

# Mapping the Physical World into the Virtual World

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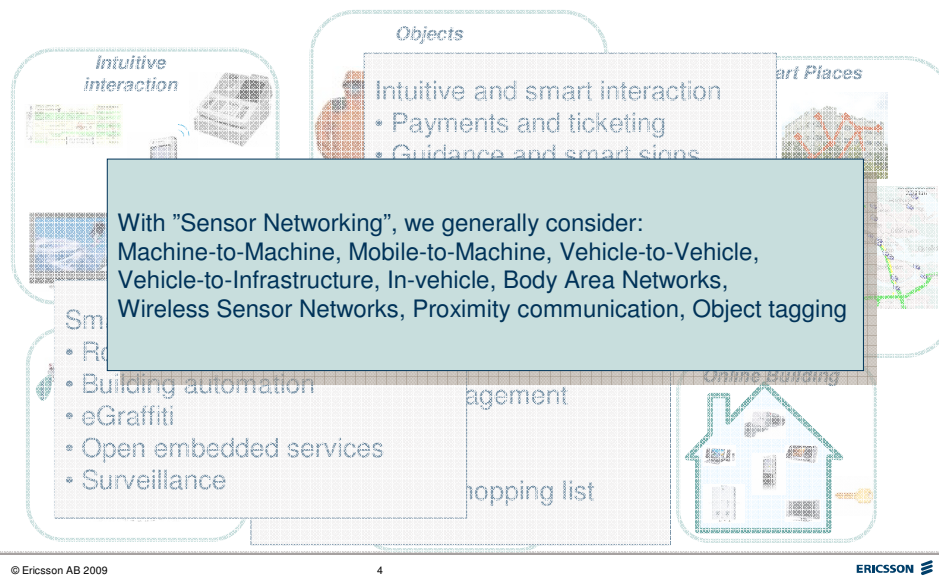
## Sensor Network research

- Traditional topics of WSN research
  - Radios
  - Operating Systems
  - Network Protocols
  - Energy Efficiency
- Fine, but this is just part of the big picture
- ***How are sensors networks going to be used?***
- The applications, use cases & scenarios will be a major driver of the "good old fashioned" WSN research

## Alternative Outlook

- We are not interested in
  - sensors and actuators
  - embedded computing issues
  - WSN research issues
- We are partially interested in gateways
  - to sensor networks as a demarcation point, and
  - how services of the physical world are triggered and exposed
- We are primarily interested in an infrastructure that
  - ties together the multitude of sensor and actuator deployments
  - exposes the collective set of services to be used by applications

## A few illustrative scenarios



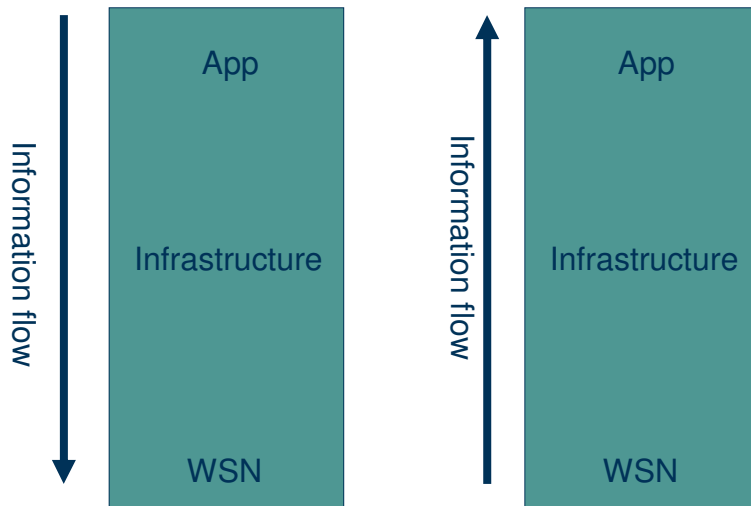
## Assumptions of a future M2M world

- We imagine a wide variety of sensor networks:
  - Heterogeneity in terms of manufacturers
    - OEMs / Re-sellers
  - Heterogeneity in terms of capability of sensors
    - CPU / Memory / Storage
  - Heterogeneity in terms of networking technologies
    - Zigbee / Wibree / Acoustic / Free Space Optics
  - Heterogeneity in terms of applications
    - Consumer / Enterprise / Security
  - Heterogeneity in terms of client devices
    - PCs / Mobile Phones / MIDs
- There's a pattern emerging! ☺

## Solution landscape

- An architecture is required, but which one?
- **Client/Server** a.k.a Two Tier architecture
  - Very common architecture
  - Easy to deploy
  - Foundation of the Web and much more
- Challenges to C/S
  - Management: How to manage many WSNs?
  - Scalability: Every app has a link to every WSN?
  - Security: Where to do AAA?
  - Service composition: Mashups which require more computational power than a mobile phone / MID?

## Client/Server silos



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## Solution landscape

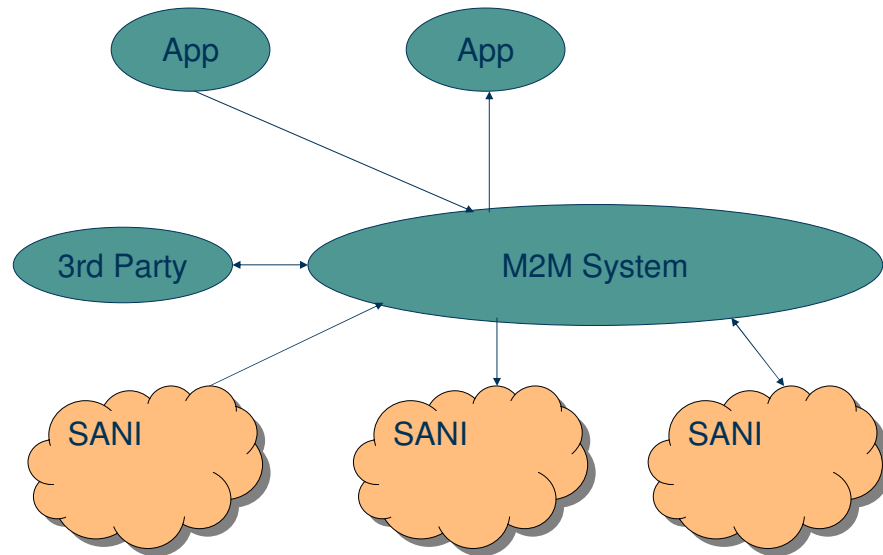
- An architecture is required, but which one?
- **Middleware** a.k.a Three Tier architecture
  - Also popular for distributed applications
  - Provides interoperability support by design
  - Adds extra complexity to the system
- Following advantages:
  - Management: central point to manage WSNs
  - Scalability: Many-to-many connections unnecessary
  - Security: central point natural place to do AAA
  - Service composition: Middleware infrastructure can be as powerful as necessary as it does not have to be mobile

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## Middleware "horizontalization"



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## The Horizontalization alternative

- Break the vertical silos apart into their components
- Data & services are now recombining without deploying a new silo
- Multiple stakeholders:
  - Users
  - WSN providers
  - Application service providers
  - M2M providers
- 3rd parties are brought into the game

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## What needs to be done?

- Standardized set of interfaces:
  - Interface from the application to the service providers
  - Interface between (3rd party) providers
  - Interface from the service providers to the WSNs
- Middleware architecture to mediate between WSNs and applications – **M2M System**
  - Layer of abstraction
  - Resolve high-level user queries to low level WSN calls
  - Combine information from multiple sources to present a coherent view to the user
- Some pieces of the puzzle already exist, e.g., AAA

## Demo scenario: Social Networking

- Social networking application: users which to ascertain the **mood** of other users of the system
- One user uses the application running on his mobile phone to access the Com2monSense infrastructure
- The C2S infrastructure then:
  - Parses the mood rules to work out what sensor information is required
  - Looks up in a Registry which sensors supply that information
  - Uses the results to query a database which is continuously updated with live sensor readings
  - These readings are placed into an ontology
  - Rules regarding mood are fired over the updated ontology
  - The result of the rule firing is then passed back to the user:
    - Positive / negative / neutral



## Conclusions

- GOFSSNR important & useful but it's not everything
- How WSNs will be used in the future is both interesting and important
  - M2M communication is already out there in the real world
- Vertical silos are not a good long-term solution
- Break them apart and expose their data and services for reuse and recombination
- M2M layer required to enable this "horizontalization"
- Prototyping work already underway
- EU FP7 "SENSEI" project started Jan 2008

