

Wireless Internet — Challenges and Solutions

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Presentation Outline

- **What is Wireless Internet**
- **Current Practice**
- **Research Challenges**
- **Solutions from University of Helsinki**
- **Other Players**

What Is Wireless Internet?

- Various visions proposed:
 - **Mark Weiser** spoke about *invisible computing* and *ubiquitous computing*
 - **Leonard Kleinrock** speaks about *nomadic computing*
 - **Satyanarayanan** speaks about *pervasive computing*
 - **European Commission** speaks about *ambient intelligence*
 - **Wireless World Research Forum** speaks about *adaptable personalised ambient-aware services*

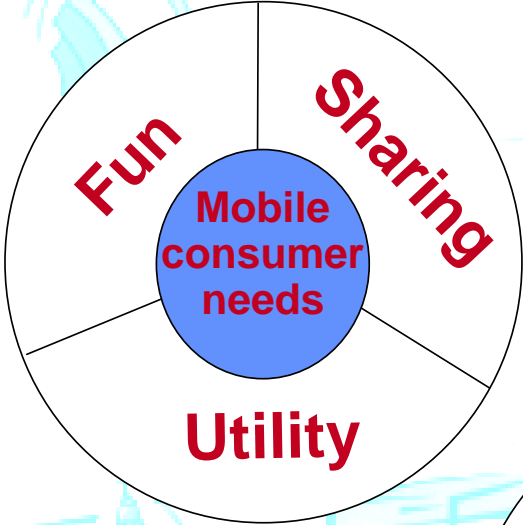
European Virtual Center for Wireless Internet

- **Merger of mobile communications and the Internet**
 - new technologies, business models, and business opportunities
- **This transition will be much more challenging than the transition from fixed lines to mobile phones in voice services**
 - due to the diversity in application requirements
- ***Wireless Internet is more than just Internet access from a mobile device***
- **Wireless Internet will also be used to control our lives and give us more time to do the things we choose to do**
- **An evolutionary path may be possible but we must also be ready for a revolution**

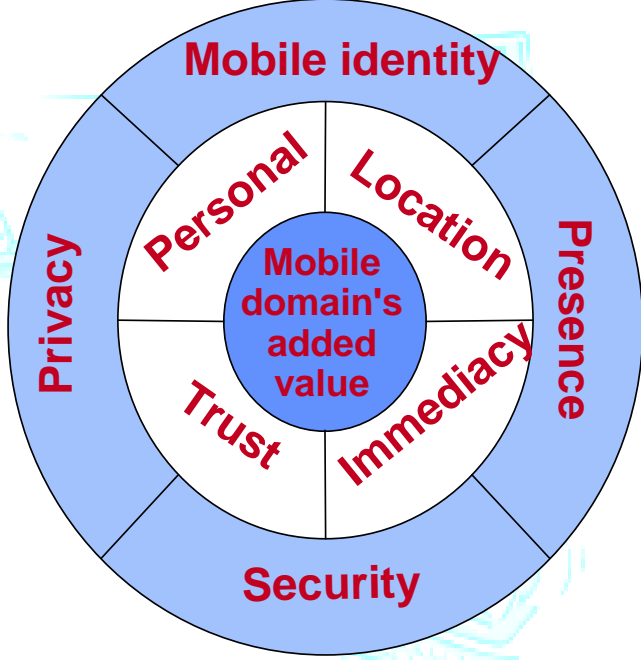
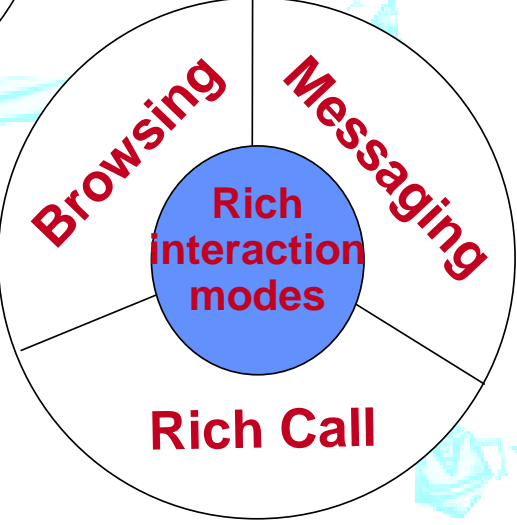
Nokia Vision

Fundamental consumer needs...

+ mobile domain's added value



+ added value from rich and consistent interaction modes



What is Wireless Internet?

- Nobody really knows today but
 - more than Internet access from mobile devices
 - increased intelligence in the network
 - ***but Artificial Intelligence has failed many times***
 - most probably a combination (not a union) of all published visions

What is the killer application?

- Most probably there will not be a killer application
- A trend seems to be divergence
 - in spite of the hype of convergence
- The killer might be managing divergence
 - heterogeneity in technology
 - differences in consumer cultures
 - Asia, Europe, and North America are different
 - South America, Africa, Oseania ...

Current Practice

Internet

GSM, GPRS, WLAN

Agent Technology

Mowgli

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Current Practise

- **Mixture of Internet and traditional telecommunications protocols**
 - Trend towards all IP
- **Various service and application frameworks and platforms: MIDDLEWARE**
 - ever-faster service development and deployment
- **Middleware solutions (e.g., CORBA, J2EE, J2ME) provide much better programming models than Internet APIs**
- **Multiple middleware solutions will be used in the near future: One size does not fit all**

TCP-HTTP-XML Dilemma

- Baseline TCP behaves poorly on transmission paths containing both wireless and wired links
 - promising progress in IETF
- HTTP is one of the best examples of using TCP capabilities in an extremely inefficient manner
 - some proprietary improvements proposed
- XML is verbose and expensive to process
 - why human readable presentation on wire if no human is reading or writing it
 - XML Protocol Activity (SOAP) in W3C is of crucial importance

Research Challenges

Internet

GSM, GPRS, WLAN

Agent Technology

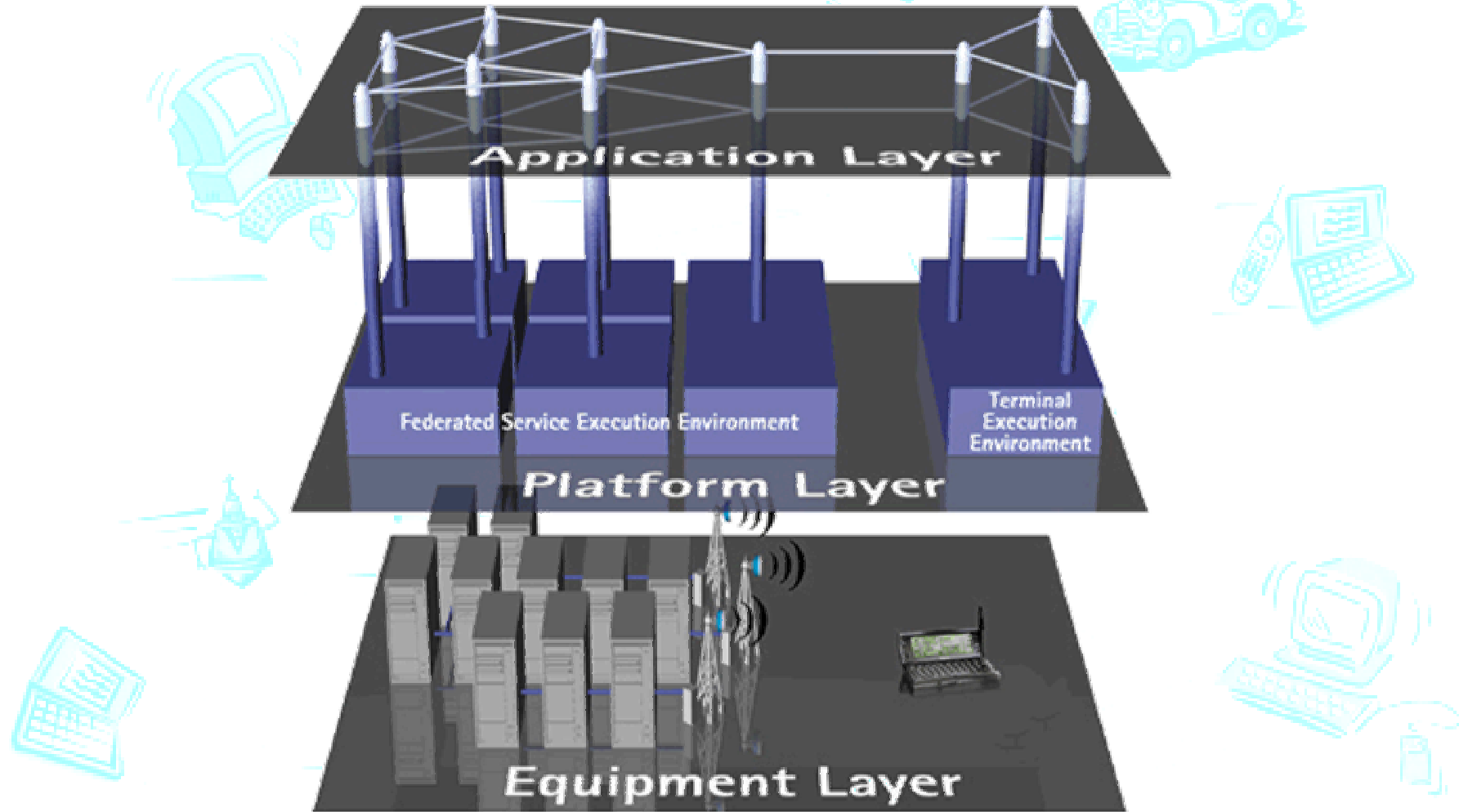
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Future Mobile Applications

- communication characteristics
 - The most significant feature will be diversity.
 - All kinds of applications will be in use.
 - QoS requirements and communication patterns will be numerous.
 - Some applications will also adjust their behaviour according to the properties of connectivity.
 - Future mobile terminals will have a few applications simultaneously active.
 - Some terminals will also be able to use different access technologies either simultaneously or one at a time.

Mobile Distributed Application



Research Challenges

1. Adaptability
2. Efficient and Always-On Connectivity over Wireless Links
3. Distribution, Partitioning, Reconfiguration
4. Context Awareness
5. Mobile Distributed Information Base

Not an orthogonal division:

- A research issue appears in more than one challenge

1: Adaptability

- Adaptability means that
 - when the circumstances change, then the behavior of an application changes
- Research items in adaptability:
 - learning wishes and desires of a user
 - knowledge partitioning and combination
 - proactive actions \Rightarrow short-term predictions
 - environment monitoring to detect essential changes

2: Wireless Communication

- Air link is and will remain narrow and error-prone
- Optimization on all levels is necessary
 - link, network and transport layers
 - messaging layer
 - communication languages
 - interaction protocols and patterns
- Research issues:
 - Quality-of-Service in wireless and mobile systems
 - Group communication
 - Multicast
 - Mobility management: terminal mobility, personal mobility, session mobility

3: Distribution, Partitioning, Reconfiguration

- Issues:
 - partitioning of applications
 - placement of different co-operating parts
 - decision rules for redistribution
 - ***detection of essential and persistent changes***
- New kind of fault-tolerance is needed:
 - replication is not sufficient alone
 - baseline applications must remain operational, at least in a tolerable manner, even if some services of the underlying execution environment cannot be utilized

3: Distribution, Partitioning, Reconfiguration

- End-user system instead of end-user device
- This “FuturePhone” will be the core of the personal computing and communication system
 - probes its surroundings looking for suitable peripheral devices
 - dynamically builds up the most appropriate end-user system that can be auto-configured
- Research issues:
 - simultaneous ad-hoc networks
 - profiles, various kinds of context, roles and trust
 - authentication, authorization, and delegation

4: Context Awareness

- Context: the physical and social situation in which computational devices are embedded
- Goal: to acquire and utilize information about the context of a mobile device to provide personalised services that are appropriate to particular people, place, time, and events
- ***Almost any information available at the time of interaction can be seen as context information***
- Context-awareness means that one is able to use context information

4: Context Awareness

- Research issues:
 - extraction of context information
 - interpretation of context information
 - reasoning about the current contextual situation
 - adaptation of application behaviour
 - ways to express which pieces of information belong to the context
 - distributed data management is an essential enabler of context-aware applications

5: Mobile Distributed Information Base

The background features a light blue, sketchy illustration of various mobile devices and communication elements. It includes a satellite dish, a car with a mobile phone antenna, a laptop, a mobile phone, a desktop computer, and a handheld device, all connected by faint lines suggesting a network or data flow.

- Distributed and replicated world-wide information storage
 - data consistency
 - efficient and reliable access
 - high availability
 - costs, performance
- Intelligent synchronization after disconnections
- Shared access and transactional operations

Solutions from University of Helsinki

Internet

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NODES Group

- 3 professors
- 8 lectures
- c. 25 researcher in projects
 - c. 15 M.Sc students
 - c. 10 Ph.D. students
- c. 15 Ph.D. students in industry

Motto:

*Any technology distinguishable from
magic is insufficiently advanced.*

Gregory Benford

RESEARCH AREAS (The NODES Group):

***Wireless Internet, Distributed Software Systems, Formal Methods for
Protocol Development, Linux Development***

- **Studies how systems can be divided into independently working parallel parts, and how these parts communicate with each other**
 - **Functionality in the basic components,**
 - **the protocols between the parts,**
 - **performance evaluation**

Some NODES Research Topics

- **Wireless Internet**

- Communication over wireless (all protocol layers)
- Middleware for mobile computing

- **Linux Developments**

- Timeliness and high availability in Linux
- Open Source Middleware for Linux OS

- **Standardization**

- IETF, OMG, W3C

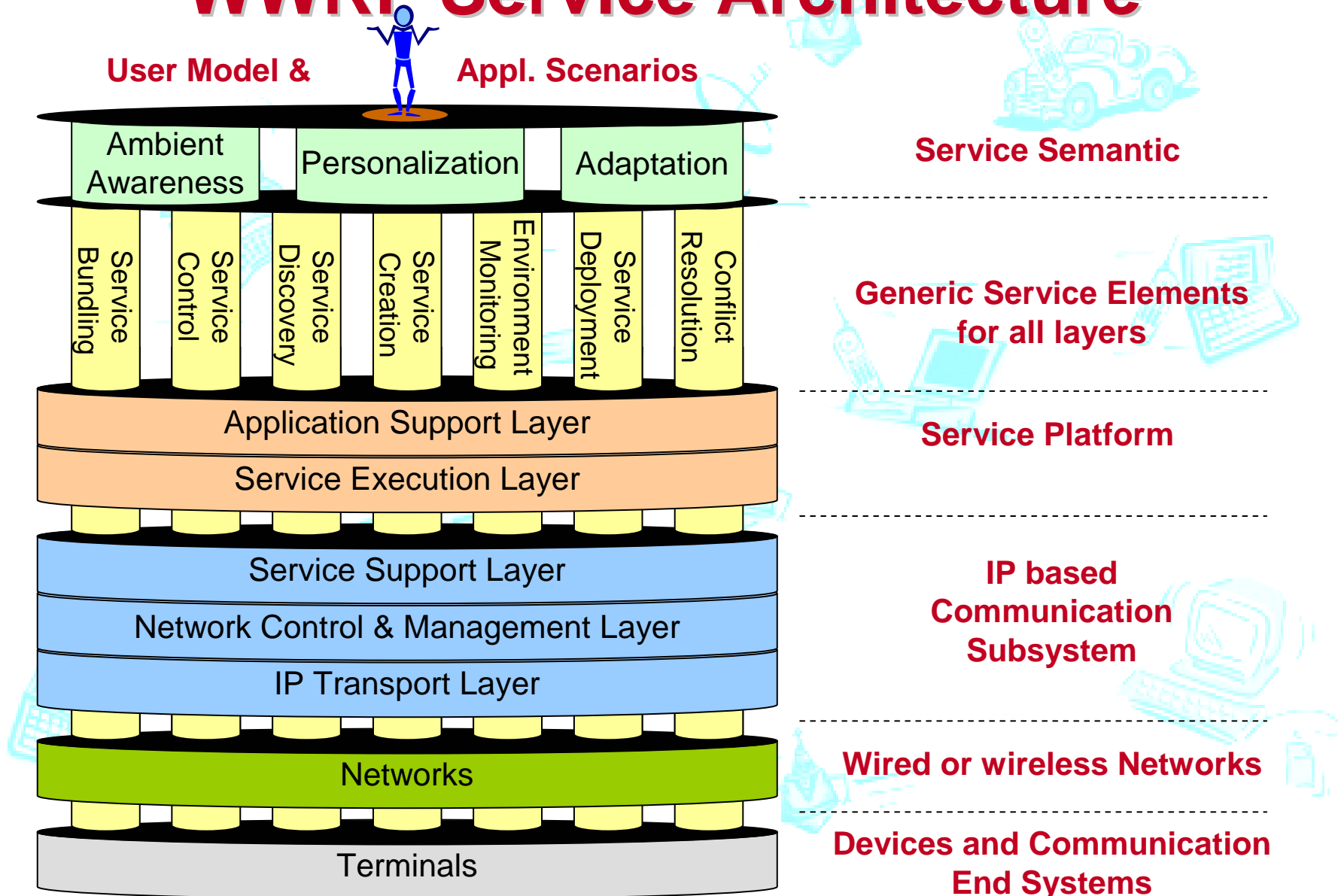
NODES Contributions to Wireless Internet

- Improved Wireless Communication
 - TCP enhancements: *RFCs, Internet drafts, and Linux kernel*
 - Localized RSVP for resource allocation in access network alone: *Internet draft*
 - IP QoS in access networks using DiffServ
 - Wireless CORBA: *OMG standard*
 - Wireless JAVA RMI: *standardization under evaluation*
 - Efficient Agent communication: *FIPA standard*
 - TCP-friendly Adaptive Link Layer protocol for satellite links: *under construction in an ESA project*
 - SOAP for wireless links: *under construction*

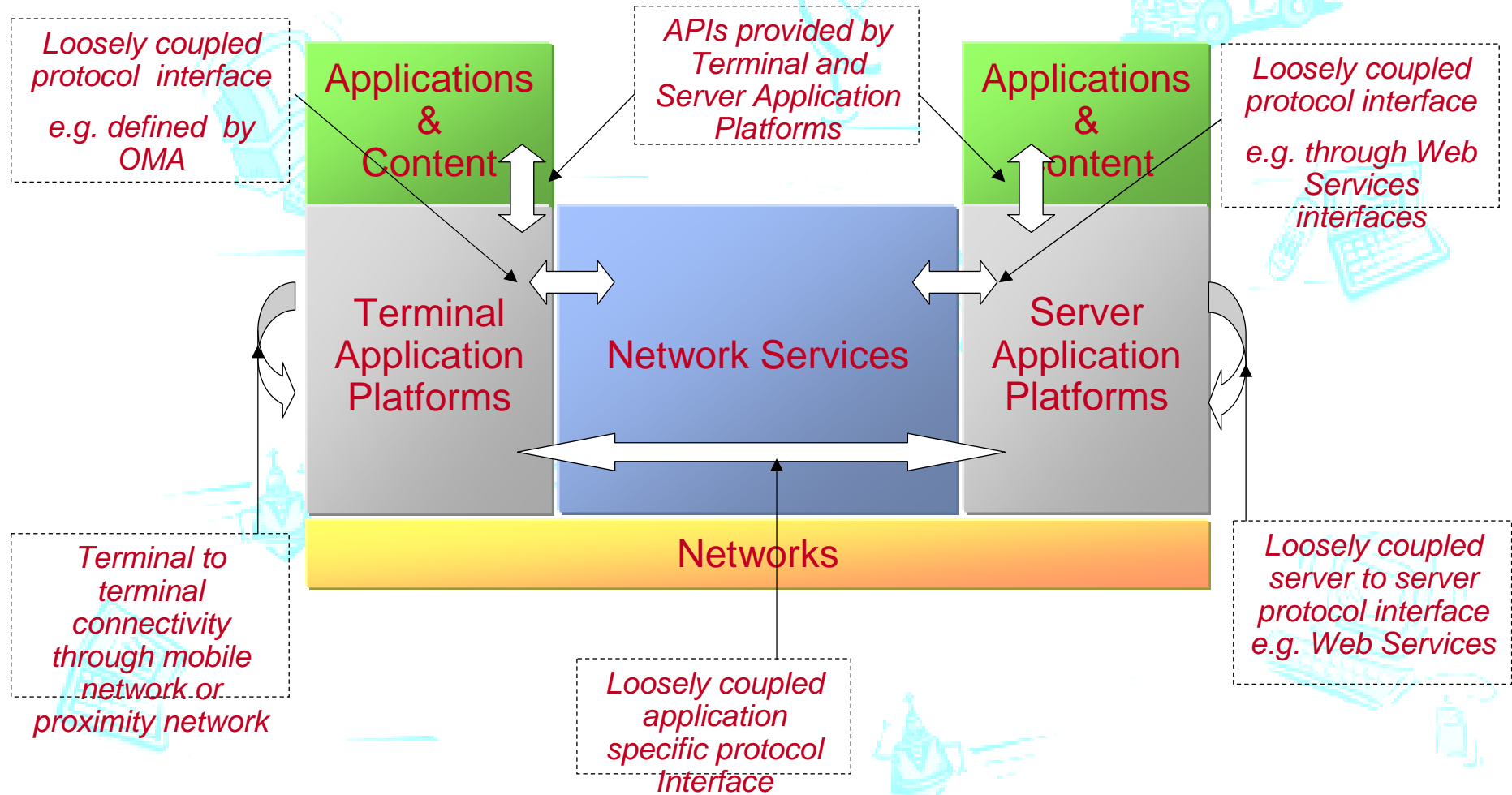
NODES Contributions to Wireless Internet

- ***Middleware for Mobile Computing***
 - ***Contributions to WWRF Service Architecture***
 - ***Preliminary results***
 - Mobile distributed event system
 - Mobile distributed file system
 - Mobile presence
 - Metadata investigations
 - Studies on session concepts

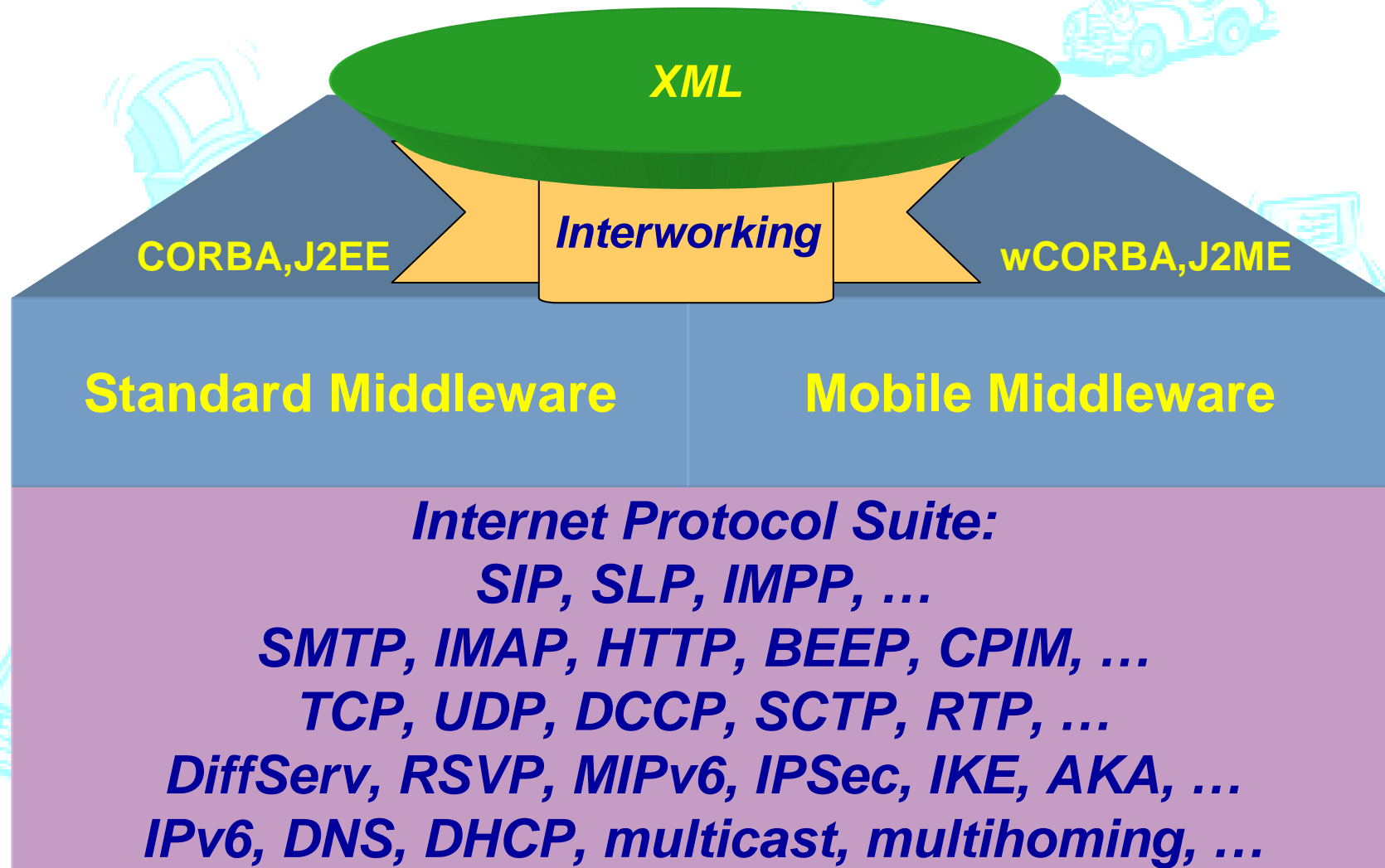
WWRF Service Architecture



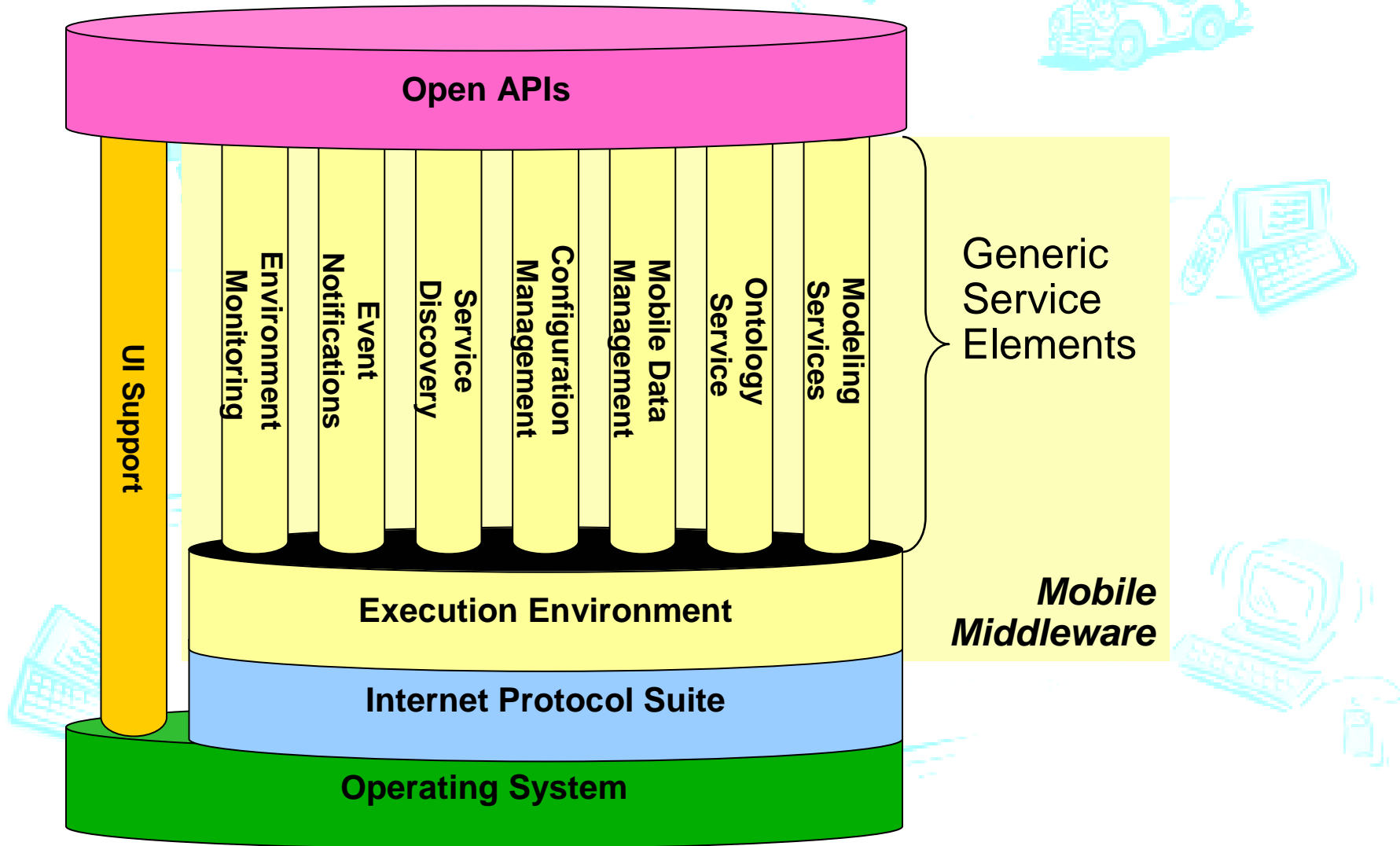
OMA Architectural Framework



NODES Vision on Wireless Internet



Mobile Middleware



Highlights of Project Results

Internet

GSM, GPRS, WLAN

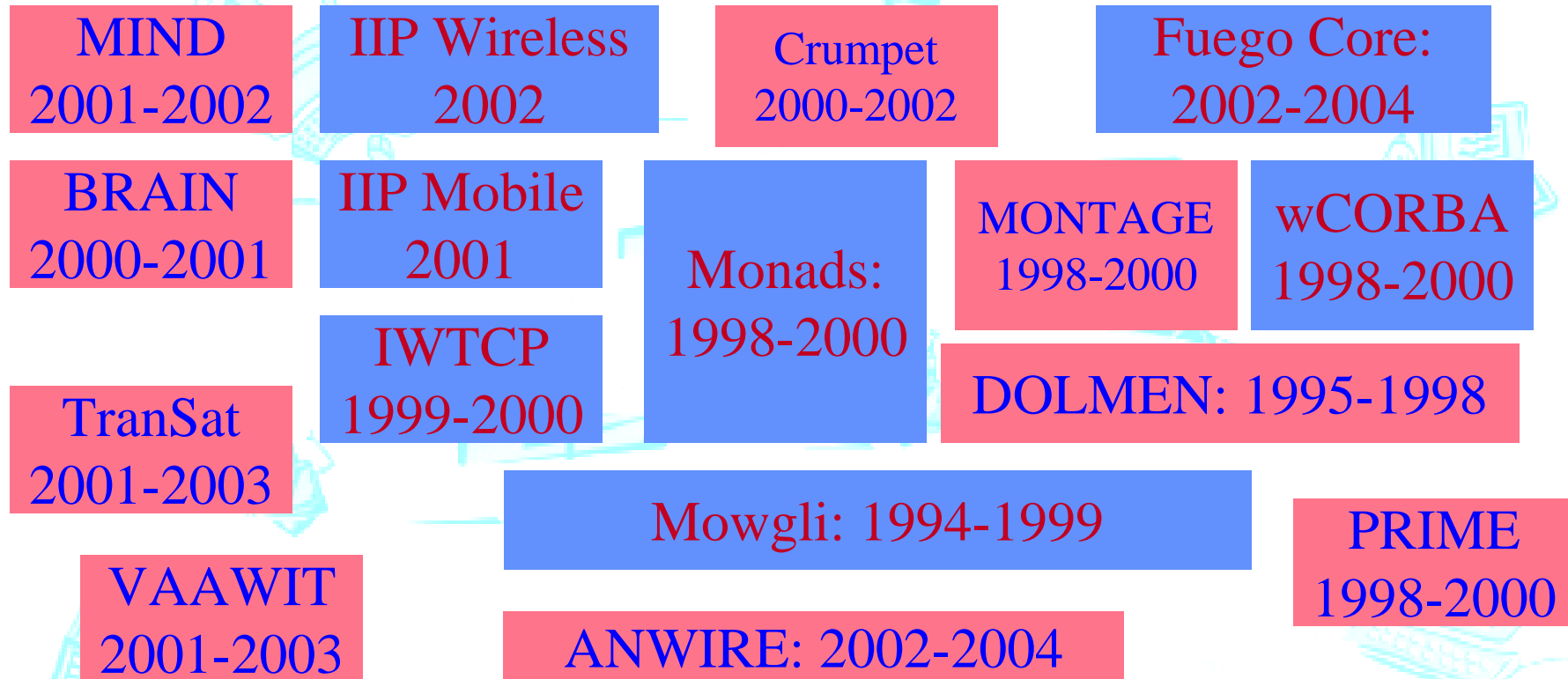
Agent Technology

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Wireless Internet Project Family

Involvement in WWI and other FP6 initiatives



<http://www.cs.Helsinki.FI/Kimmo.Raatikainen/#projects>

Mowgli

- Phase I: 1994-1997
- Phase II: 1998-1999
- Partners:
 - Digital (Phase I)
 - Nokia (NTC, NMP, NRC [Phase II])
 - Sonera
 - SSH (Phase II)

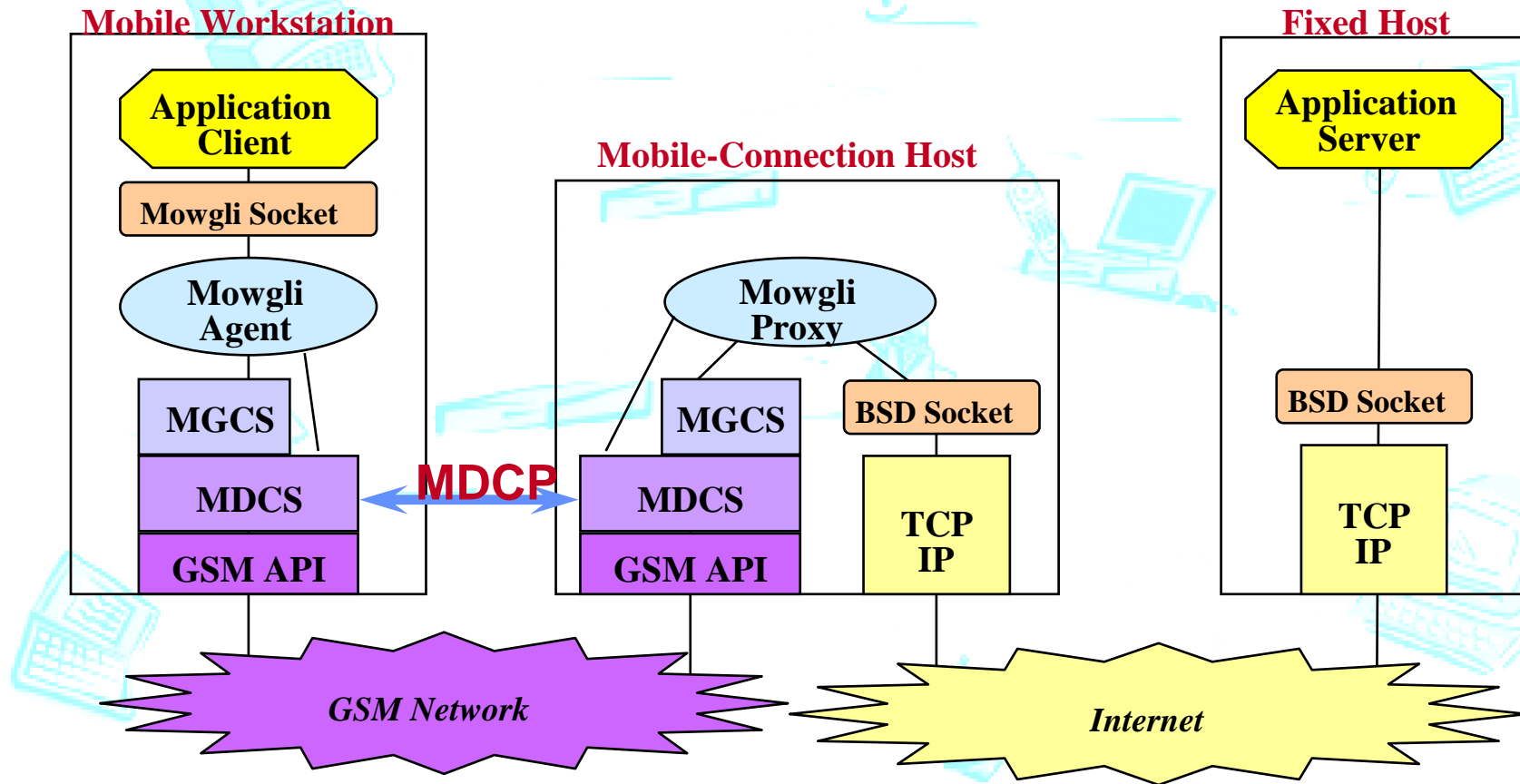
- Phase II topics:

- IETF standardization
- security
- Seawind simulation tool
- Performance of TCP/IP in GPRS

Problems in TCP/IP Over Wireless Link

- **Overhead due to protocol headers**
- **High latency: “extra” round trips should be avoided**
- **TCP slow start: full bandwidth not utilized**
- **Timers will not work as intended**
- **Inefficient recovery from packet losses**
- **Simultaneous TCP connection interfere with each other**
- **No support for disconnected state**

Mowgli Architecture



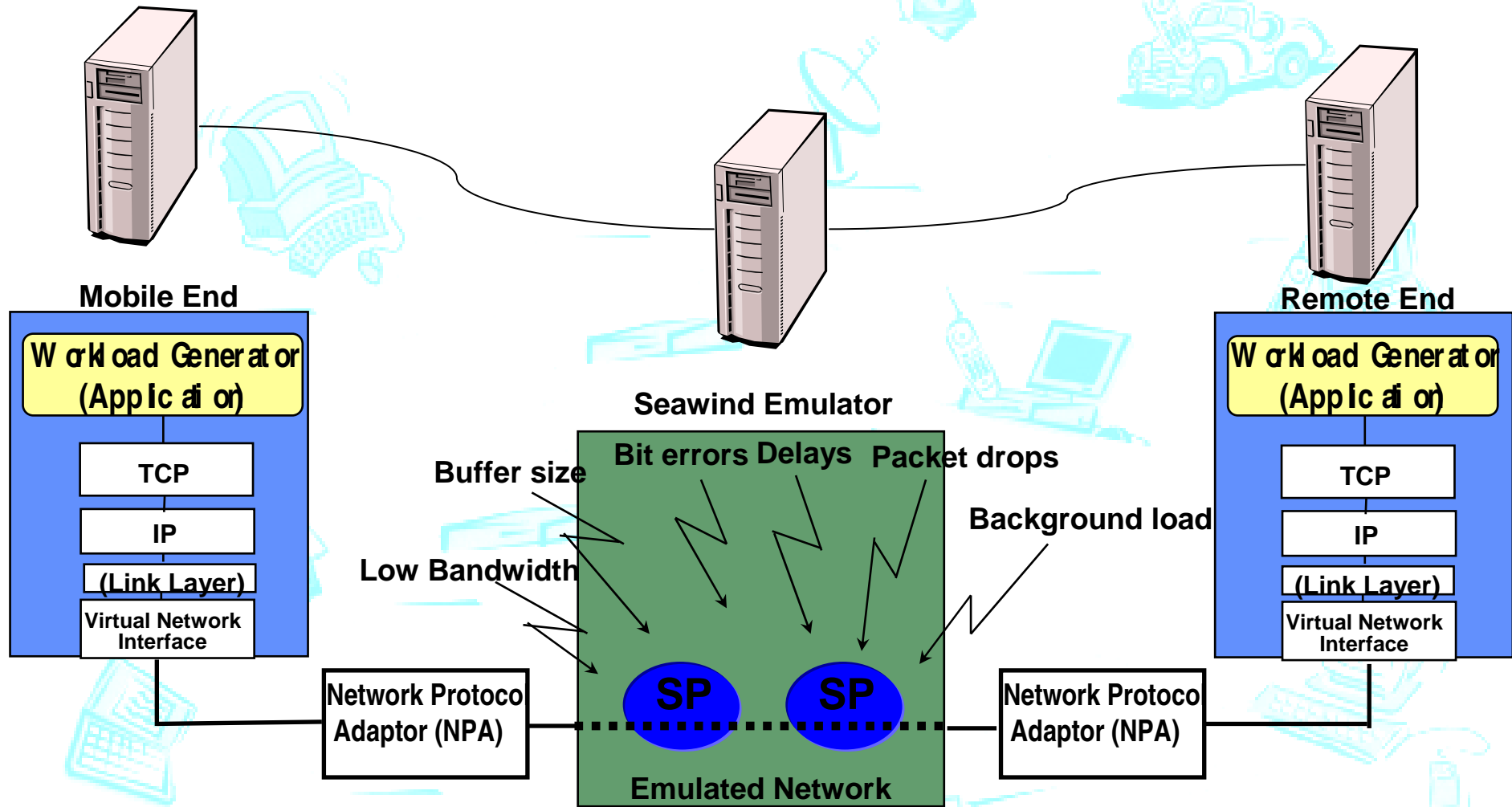
Mowgli Follow-Ups

- IWTCP, IIP Mobile, IIP Wireless and IIP Mixture
- Study the performance of different TCP variants on slow wireless links
- Improve TCP behaviour on slow wireless links
- Managing mixtures of traffic (CBF, VBR, BE)
- Examination of IP QoS techniques
- Examination of application level protocols
 - HTTP, IMAP, IM

Seawind

- Real-time software emulator for wireless links currently developed in IIP-Mobile
- Captures network traffic transparently from end hosts for emulation
- Allows studying the behaviour of real network protocol implementations
- User can easily control various network parameters
- License available for research institutes and universities

Seawind



DOLMEN

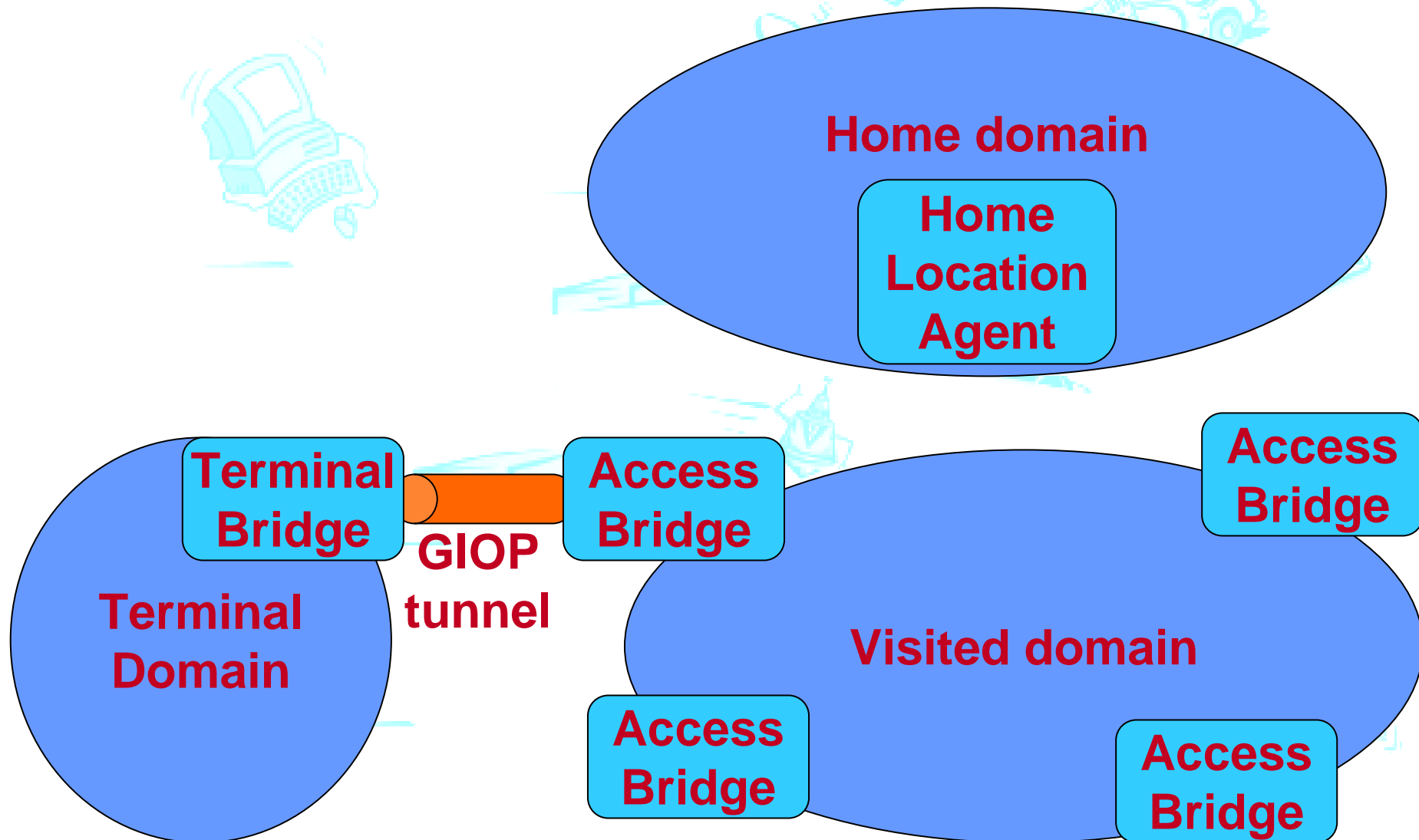
- EC/ACTS: 1995-1998
- Partners:
 - FUB, UCatania (I)
 - ICM, NTUA (Gr)
 - Orange, UPlymouth (UK)
 - Sema (Fr)
 - VTT, Sonera, UHelsinki (Fi)
 - KPN, Lucent (NL)
- Topics:
 - extensions to TINA for personal and terminal mobility
 - **Mobilizing DPE**
 - Mobile network adaptation
 - Enhanced WWW

www.fub.it/dolmen/

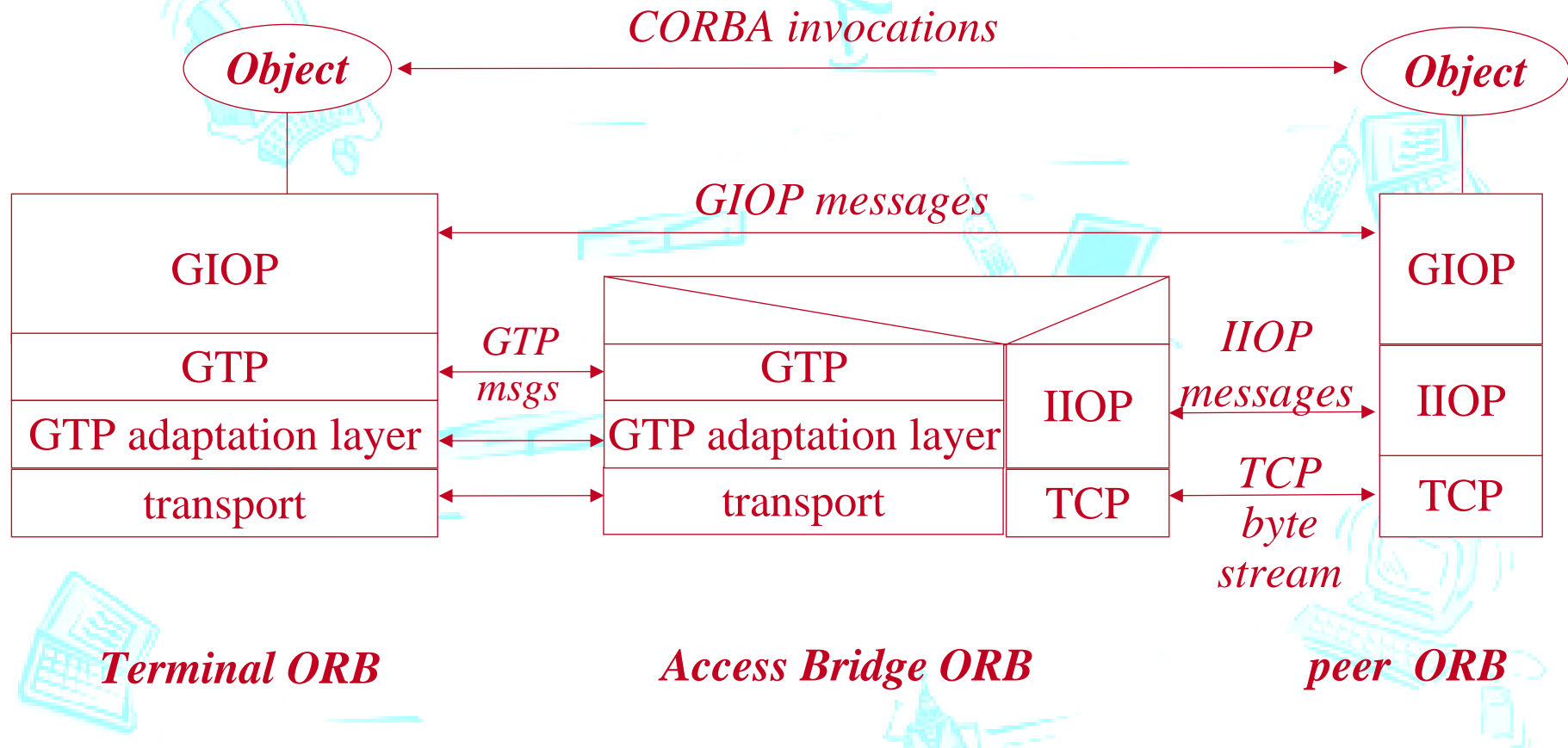
Wireless CORBA

- **OMG standardization of Wireless Access and Terminal Mobility in CORBA**
 - based on DOLMEN results (1997)
 - OMG Formal Standard in April 2003
 - *GIOP Tunneling Over Bluetooth RFC* in March 2003
- **Open Source Implementation of OMG Wireless CORBA Specification**
 - NRC, NMP, Sonera
 - demonstrated in November 2001

Wireless CORBA Architecture



Wireless CORBA Protocol Stack



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- 1998-2000

- Partners:

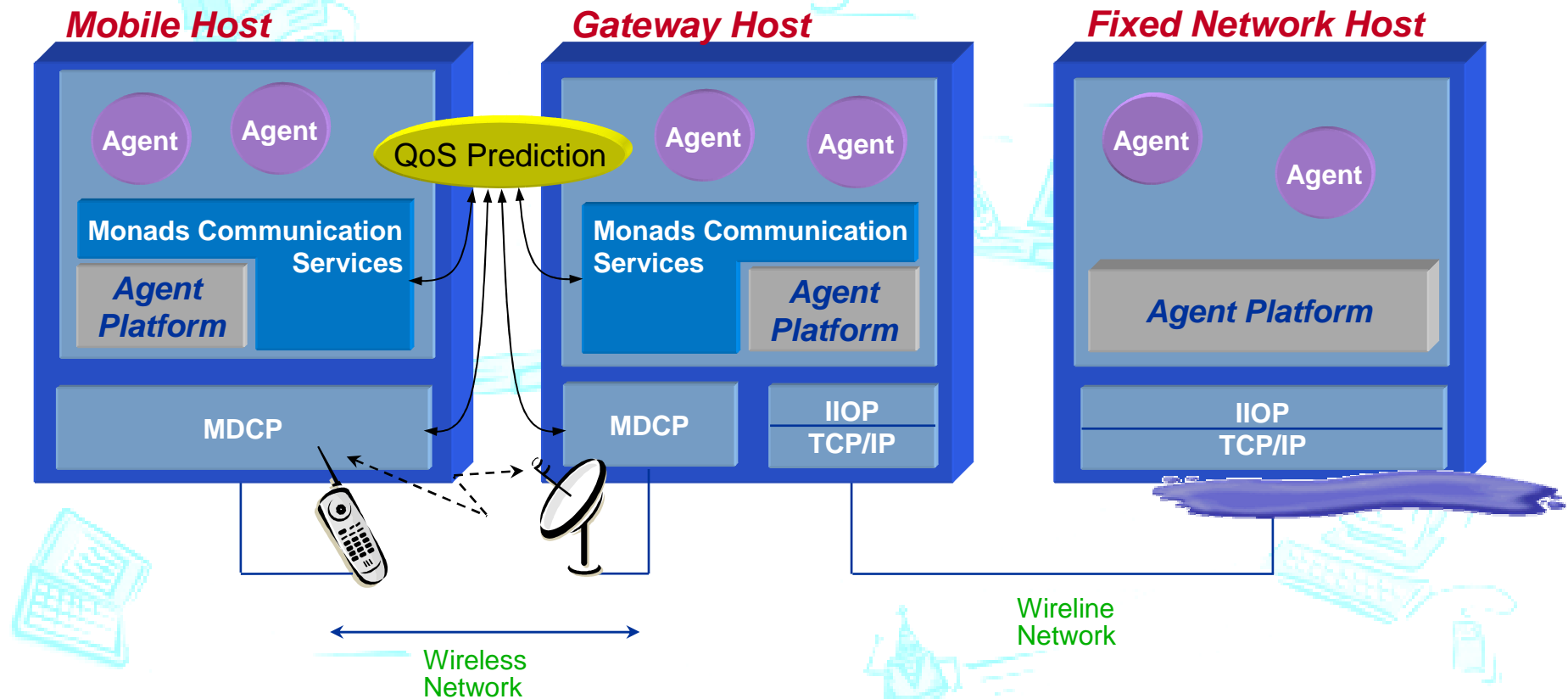
- NMP
- NTC/NRC
- Sonera

- Topics:

- agent communication in wireless environments
- adaptability to available resources
- short-term predictions of available resources

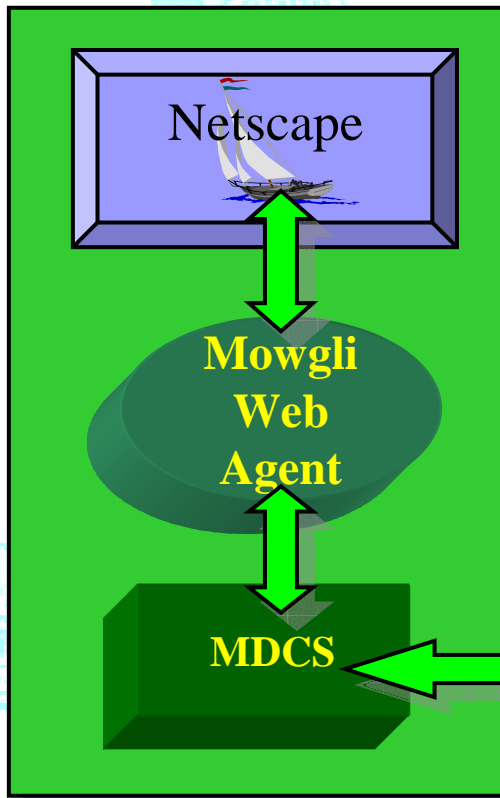
www.cs.helsinki.fi/research/monads/

Monads Communication Architecture

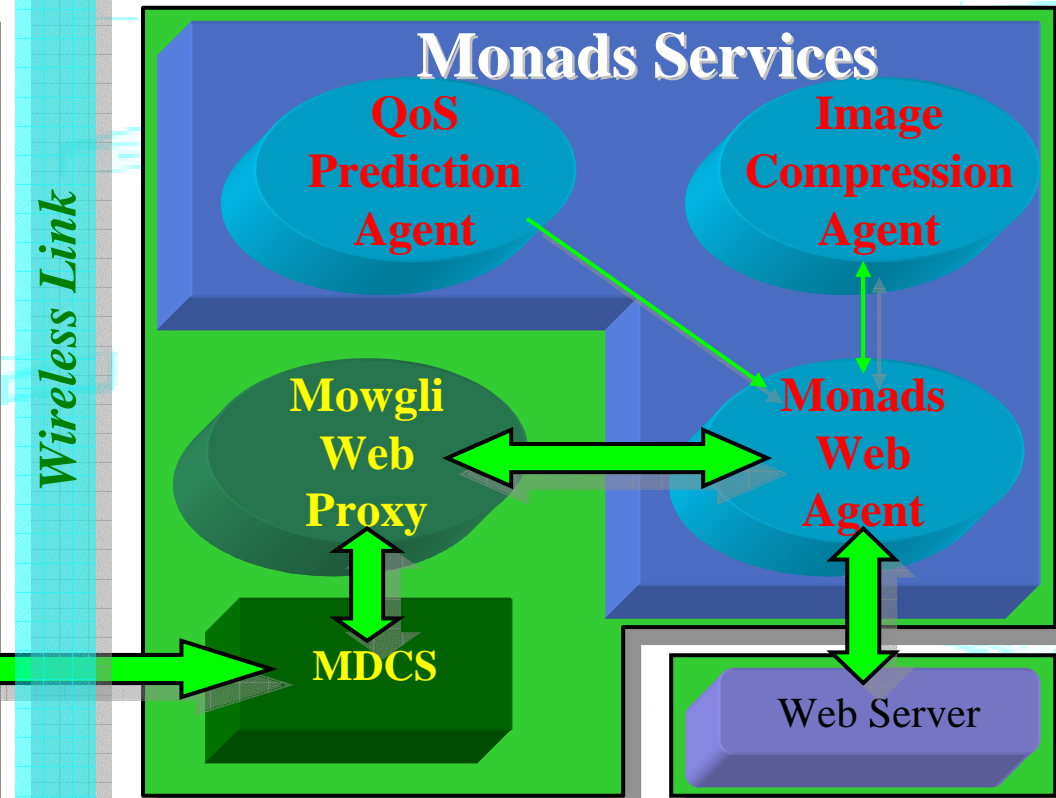


Monads Web Agent Architecture

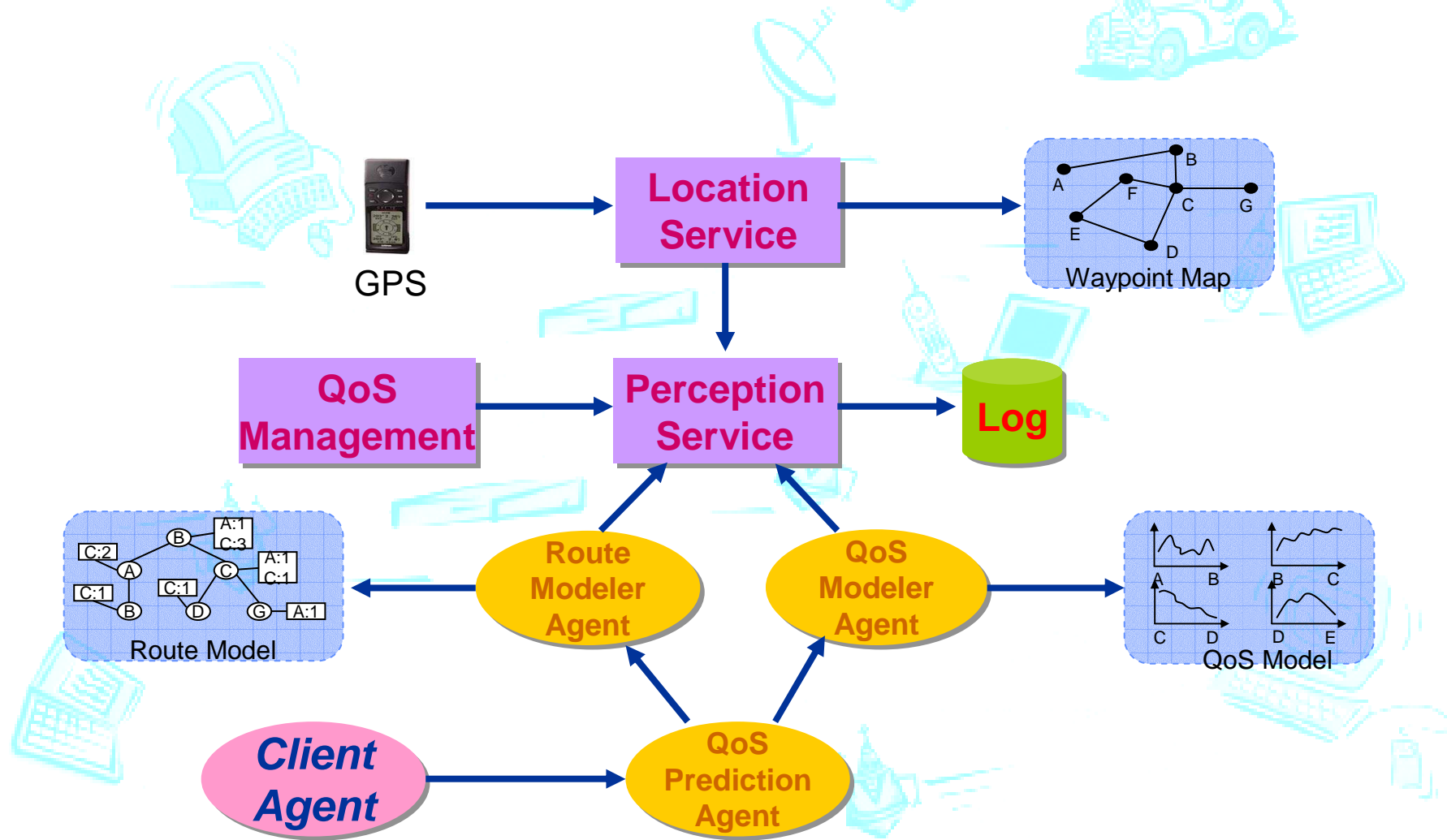
Mobile Terminal



Fixed Network



Monads Qos Prediction Architecture



Fuego Core

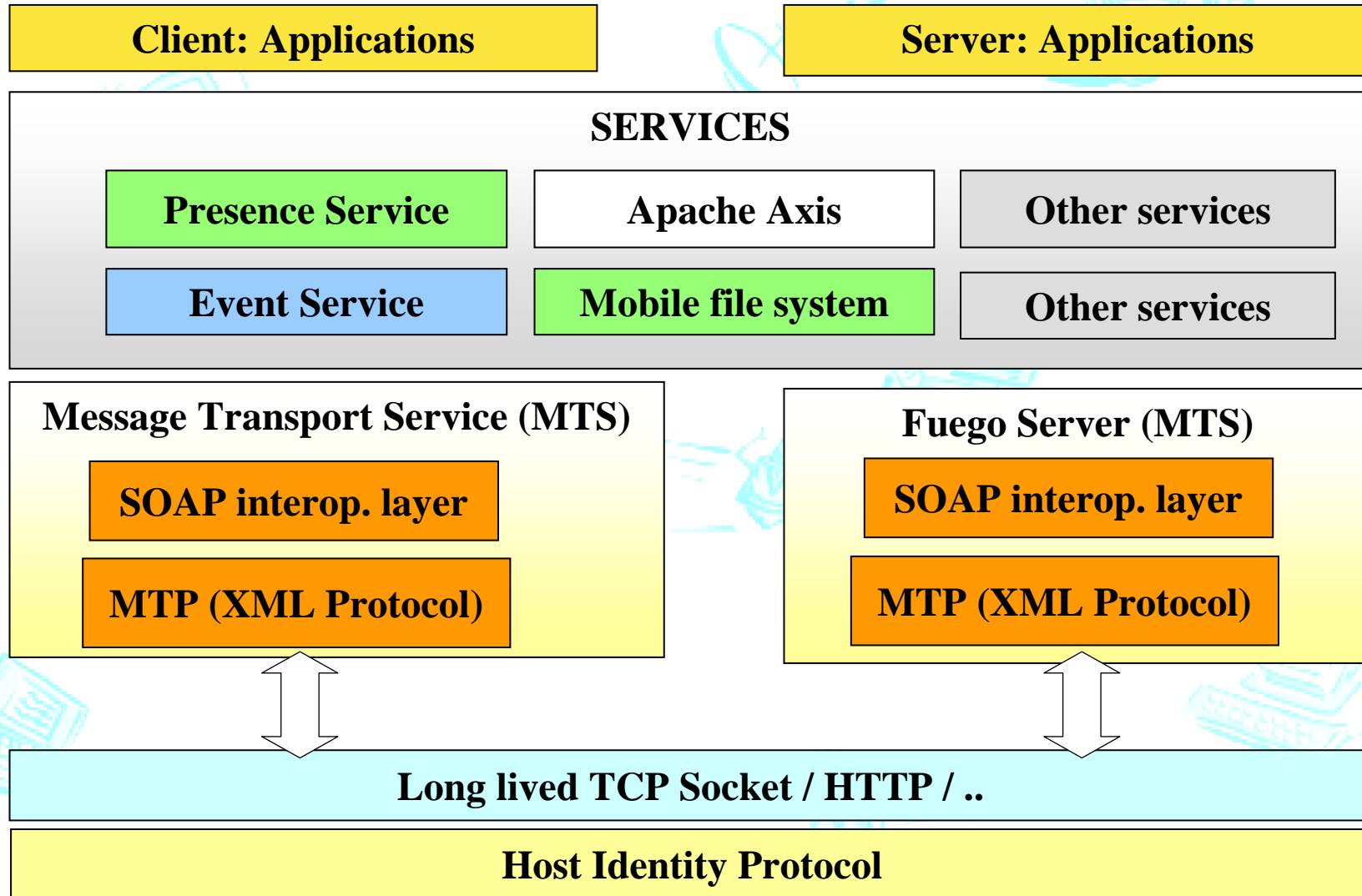
- 2002-2004
- Partners:
 - Creanor*
 - Elisa
 - Ericsson*
 - More Magic Software
 - Nokia
 - TeliaSonera

* from 2003

• Topics

- Mobile Distributed Event Systems
- SOAP in Wireless World
- Mobile Distributed File System
- Mobile Presence
- Host Identity Payload (HIP) protocol
- Metadata for mobile applications
- Session concepts (SIP applicability)

Fuego Core Architecture



Other Mobile Projects

- **BRAIN:** Broadband Radio Access for IP based Networks
- **MIND:** Mobile IP-based Network Developments
- **MONTAGE:** MOBILE iNTelligent AGENTS in Accounting, Charging, and Personal Mobility Support
- **PRIME:** PRomoting Interoperability for Multimedia communication in Europe
- **CRUMPET:** Creation of User-friendly Mobile Services Personalised for Tourism
- **Robocop:** Robust Open Component Based Software Architecture for Configurable Devices Project
- **TranSat:** Improving Transport over Satellite
- **ANWIRE:** Academic Network for Wireless Internet Research in Europe
- **VAAWIT:** Wireless Internet Applications for Agriculture

Other Players

and conclusions

Internet

GSM, GPRS, WLAN

Agent Technology

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Other Players

- Endeavour Expedition at the University of California in Berkeley: <http://endeavour.cs.berkeley.edu/>
- Oxygen in the MIT: <http://www.oxygen.lcs.mit.edu/>
- Project Aura at Carnegie Mellon University: <http://www.cs.cmu.edu/aura.html>
- The Future Computing Environments (FCE) Group at Georgia Tech: <http://www.cc.gatech.edu/fce/>
- The Portolano project in the University of Washington at Seattle: <http://portolano.cs.washington.edu/>
- The 2K project (A Component-Based, Network-Centric Operating System for the next Millennium) in the University of Illinois at Urbana-Champaign: <http://choices.cs.uiuc.edu/2k>
- The Mobile Computing Group at Stanford University (MosquitoNet): <http://mosquionet.stanford.edu/index.html>

Conclusions

