langheinrich, Matthias Ringwald, Kay Römer, Friedemann Mattern
- Philipp Blum, Matthias Dyer, Martin Hinz, Kevin Martin, Lennart Meier, Luca Negri, Mustafa Yucel, Lothar Thiele



Material used on this presentation is courtesy of

- Koen Langendoen (TU Delft), Prabal Dutta (UC Berkeley), Gilmann Tolle (UC Berkeley)

Related publications

- M. Dyer, J. Beutel, L. Thiele: *S-XTC: A Signal-Strength Based Topology Control Algorithm for Sensor Networks*. AHSP 2007.
- M. Dyer, J. Beutel, L. Thiele, T. Kalt, P. Oehen, K. Martin, P. Blum: *Deployment Support Network - A Toolkit for the Development of WSNs*. EWSN 2007
- J. Beutel: *Fast-prototyping Using the BTnode Platform*. DATE 2006
- J. Beutel, M. Dyer and K. Martin: *Sensor Network Maintenance Toolkit*. EWSN 2006.
- J. Beutel, M. Dyer, L. Meier, and L. Thiele. *Scalable topology control for deployment-sensor networks*. IPSN 2005.
- J. Beutel. *Robust Topology Formation using BTnodes*. Computer Communications 2005.
- J. Beutel, M. Dyer, M. Hinz, L. Meier, M. Ringwald. *Next-Generation Prototyping of Sensor Networks*. SenSys 2004.
- J. Beutel, O. Kasten, F. Mattern, K. Römer, F. Siegemund, and L. Thiele. *Prototyping wireless sensor network applications with BTnodes*. EWSN 2004.

To probe further...

BTnodes - A Distributed Environment for Prototyping Ad Hoc

Main :: Overview View Et

Overview

- Features
- BTnode Products
- History and Team
- Links

Documentation

- Installation
- Tutorials
- BTnut Software
- Hardware Reference
- TinyOS on BTnodes
- Tips and Tricks

Projects

- Jaws
- Sensor Network Museum

Development

- sourceforge.net
- CVS
- BTnut Build Status

Wiki

- Search
- WikiSandbox
- Recent Changes

[Edit Menu]

Welcome to the BTnode Platform

Latest News
 [2005-11-18]: [New Hor](#)
 [2005-10-29]: [Online U](#)
 [2005-06-07]: [BTnode](#)

Overview

The BTnode is an autonomous wireless communication and computing platform base microcontroller. It serves as a demonstration platform for research in mobile and ad and distributed sensor networks. The BTnode has been jointly developed at ETH Zu [Engineering and Networks Laboratory \(TIK\)](#) and the [Research Group for Distribute BTnode](#) is primarily used in two major research projects: [NCCR MICS](#) and [Smart-It](#)



The low-power radio is the same as used on the Berkeley Mica2 Motes, making the Mote and the old BTnode. Both radios can be operated simultaneously or be in deep when not in use, considerably reducing the idle power consumption of the device.

BTnode rev3 features at a glance

- Microcontroller: Atmel ATmega 128L (8 MHz @ 8 MIPS)
- Memories: 64+180 Kbyte RAM, 128 Kbyte FLASH ROM, 4 Kbyte EEPROM
- Bluetooth subsystem: Zeevo ZV4002, supporting AFH/SFH
- Scatternets with max. 4 Piconets/7 Slaves, BT v1.2 compatible
- Low-power radio: Chipcon CC1000 operating in ISM band 433-915 MHz
- External Interfaces: ISP, UART, SPI, I2C, GPIO, ADC,Timer, 4 LEDs
- Standard C Programming, TinyOS compatible

[Download Product Brief \(PDF\)](#) [rev3.22 2005-04-04]



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Main :: Purchase View Edit Print

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- NCCR-MICS WG2

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Purchasing

The BTnode products are available for purchase through a contract manufacturer:


- [Art of Technology](#), Zurich, Switzerland
- Sales Contact Fax +41-44-445 28 35
- Email btnode@art-of-technology.ch
- [Order form \[txt\]](#)

BTnode rev3

Pricing:

- USD 215/EUR165/CHF255 for samples
- larger quantities upon request

[Download Product Brief \(PDF\)](#) [rev3.22 2005-04-04]




BTnode rev3 Developer Kit

Contents:

- 2 BTnode rev3
- 1 usbprog rev2
- 1 Atmel ATAVRISP programmer
- 1 serial cable
- 1 USB cable
- 1 BTnode CDROM

Pricing:


- EUR500/CHF750



BTnode usbprog rev2

Pricing:

- upon request



<http://www.btnode.ethz.ch>