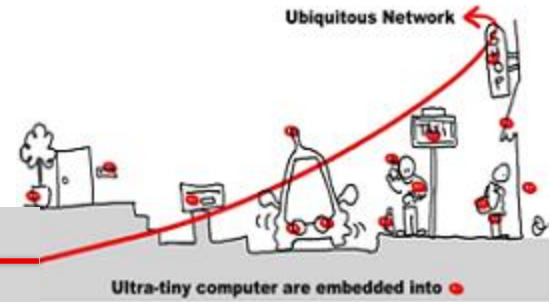


Middleware for Ubiquitous Computing



- Middleware ... from distributed systems to network of things.

Main Instructor : Ass. Prof. Jean-Yves Tigli

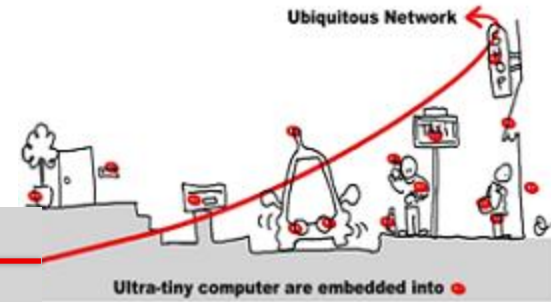
<http://www.tigli.fr>

at Polytech of Nice - Sophia Antipolis University

[Email : tigli@polytech.unice.fr](mailto:tigli@polytech.unice.fr)



Network of Things and Devices: Ubiquitous Computing



■ [Mark Weiser 1991]

« *Silicon-based information technology, is far from having become part of the environment.* »

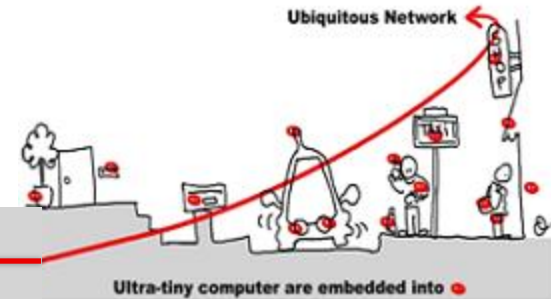


Scientific American,
Vol. 265 N.9, pp. 66-75, 1991

*Ubiquitous applications used
everyday life connected objets
and devices*

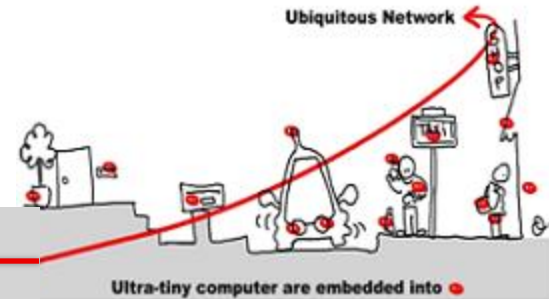


Early ubiquitous applications



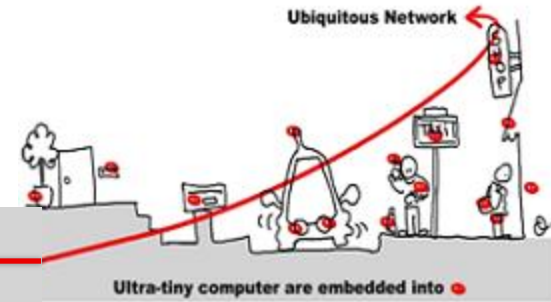
- Smart Objects and Devices are well-known at Design time, Embedding for smart control
 - Embedded systems for cars, airplanes, etc
- First Ubiquitous Application are generally Ad-Hoc applications without middleware, creating new computing devices
 - Hi-tech, silicon-based gadgetry, e.g. PDAs, cell phones, mp3 players, active displays

Four reasons for UbiComp [Friedemann Mattern]



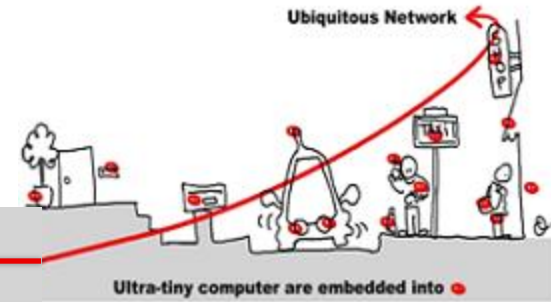
- First Reason for Ubiquitous Computing: Moore's Law (1965)
- Second Reason: New Materials
- Third trend : Progress in Communication Technologies
- Fourth reason: Better Sensors
- Then ... Smart Objects
- All trends together lead to a New Era

First Reason for Ubiquitous Computing: Moore's Law (1965)



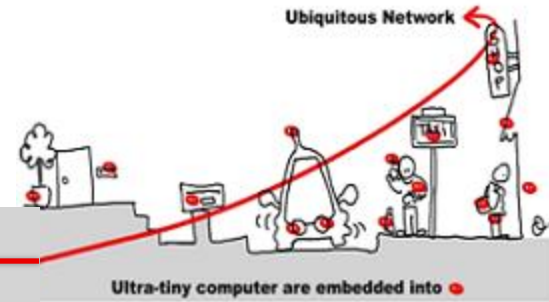
- Generalized Moore's Law :
 - Most important technology parameters double every 1 – 3 years:
 - computation cycles
 - memory, magnetic disks
 - Bandwidth
- Consequence:
 - scaling down

Second Reason: New Materials



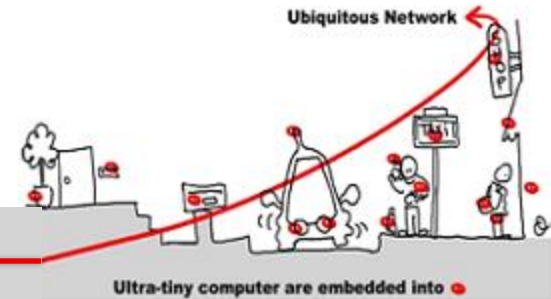
- More recently: semiconductors, fibers
 - information and communication technology
- Organic semiconductors
 - change the external appearance of computers
- « Plastic » laser
 - opto electronics, flexible displays,...

Third trend : Progress in Communication Technologies



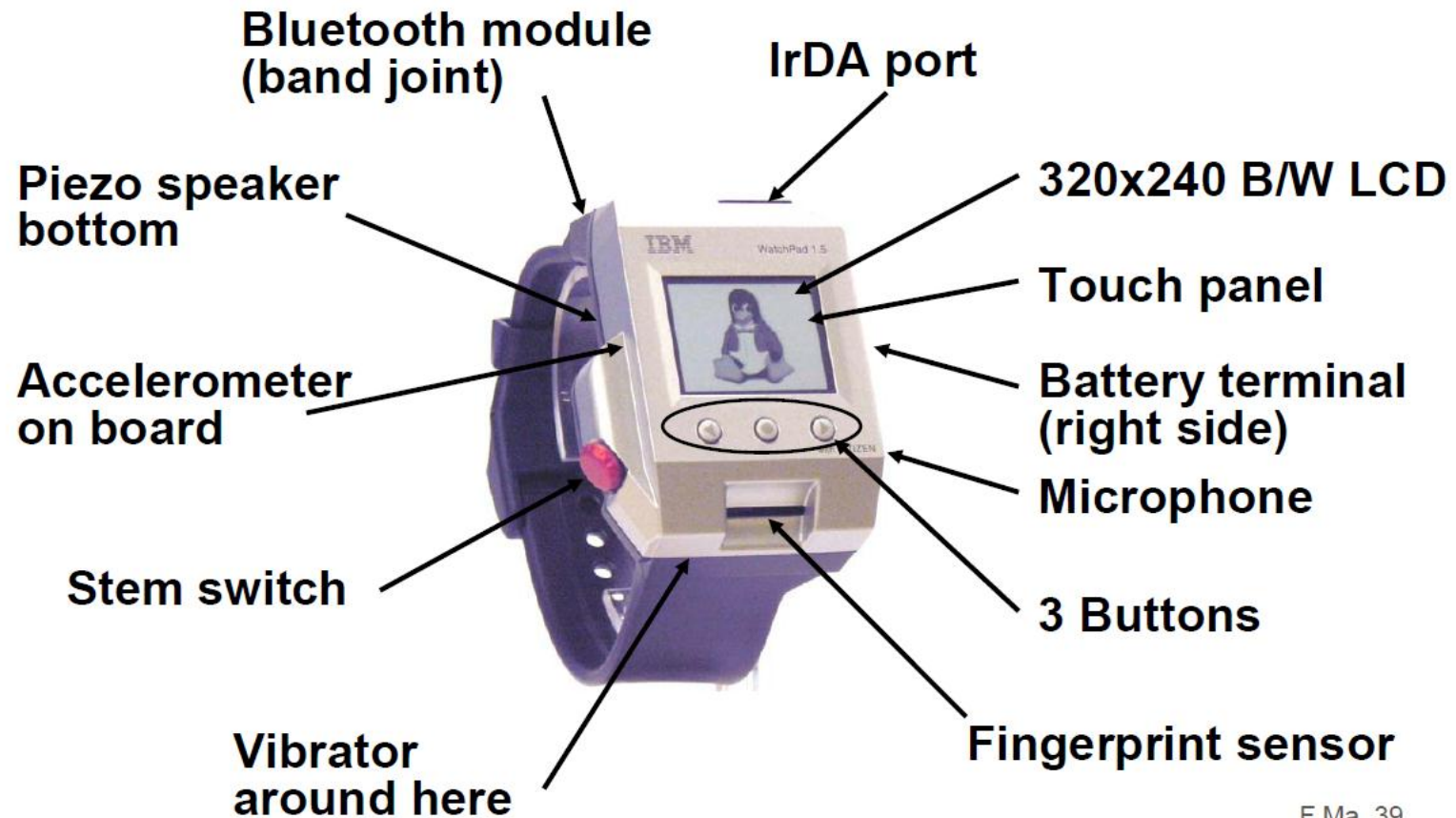
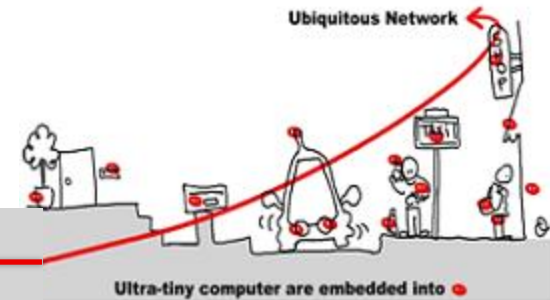
- Fiber optics: from Gbit/s to Tbit/s
- Powerline technique
 - coffee maker « automatically » connected to the Internet
- Wireless
 - mobile phone: GSM, UMTS
 - wireless LAN (> 10 Mbit/s)
- Body area networks

Fourth reason: Better Sensors



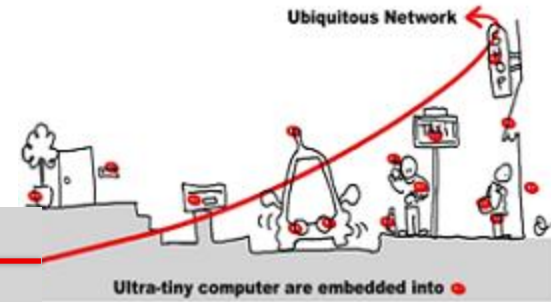
- Very small cameras and microphones
 - pattern recognition, assisted by heuristics (« user is in a meeting... »)
 - speaker recognition, speech controlled devices
- Fingerprint sensor on mobile objects
 - (« we already know this guy »)
- Many other types of sensors (e.g., « location »)

Then ... Smart Objects



F.Ma. 39

All Trends Together... lead to a New Era

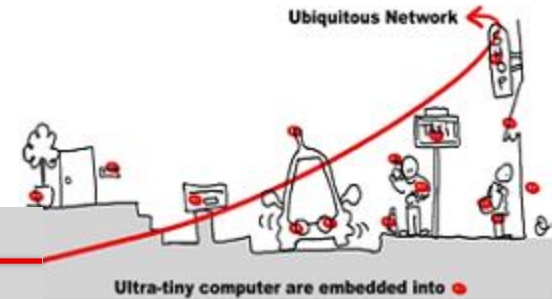


- Progress in
 - computing speed
 - communication bandwidth
 - material sciences
 - sensor technology
 - computer science concepts
 - miniaturization
 - energy usage
 - battery techniques
 - display technologies
 - price
 - ...

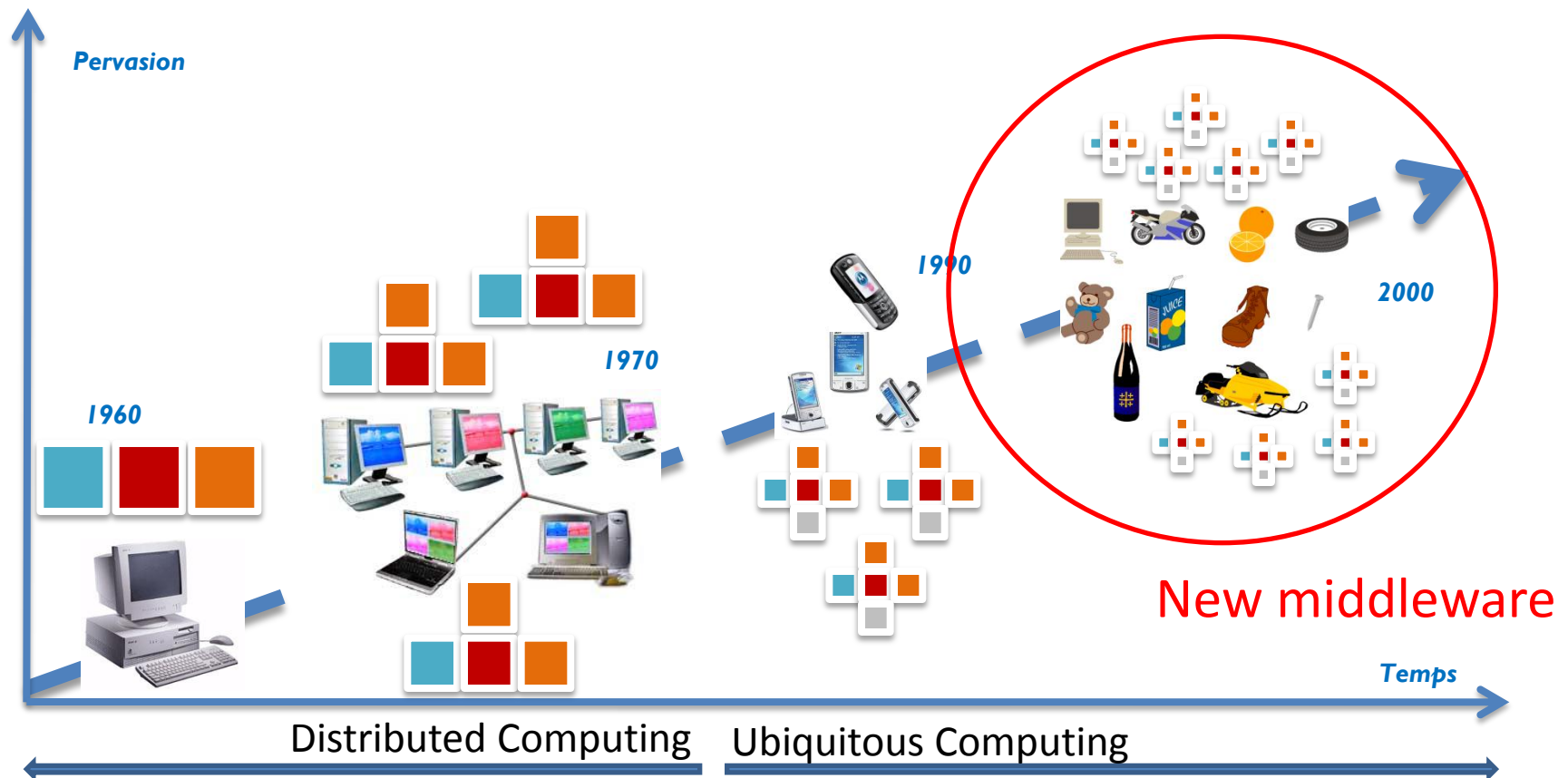
Lead to :

- Ubiquitous Computing
- Pervasive Computing
- Ambient Intelligence
- Disappearing Computer
- Invisible Computing

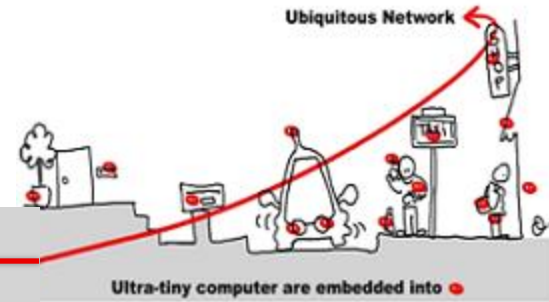
Then network of Things ...



- From distributed systems to network of things...

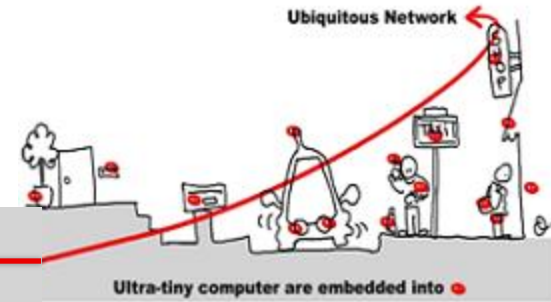


Some new issues and new challenges for middleware



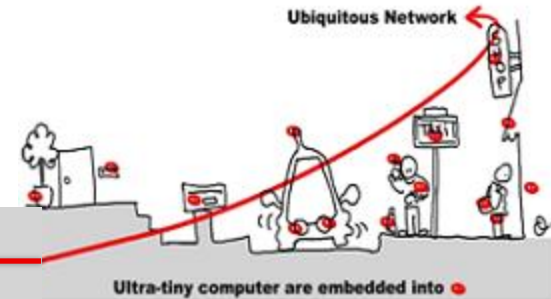
- Reference : A Perspective on the Future of Middleware-based Software Engineering.
 - V. Issarny, M. Caporuscio, N. Georgantas. In Future of Software Engineering 2007 (FOSE) at ICSE (International Conference on Software Engineering), IEEE-CS Press. 2007.
- UbiComp scientific community issues and Challenges
 - User mobility
 - User intent
 - Context awareness and adaptation
 - Delegation
 - High-level energy management
 - Privacy and Trust

User mobility and User intent



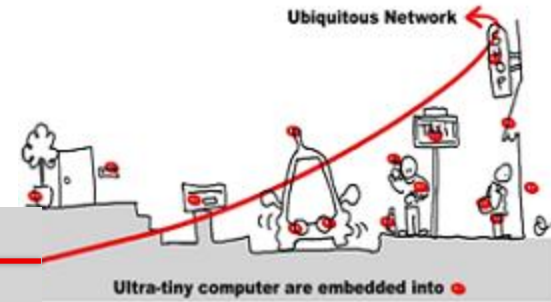
- User mobility
 - In relation with “everywhere” and “everytime” accessibility, the system should allow user mobility providing **support for mobile networking and information access**.
- User intent
 - with respect to making technologies “disappearing”, the **system shall have the ability of capturing, tracing and exploiting the users’ intents** in order to anticipate their need and proactively provide assistance.
 - At the design level of the system : from end user programming to zero-interaction

Context awareness adaptation and delegation



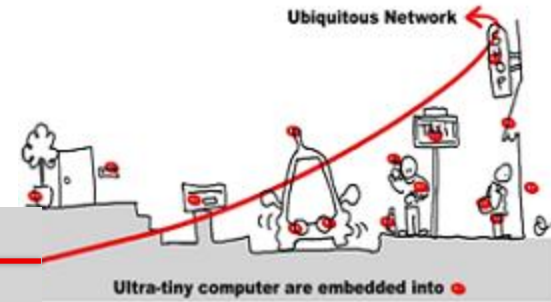
- Context awareness adaptation
 - the system shall be able to sense the context and possibly adapt its behavior accordingly so that users always experience the best quality possible (e.g., changing the user interface modality from speech to text display on the user's handheld in a noisy environment).
- Delegation
 - ubiquitous computing environment is typically composed of highly heterogeneous digital resources, with possibly limited computing and communication capabilities. Still to make computing capabilities always available, the system should support delegation of computing tasks from tiny-scale to wealthy resources.
 - From smart object and device to the cloud ...

High-level energy management, Privacy and Trust



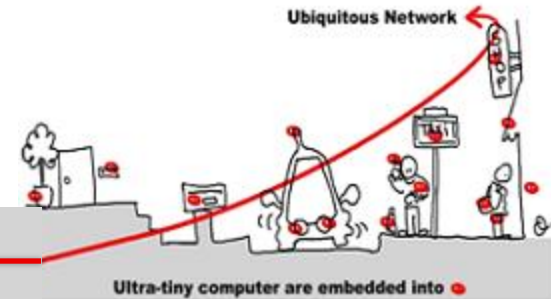
- High-level energy management
 - A key enabler of ubiquitous computing is wireless networking. However, this makes **energy a critical resource**, which needs to be managed comprehensively, possibly leading to dynamically adapt computation.
 - From device autonomy to Green-IT
- Privacy and Trust
 - Satisfying the requirements listed above needs intensive management and spreading of user information. This requires both to trust the environment and **to assure privacy** in order to avoid undesired use of sensitive data.

Extended definition of Middleware

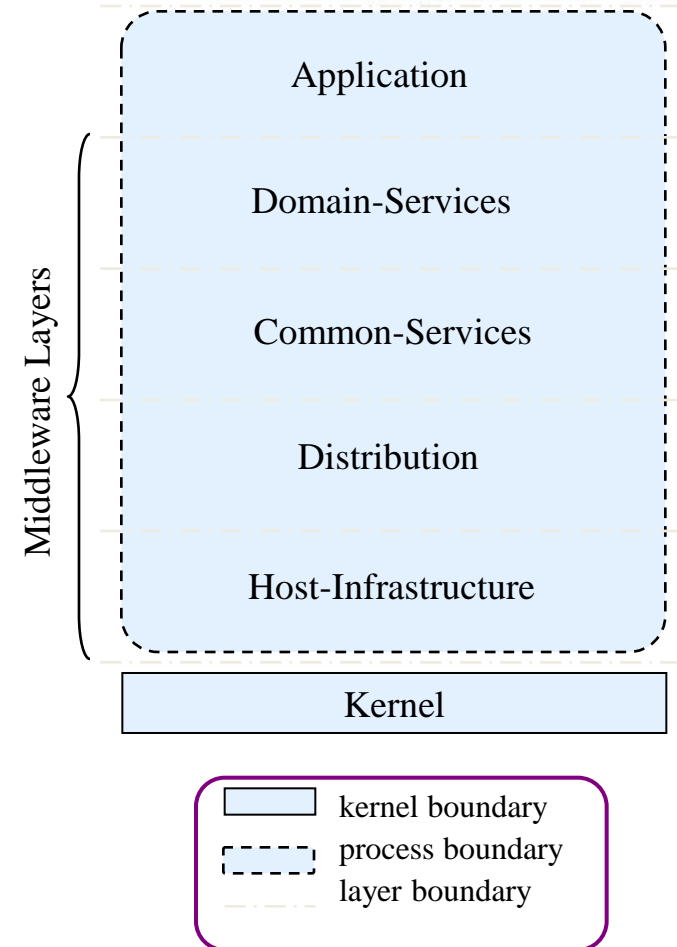


- From distribution to other functionalities...
- *...middleware is a general term for any programming that serves to "glue together" or mediate between two separate and usually already existing programs.*
- Not only for distribution but also to manage other requirements ...

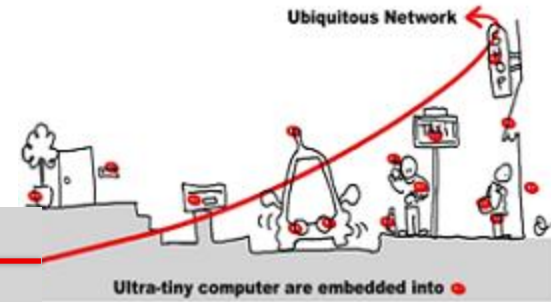
Exemple : R. E. Schantz and D. C. Schmidt Taxonomy (2002)



- Schantz and Schmidt decomposed middleware into four layers:
 - Domain-Services
 - Tailored to a specific class of distributed applications
 - Common-Services
 - Functionality such as fault tolerance, security, load balancing and transactions
 - Distribution
 - Programming-language abstraction
 - Host-Infrastructure
 - Platform-abstraction

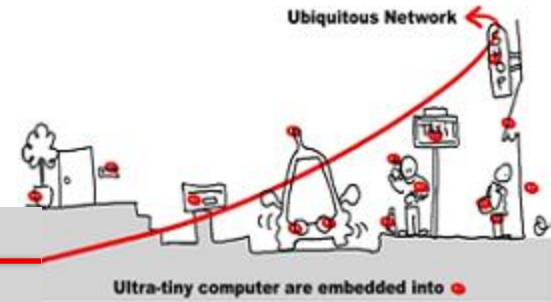


SoM for Device, New Service oriented Middleware



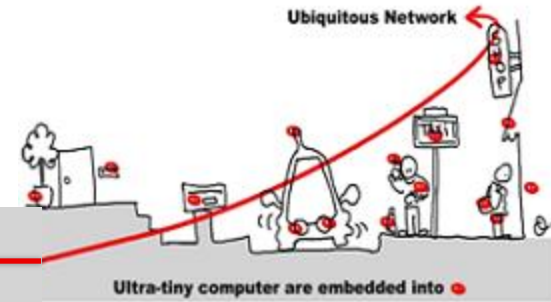
- Remember from the lack of SoM
- Web Service standards for Device
 - data values from sensors
 - lightweight software
- Interaction pattern « one to many »
- Interaction pattern based on « notification »
- Dynamic joining and leaving

Event based interaction pattern



- First Requirements :
 - System requirement : Ubiquitous Applications applications are continuously interacting with a real world
 - Design requirement : Smart objects and devices must be able to communicate spontaneous information from the environment to the application
 - Software requirement : Software application must be event-driven
- Before Adaptive Middleware Layer ...

New services standard : Heterogeneity of Devices



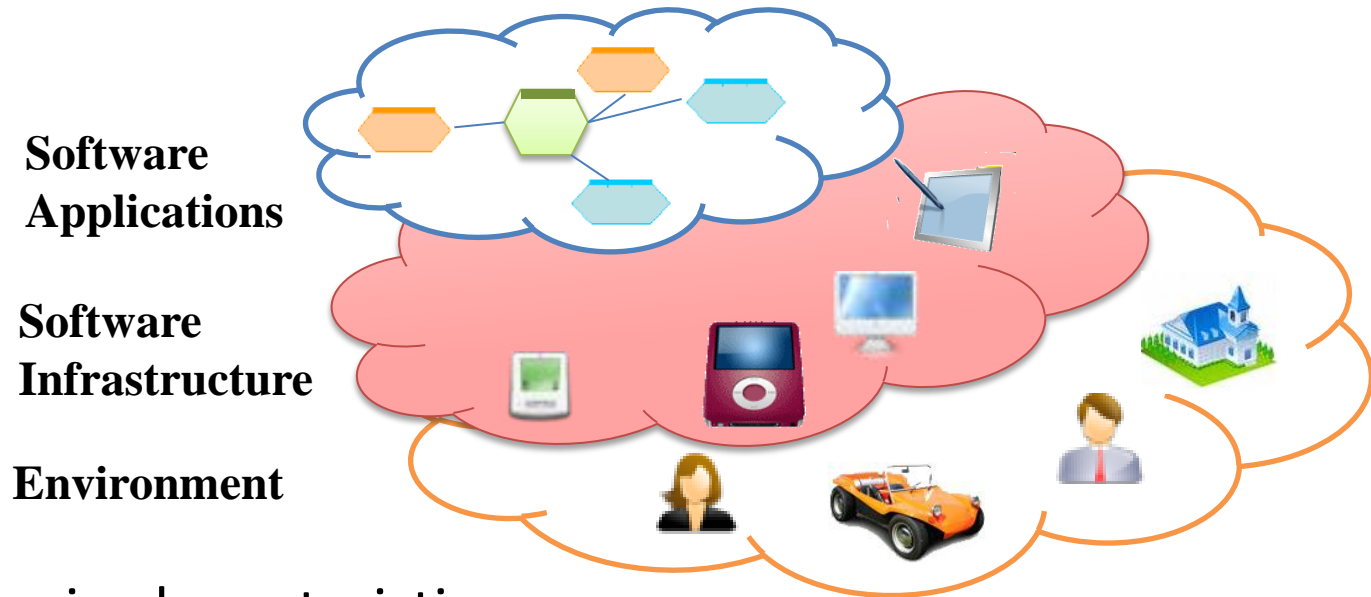
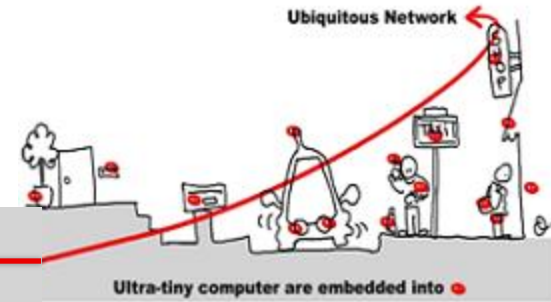
- **Technological Heterogeneity** of smart objects and devices
 - Numerous software and network technologies



- But also **Semantic Heterogeneity**
 - Various Smart Objects and Devices (sensors, mobile phones, ..., coffee machine, mug ...)
 - Variation of capabilities between them (ex. from J2ME to JSRs in mobile phones)

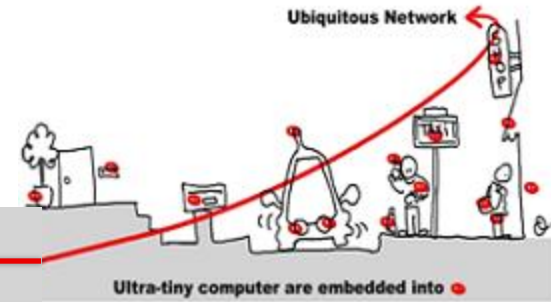


Main Ubiquitous Computing Characteristics



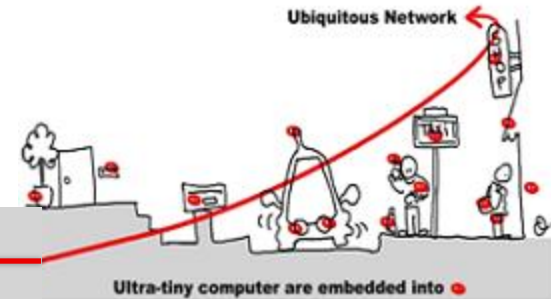
- Three main characteristics are :
 - Use embedded devices in a real environment
 - Deal with Multiple Heterogeneous Devices
 - Deal with Highly Dynamic variation at Runtime

Dynamic joining and leaving



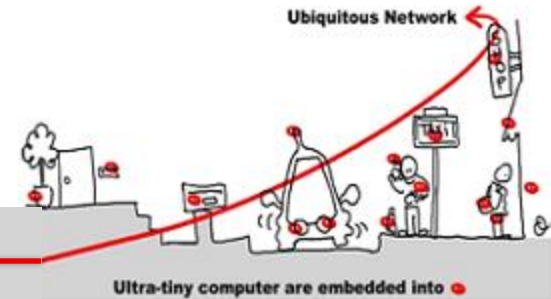
- Mobility => Deal with dynamic appearance and disappearance of smart objects and devices
- Mobility => Deal with dynamic composition (at runtime)
- Then new SoM functionalities ...

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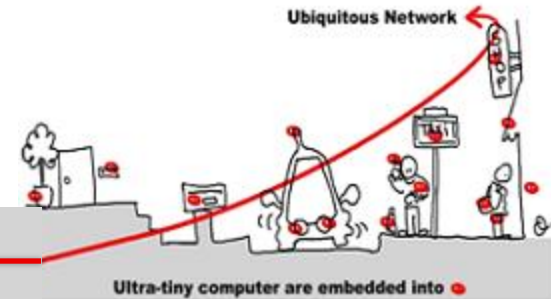
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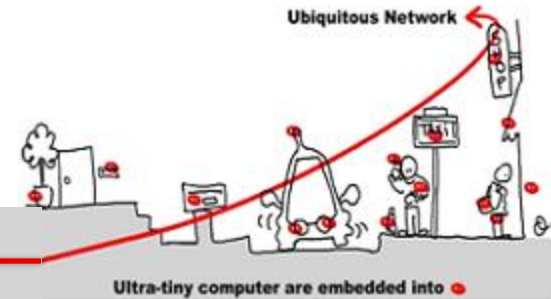
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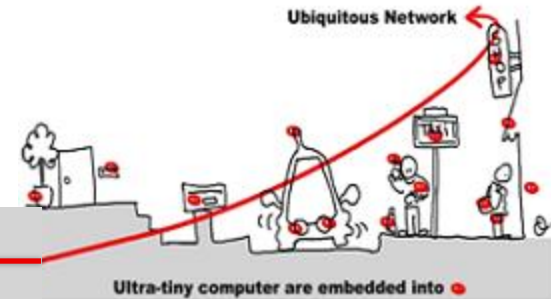
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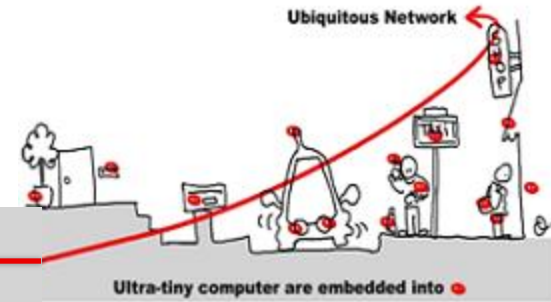
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