Towards the 4G

José Jiménez
Director for Innovation
Telefónica I+D

It is coming...!

DoCoMo aims to start 4th-generation cellular service in 2006

EMAIL ARTICLE TO A FRIEND

SUBMIT A RUMOUR

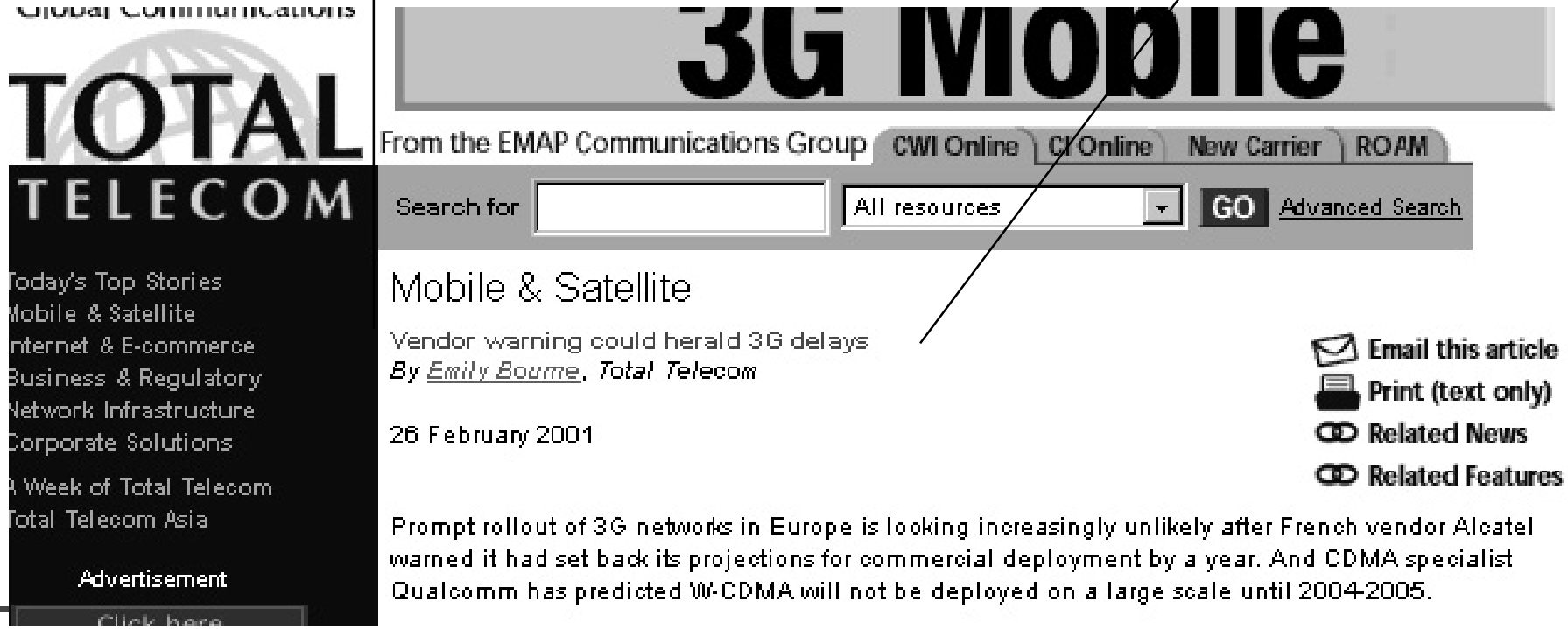
Monday, March 19, 2001, 9:56

BLOOMBERGNTT DoCoMo, Japan's largest cellular phone company, plans to launch fourth-generation cellular phone services as early as 2006, aiming to make the system the world standard, the Yomiuri newspaper said, citing unnamed industry sources.

The 4G cellular phones will let users watch high-resolution movies and television programs, the paper said, adding that their maximum data transmission speed of more than 20 megabits per second will be 2,000 times faster than existing mobile phones and 10 times faster than the high-speed mobile phone services, or the so-called third-generation phone service, that DoCoMo plans to introduce in May.

But, when it will be 3G?

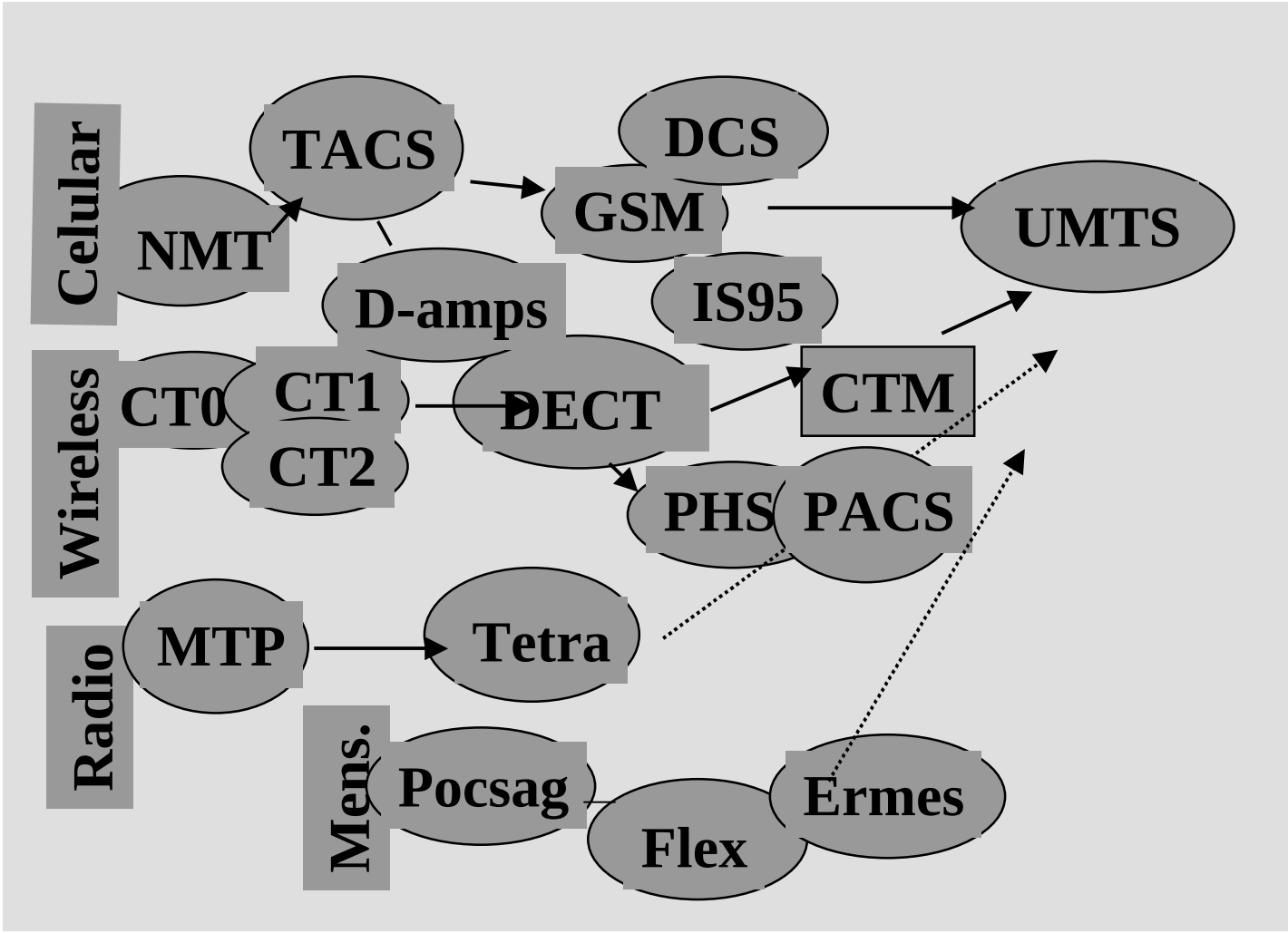
Vendor warning could herald 3G delays
By Emily Bourne, Total Telecom



What went wrong?... If anything

- The story behind 3G
  - An unification objective
  - The USA/Japan requirements different from those of Europe
  - Was anything wrong, after all?.
    - Many open planning problems
- What should we do now?
  - UMTS-WLAN for hot spots
  - Unified network architecture vs. ad hoc architecture
    - How to live with IP?. Integration issues
- Some research areas
  - As suggested in the WWRF

The objective in 1992

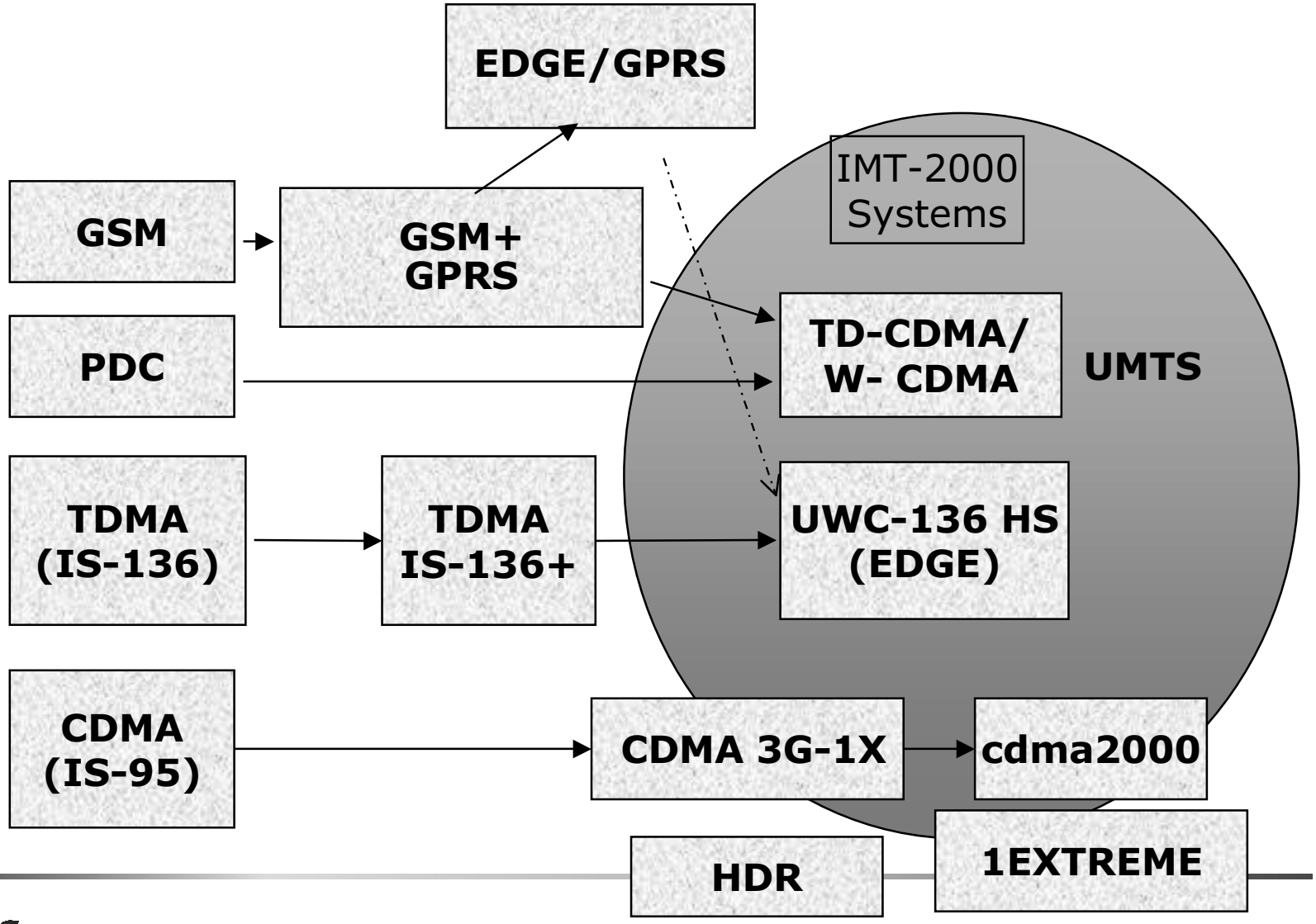


PROJECT FRAMES (1995-1998)

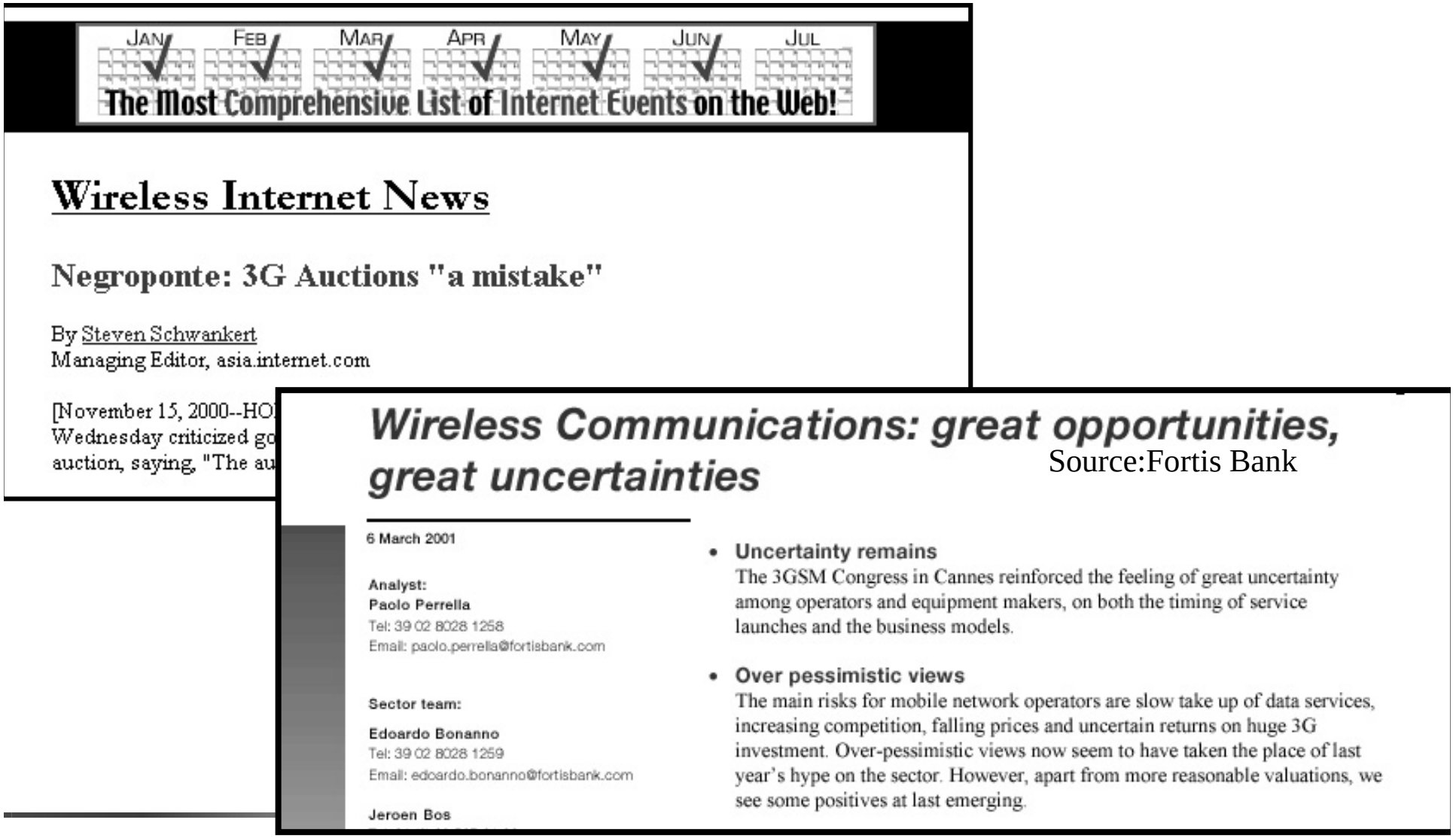
- FRAMES can be considered as the technical "father" of UMTS.
  - Siemens, Nokia y Ericsson

- Based on previous work on CDMA (CoDiT) and ADTMA
- A system capable of two operation modes
  - FMA1: TDMA with CDMA to be used with joint detection
    - Evolution of GSM
    - Good for packet traffic indoors
  - FMA2: WCDMA (Evolution of CoDiT)
    - More efficient spectrally
    - Inspired in IS-95
- One single radio interface was not technically efficient.

Evolution of different systems



Other mistakes…uncertainties



JAN FEB MAR APR MAY JUN JUL

The Most Comprehensive List of Internet Events on the Web!

Wireless Internet News

Negroponte: 3G Auctions "a mistake"

By Steven Schwankert
Managing Editor, asia.internet.com

[November 15, 2000--HO
Wednesday criticized go
auction, saying, "The au

Wireless Communications: great opportunities, great uncertainties

Source:Fortis Bank

6 March 2001

Analyst:
Paolo Perrella
Tel: 39 02 8028 1258
Email: paolo.perrella@fortisbank.com

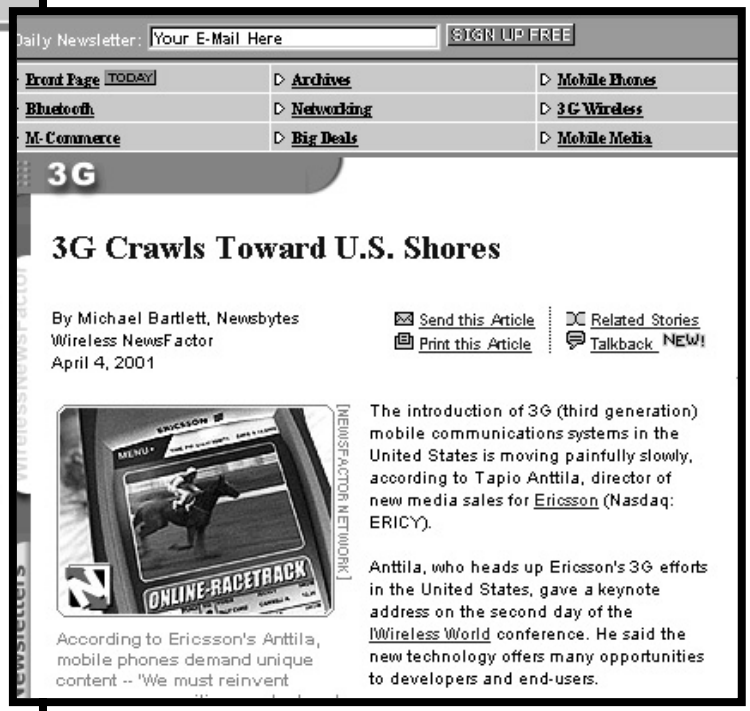
Sector team:

Edoardo Bonanno
Tel: 39 02 8028 1259
Email: edoardo.bonanno@fortisbank.com

Jeroen Bos

- **Uncertainty remains**
  The 3GSM Congress in Cannes reinforced the feeling of great uncertainty among operators and equipment makers, on both the timing of service launches and the business models.
- **Over pessimistic views**
  The main risks for mobile network operators are slow take up of data services, increasing competition, falling prices and uncertain returns on huge 3G investment. Over-pessimistic views now seem to have taken the place of last year's hype on the sector. However, apart from more reasonable valuations, we see some positives at last emerging.

But not all is gloom



Summary

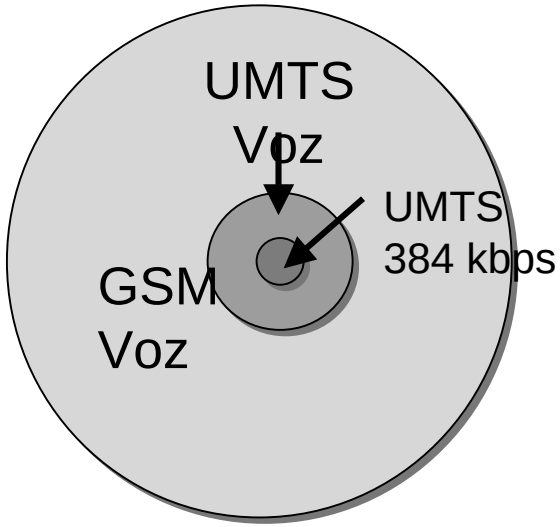
- For technical reasons and due to the commercial pressure no unified approach has been produced
- A collection of new systems has to be implemented very (too) fast.
- All the data and simulation results have been provided by interested parties.
- Many assumptions are biased

Research is required to test and improve the "comercial assumptions" and develop realistic models

- No (clear) dimensiong guidelines are provided

What is UMTS offering?

- Objectives
  - The offered data rate will depend on the type of location and user's speed.
  - Rural: 144 kb/s at 400 km/h. Objective 384 kb/s
  - Suburban: 384 kb/s 120 Km/h. Objective 512 kb/s
  - Picocells/fixed users: 2 Mb/s. Though it might not be offered with FDD nor everywhere
- Symmetric and assymetric services
- Global roaming
- Voice quality similar to fixed network
- But it may not be obtained everywhere!!



A capacity example

- To obtain multiservice cell capacity, total capacity has to be divided among different services.
- This leads to several possible combinations.
- However, much will depend on the activity factor for each service (*a) and others cell interference.*

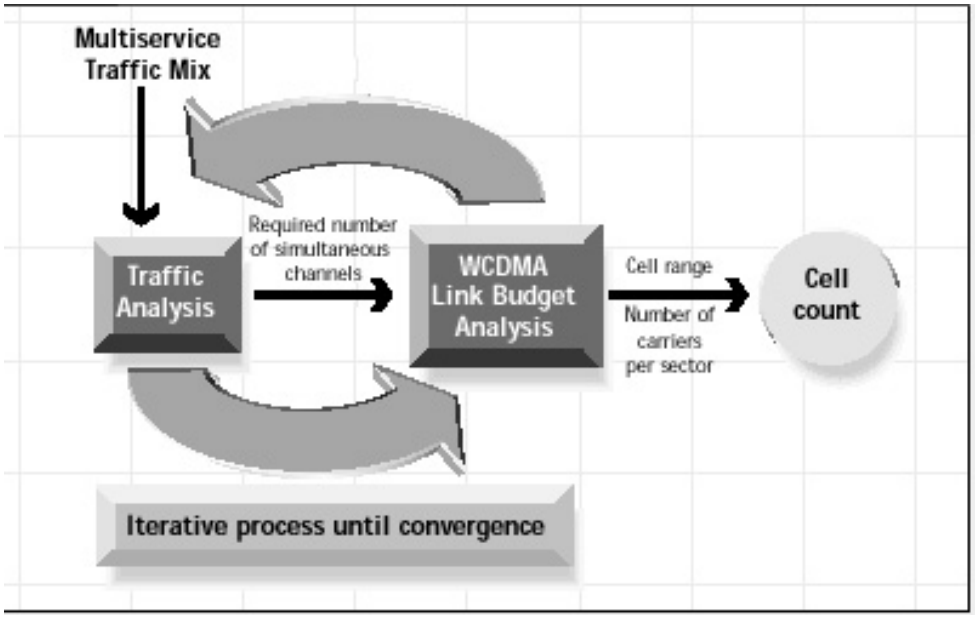
	Voice 12 Kb/s (a=3/8)	Data 64 Kb/s (a=0,5)	Data 64 Kb/s (a=0,1)	Data 384 kb/s (a=0,1)
Solution 1	**69 Erl**	**-**	**-**	**-**
Solución 2	**26 Erl**	**6,6 Erl**		**-**
Solution 3	**26 Erl**		**33 Erl**	
Solution 4	**26 Erl**			**4 Erl**
Solution 5	**-**			**9 Erl**

Note: Those results have been obtained using P_{out}=0,1 ;
Eb/No=6 dB voice; 4 dB data 64 kb/s y 3 dB data a 384 kb/s.
Intercell interference 0.7 . Power control error 2 dB

Based on Viterbi. *Principles of CDMA communications.*

Planning issues

- The 3G network CDMA has still MANY open issues
- CDMA planning
  - Coverage planning (incl. services)
    - There is no proper algorithm for CDMA planning except simulation.
    - The effect of cells over neighbouring cells is almost impossible to know before hand
    - Capacity reductions due to load increase are almost impredictable
- CDMA coverage is traffic dependent



Source: Alcatel review 2001/1

The shrinking capacity of CDMA

The coverage area decreases as:
-Traffic increases
-High data rate users enter
-Interference from other cells increases

Radio Resource Allocation

- Given a number of mobiles, find the optimum assotiation of them to the BS considering:
  - The radio environment
  - QoS requirement
  - BS power
  - traffic classes
  - number of codes
- Different traffic types

Traffic class	Conversational class Conversational RT	Streaming class Streaming RT	Interactive class Interactive best effort	Background Background best effort
Fundamental characteristics	- Preserve time relation (variation) between information entities of the stream	- Preserve time relation (variation) between information entities of the stream	- Request response pattern - Preserve payload content	- Destination is not expectin the data within a certain tim
	Conversational pattern (stringent and low delay)			- Preserve payload content
Example of the application	- Voice	- Streaming video	- Web browsing	- Background download of e-mails

RT: real time

See for example: S. Dixit, Y. Guo, Z. Antoniou. Resource Mgmtn. and QoS in 3G Wireless Networks. IEEE Comm Magzine. Feb 2001

Radio resource Allocation

- An important factor is the effect of the variable radio channel
  - Behaviour in case of bad channel
- Types of algorithms
  - Centralized
  - Decentralized

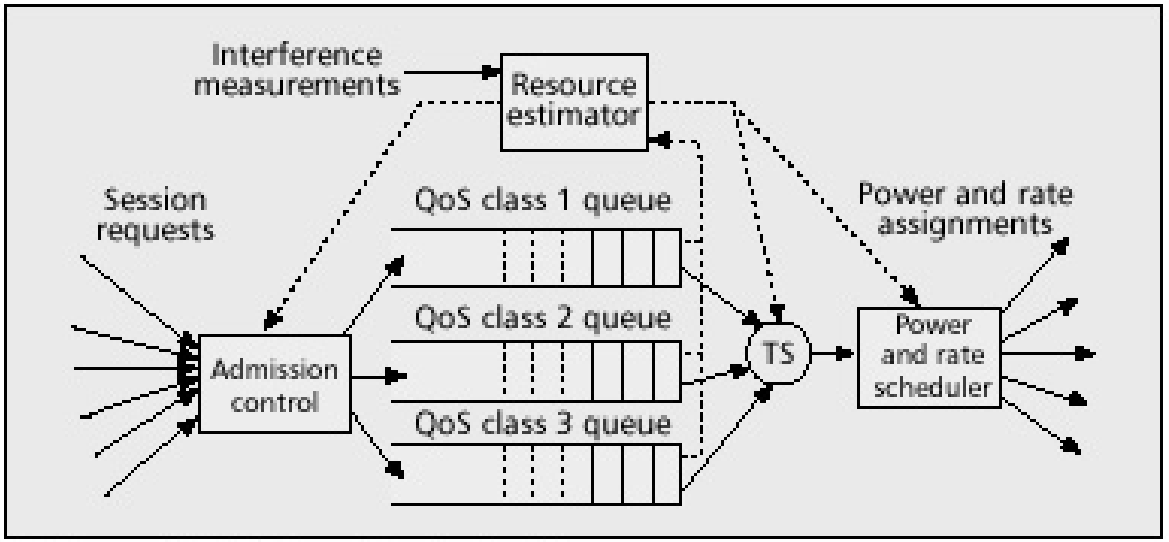
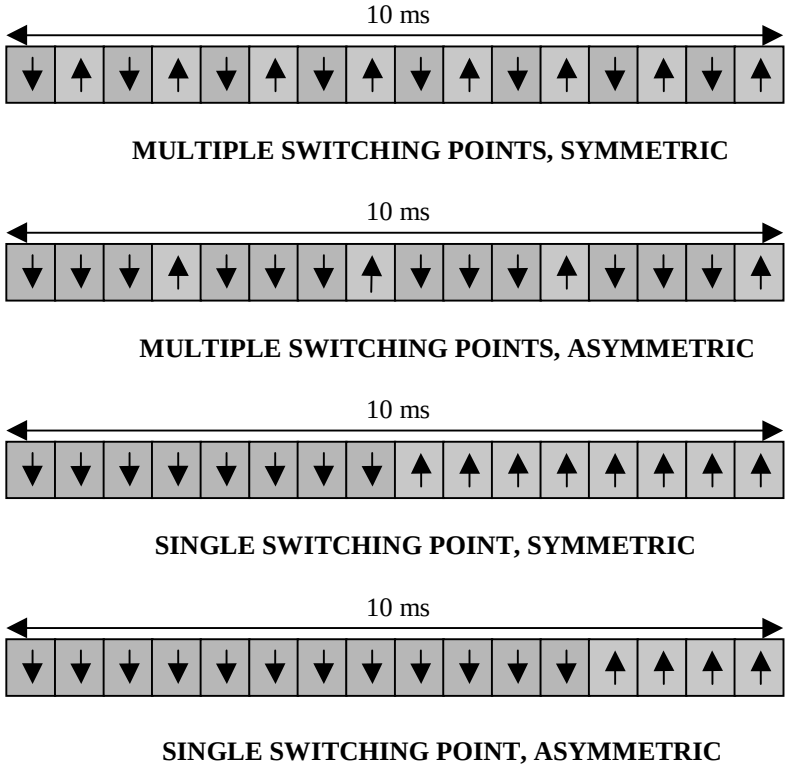


Figure 1. *RRA algorithms in the BS.*

- Source: RRA in third generation.
IEEE Com Mag. Feb 01
Jorguseski, Fledderus, Farserotu, Prasad
- Wineglass and Arrows projects (IST)

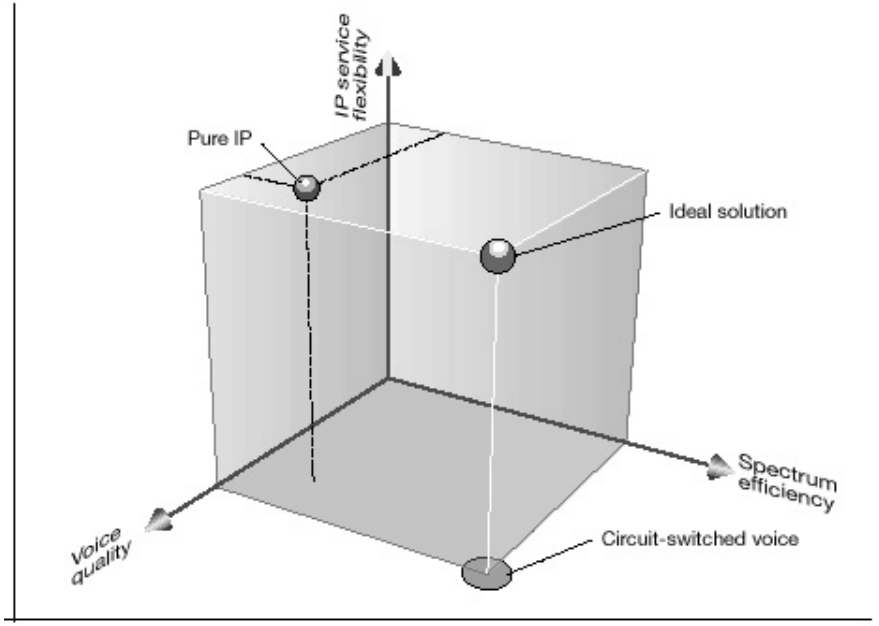
TD-CDMA planning may be even more difficult!

- TD-CDMA planning
  - There is less experience.
    - Is also CDMA but less expansion
  - FRAMES proposed several algorithms
    - Centralized resource allocation Intrabunch
    - Centralized resource allocation based on the interference matrix
    - Decentralized based on segregation
- Internal UTRA-TDD planning is more complex
  - Includes time slot
- It will coexist with WCDMA



The challenges of VoIPW

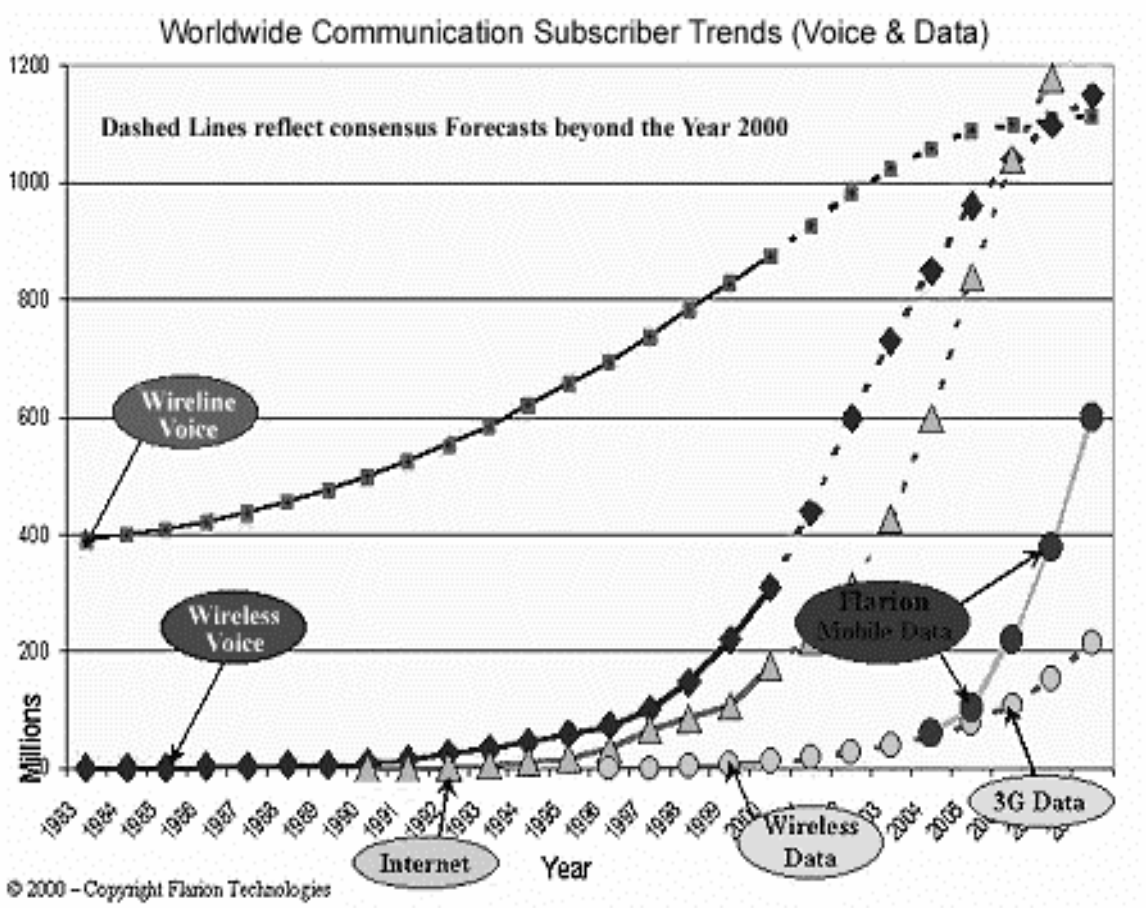
- UMTS shall normally carry voice and packets separately, but VoIPW is a challenging possibility
- The use of VoIPW in UMTS implies some extra difficulties.
  - IP is not the ideal solution for voice
  - The VoIP should use RTP (real time packets).
  - Call Control alternatives SIP, H.323
  - Traffic classification.
    - Overhead should be reduced
    - Not always possible for security reasons



Source: Ericsson Review 2000/1

Convergence of IP and mobile

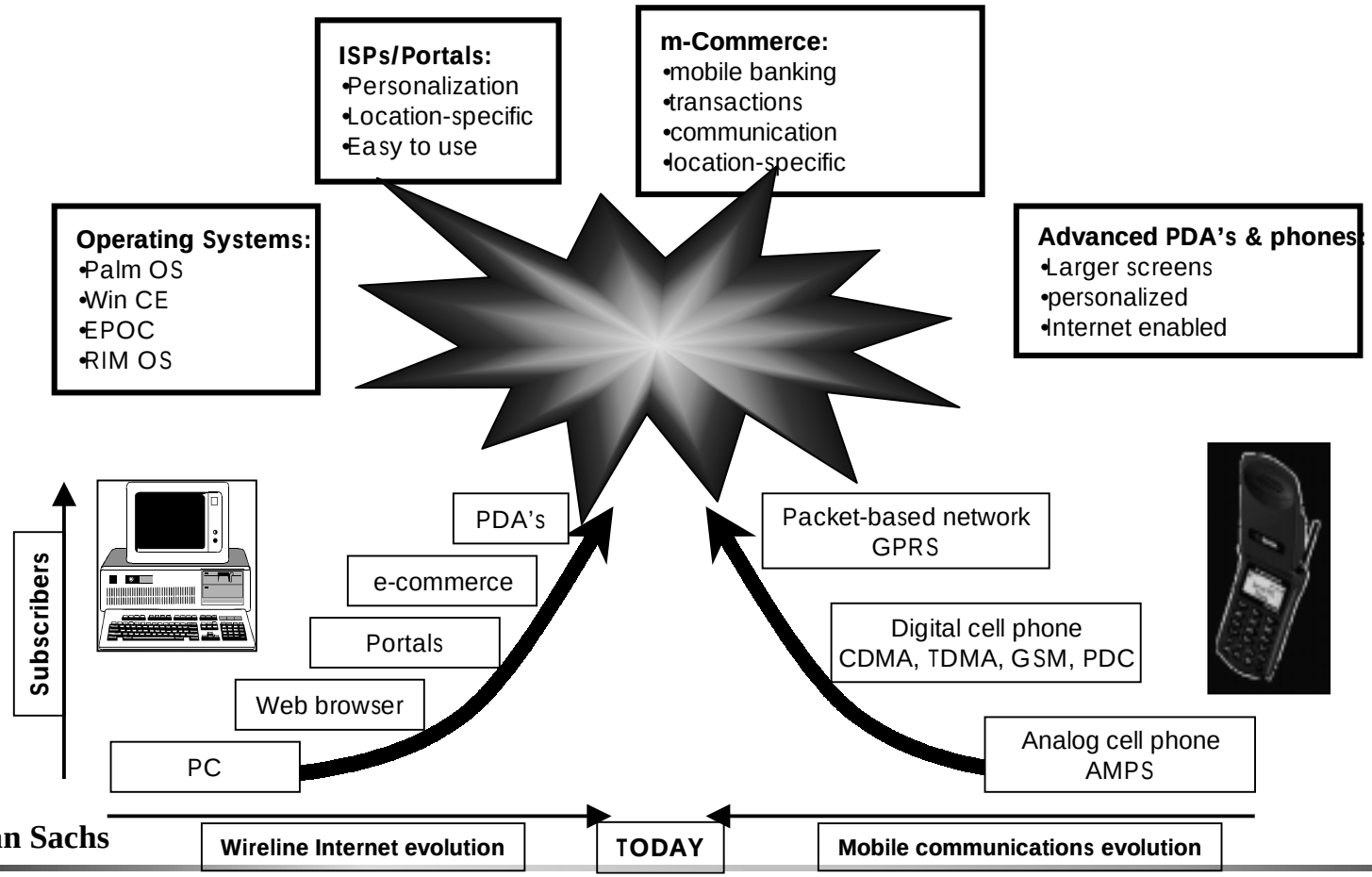
- Internet is growing very fast
- Many Internet users are also mobile users



Source: Flarion Technologies

Business oportunities

- The combination of mobile and data will give new business oportunities



Source: Goldman Sachs

WLAN could be a solution

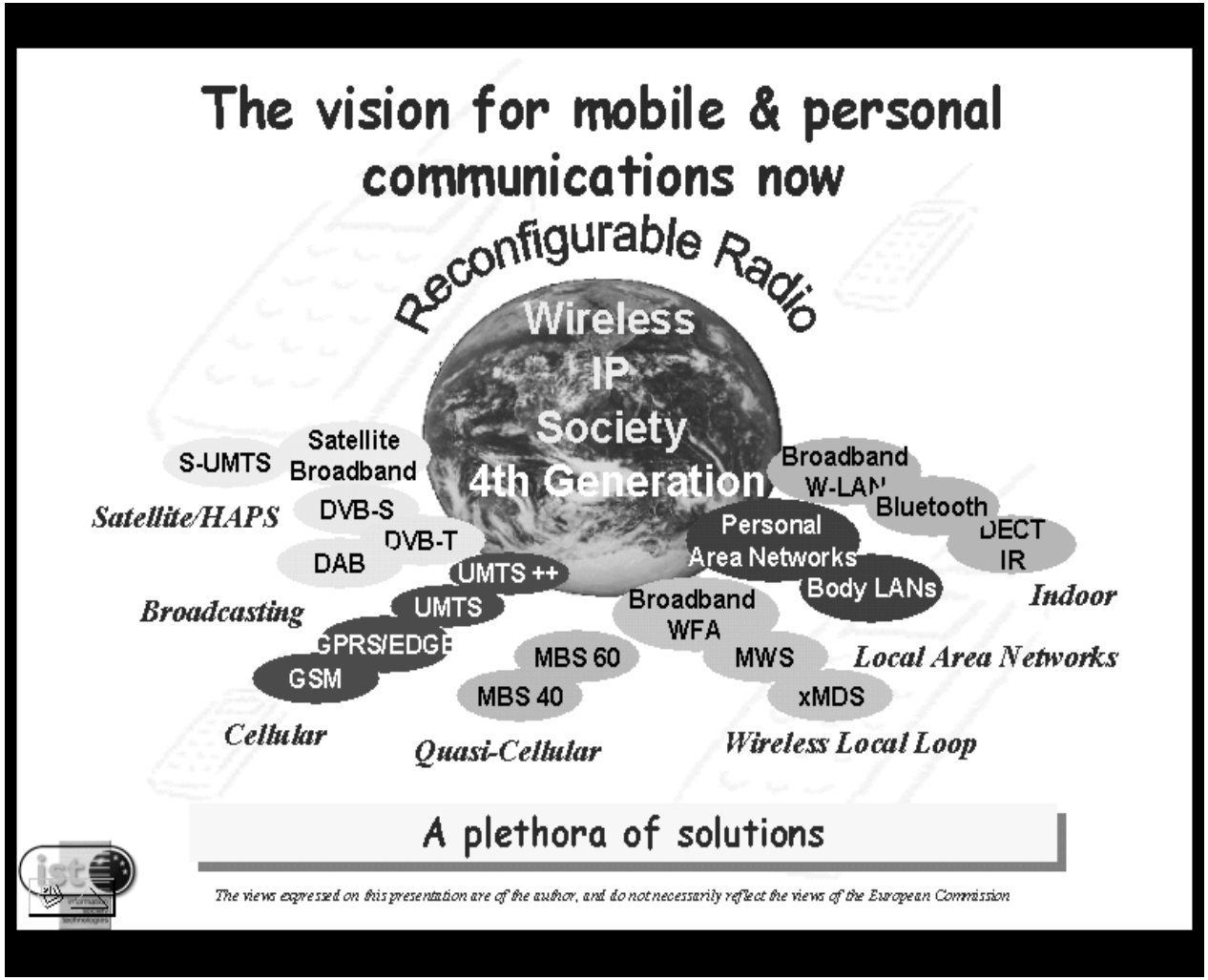
- It may be we are in a DECT like situation
  - Many standards (IEEE 802.11a/b, Hyperlan, commercial solutions..)
  - Some of them very expensive
  - Can we afford to wait for an standard "de facto"?.
- One way forward is to explore the possibilities of WLAN
  - Used in the office
  - … at home
  - … in public environments (airport, conference hall, markets, etc...)
  - … some restricted outdoor environments
- This opens compatibility/routing/roaming problems

What is a 4G system?

- Nobody knows yet;
- Nevertheless there is some consensus on what might be the features of a 4G system;
- It should include advanced and innovative concepts and technologies for self-aware, self-organising ad-hoc wireless networks;
- May be not a NEW air interface scheme but a flexible one that allows scalable wireless connectivity;
- Try to assess potential spectrum requirements and co-existence issues.

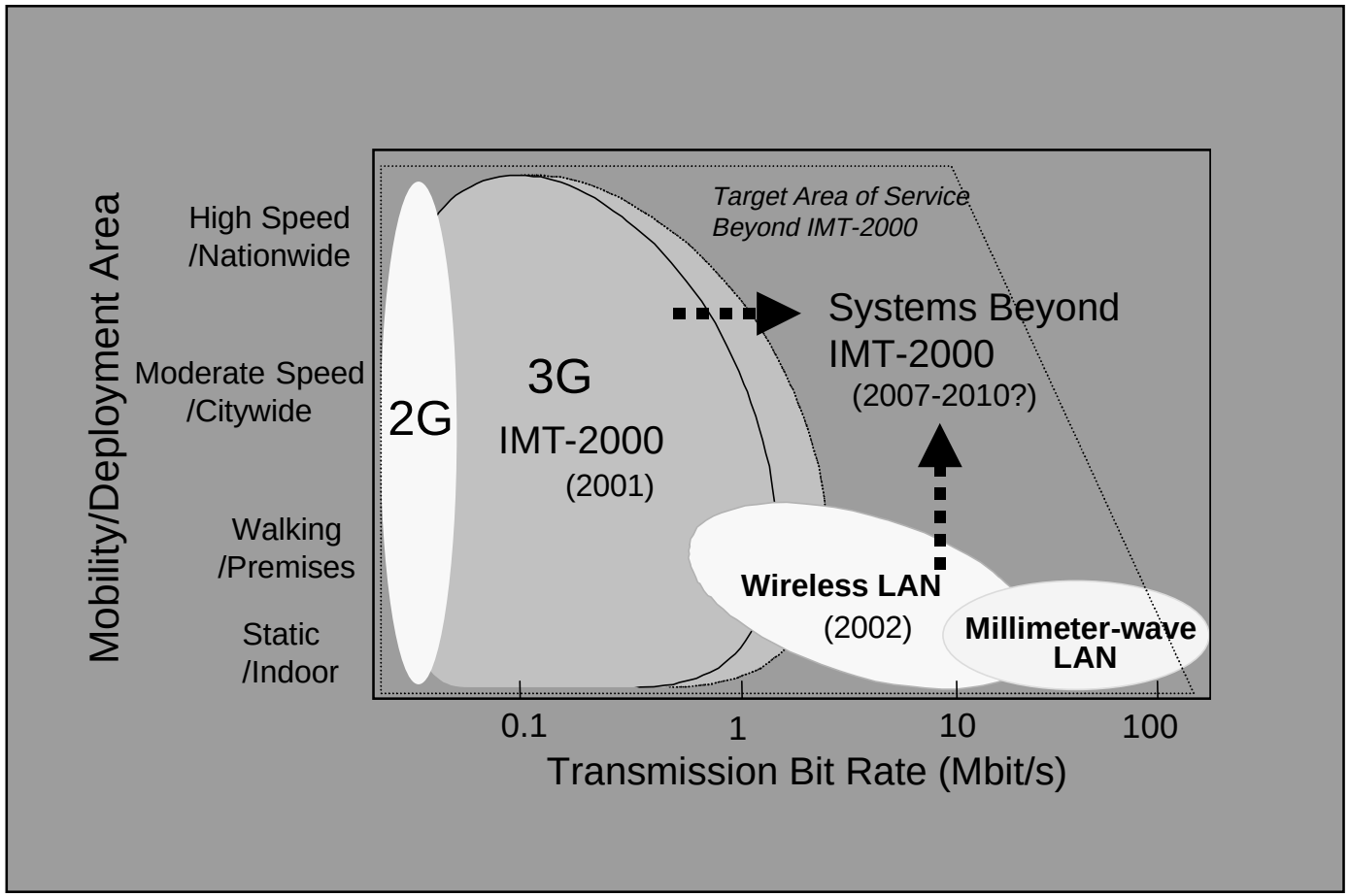
The mobile communications access component
is to be viewed as simple extensions of the fixed network infrastructure,
and not as a separate network structure with restricted interface and access mechanisms

The new vision for the 4G (CE)



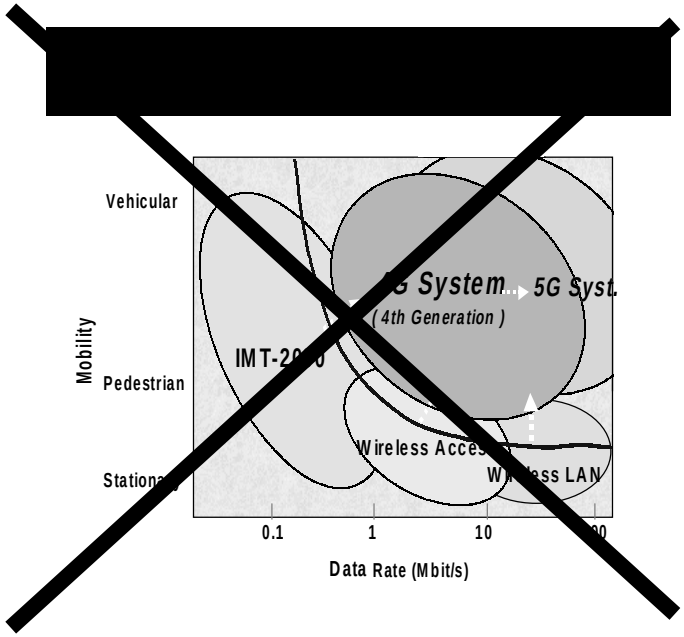
Source:http://www.cordis.lu/ist/ka4/mobil

Where is the 4G in the famous diagram?



The approach to 4G

The expression 4G should not be used to imply that UMTS will be superseded like GSM



- **A new cellular generation offering a factor of gain in speed in higher spectrum regions is not cost/effective under known technological trends.**
- **These gains can only be realised in hot/spot areas where the traffic justifies it. But in these areas other technologies (WLAN, BFWA etc) can be used.**

A forum for the 4G: WWRF

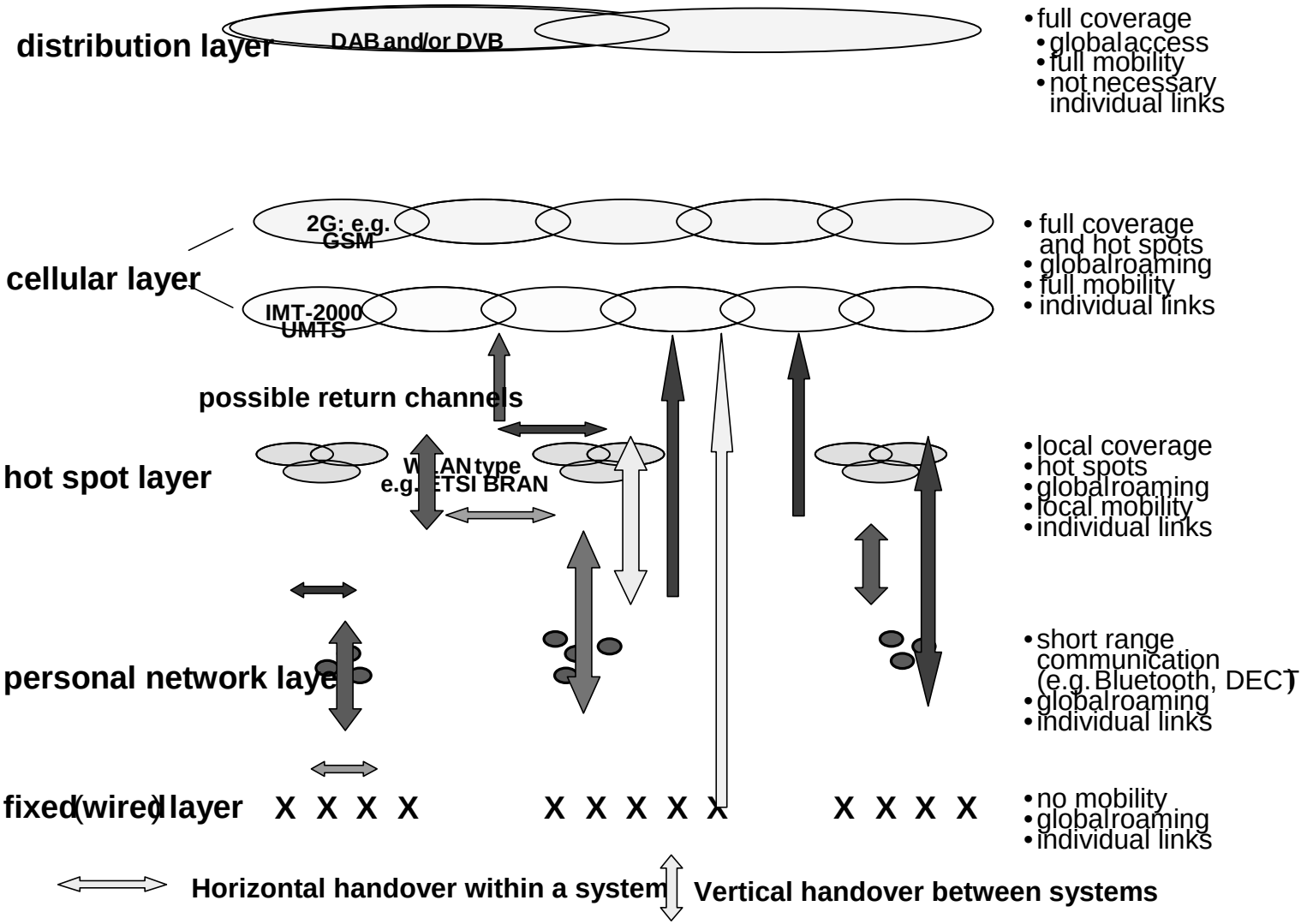
- The result of an EC 5 th FW project IST
- Based initially in the work of 4 major players in the european mobile industry in WSI project
  - Collaboration of other research institutes.
- 4 groups
  - User's view
  - Applications and services
  - Technologies
  - Spectrum
- The Wireless World Radio Forum has been formed.

http://www.ist-wsi.org

An expanding Personal Communications Space

http://www.ist-wsi.org

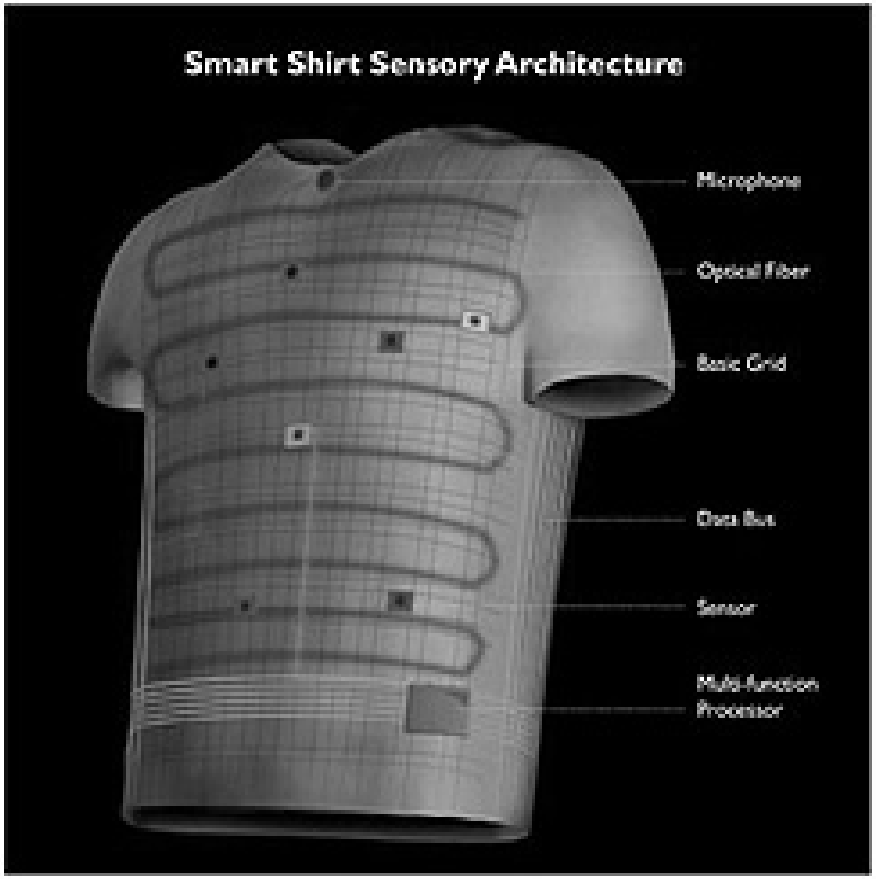
Layered structure for 4G



WG 1. The user perspective

- "The user in the driving seat"
- Future mobile systems need to start from the user's prespective
  - Users needs
  - Users segments
    - Cultural differences, the user of tomorrow
  - User modelling
    - Model user behaviour
  - Access for all
  - Common addressing in networks
  - Wereability
    - Technology and fashion
  - Health and security

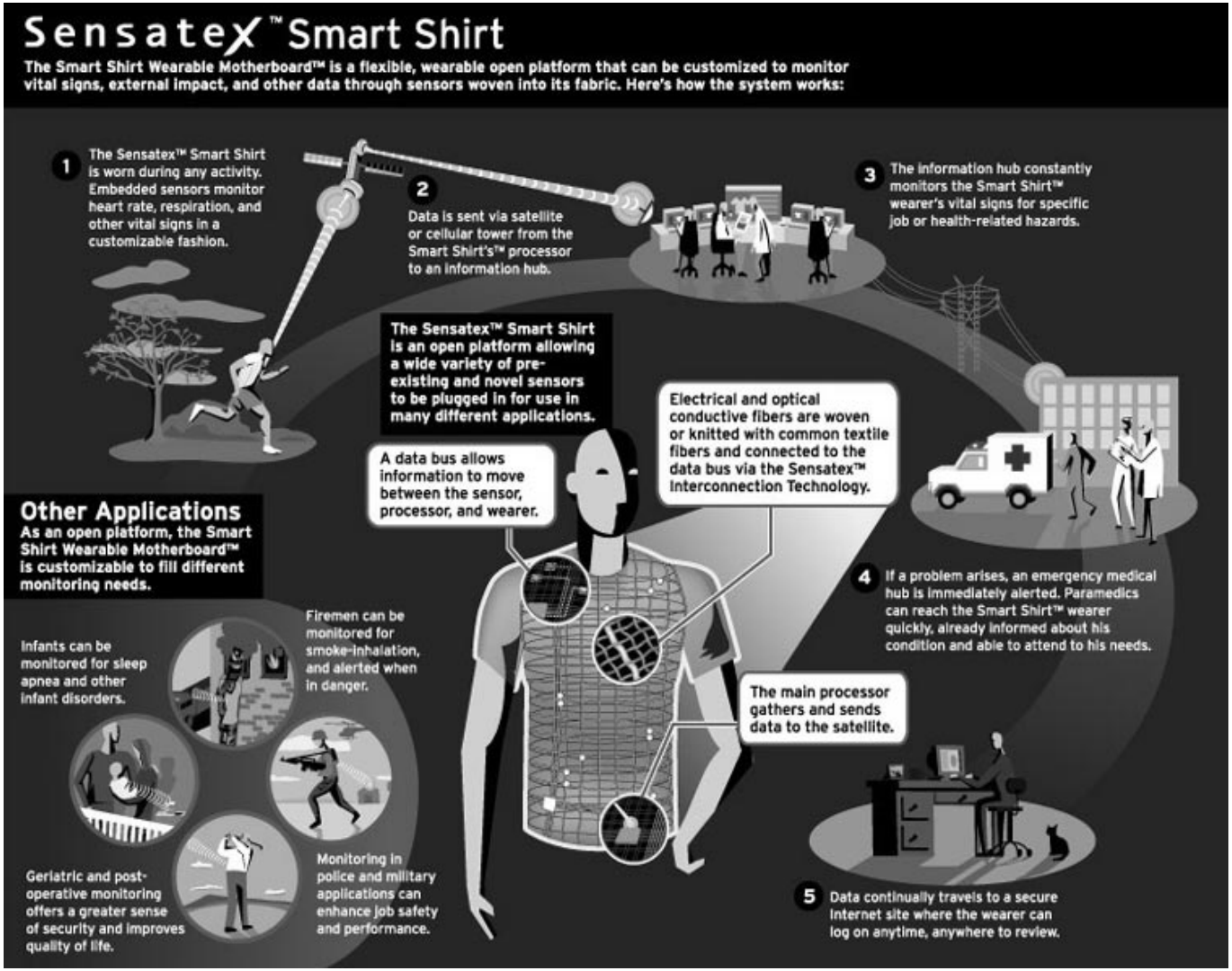
The Disappearing Terminal



- **Body area networks**
- **Mix of Human to Computer to Device**
- **Hidden RF and Processor components**
- **Wearable devices**
- **Multi-modal Interaction**
  - **Speech - Mics, Sound**
  - **Vision - Cameras**
  - **Location - Privacy issues**
  - **Hybrid Reality -**
  - **Writing - Stylus/Pad**
- **A communicating SIM in the wallet**
- **Power saving technologies**

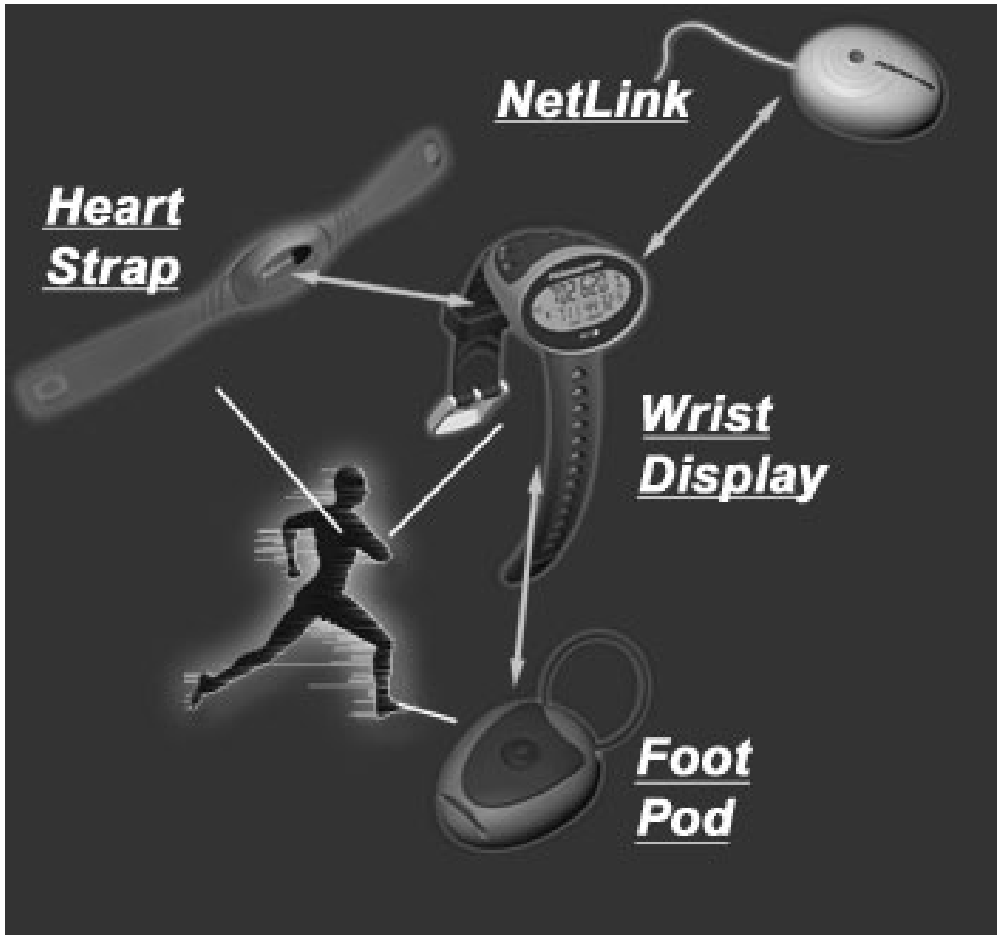
http://www.ist-wsi.org

The Wireless Shirt



An example: 'Human Body Dashboard'

- FitSense's patented foot sensor automatically adjusts to each stride to give a highly accurate measure of pace, distance, speed and caloric expenditure. A wireless, digital link sends the data from the foot sensor to the watch.
  - http://learn.fitsense.com/



http://learn.fitsense.com/

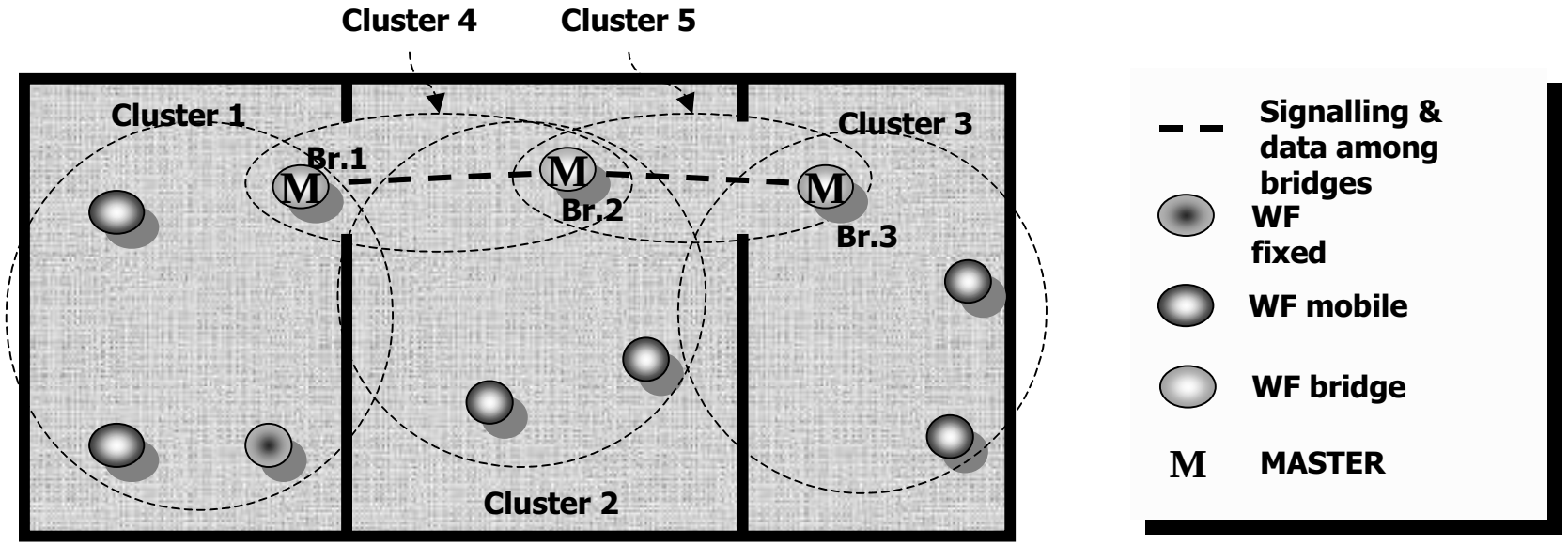
WG2. Applications and services

- Open service architecture for context awareness and ubiquous computing
  - PSE, VHE
  - profiling, personalization, context identification, gathering, privacy
- Service creation
  - Modelling
- Multimedia Management
  - Intiuitive message creation
  - Media transcoding
- Billing
- Machine to machine applications

Self organizing networks

- service discovery;
- security;
- management;
- spectrum coexistence

An example



Source: ***IST WIND-FLEX project***
http://www.vtt.fi/ele/research/els/projects/windflex.htm
Other sources: Temiodes project
IEEE Comm Magazine. Jan 2001

Self organizing networks. Some issues I

Source: IEEE PCM march 2001

- Link layer:
  - Medium access control (MAC) protocols that exploit the capabilities of the physical layer need to be developed.
  - For instance, the physical layer may be capable of performing power control, using multiple modulation or coding schemes or of providing channel-condition-related information to the upper layers. MAC protocols capable of utilizing these capabilities need to be developed to optimize performance
  - Re-transmission schemes
- Network layer:
  - Impact of mobility
    - Proactive protocols tend to maintain routes between all node pairs, regardless of whether or not those routes are used.
    - Reactive protocols tend to explicitly establish routes on demand

Some issues II

- Power conservation:
  - Batteries typically power hosts in mobile ad hoc networks.
- Security:
  - Data route is difficult to know. Security may be a big problem
- Billing
  - Who pays relay stations?.
- Cross-layer interaction
  - For instance, the link layer may be able to improve performance by knowing more about channel conditions.
  - This is applicable to all systems but in this case may be even more important.

WG. 3 Technologies

- Microelectronics.
- Dynamic link adaptation protocols
  - QoS support considering physical layer capabilities
- Wireless protocol requirementes
  - Sip, IPv6, MPLS, diffserv requirements in terms of security QoS and scalability
- Air interface adaptive techniques
  - Adaptation in frequency, modulation, time, space and coding
  - Adaptive antenna
  - Ultrawideband technologies

Tendencies in microelectronic

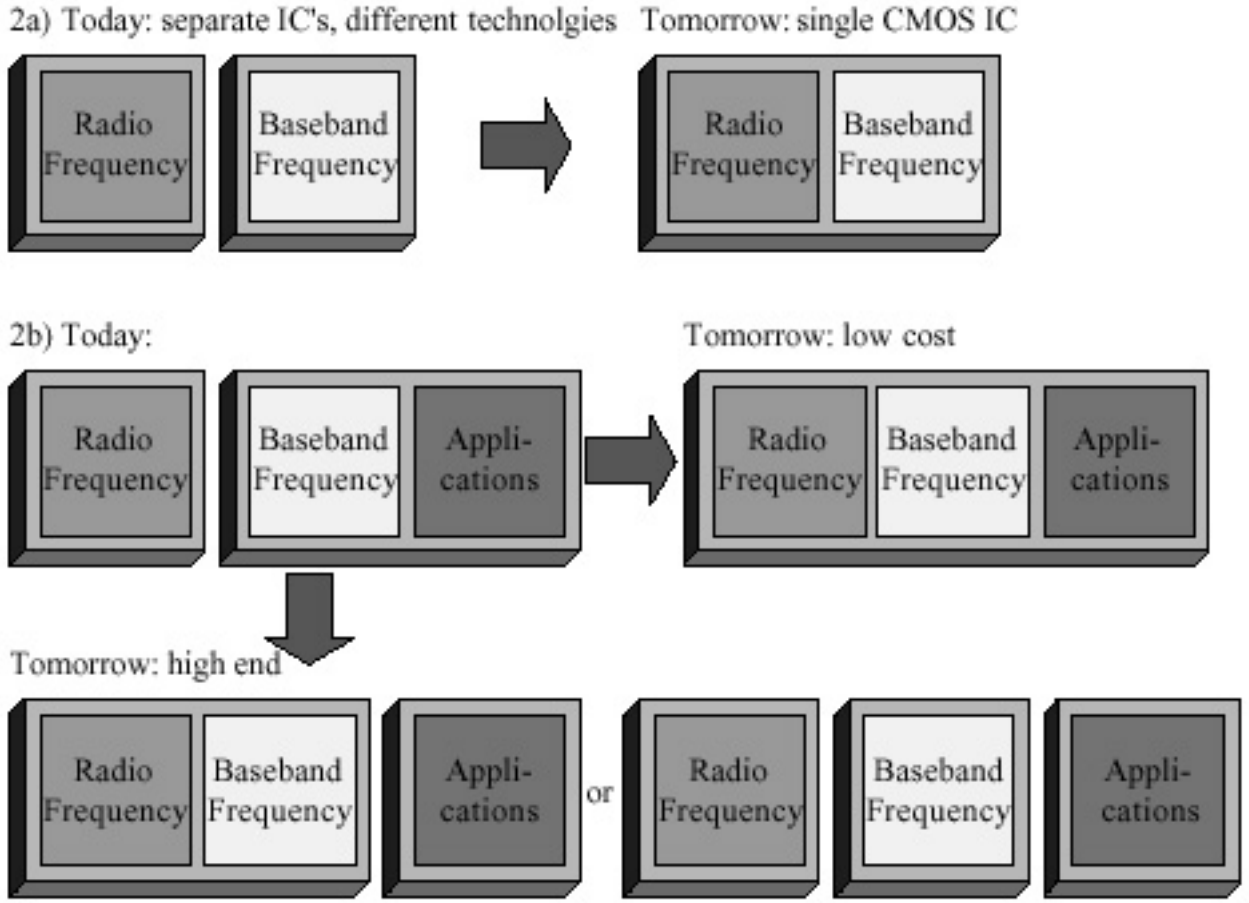
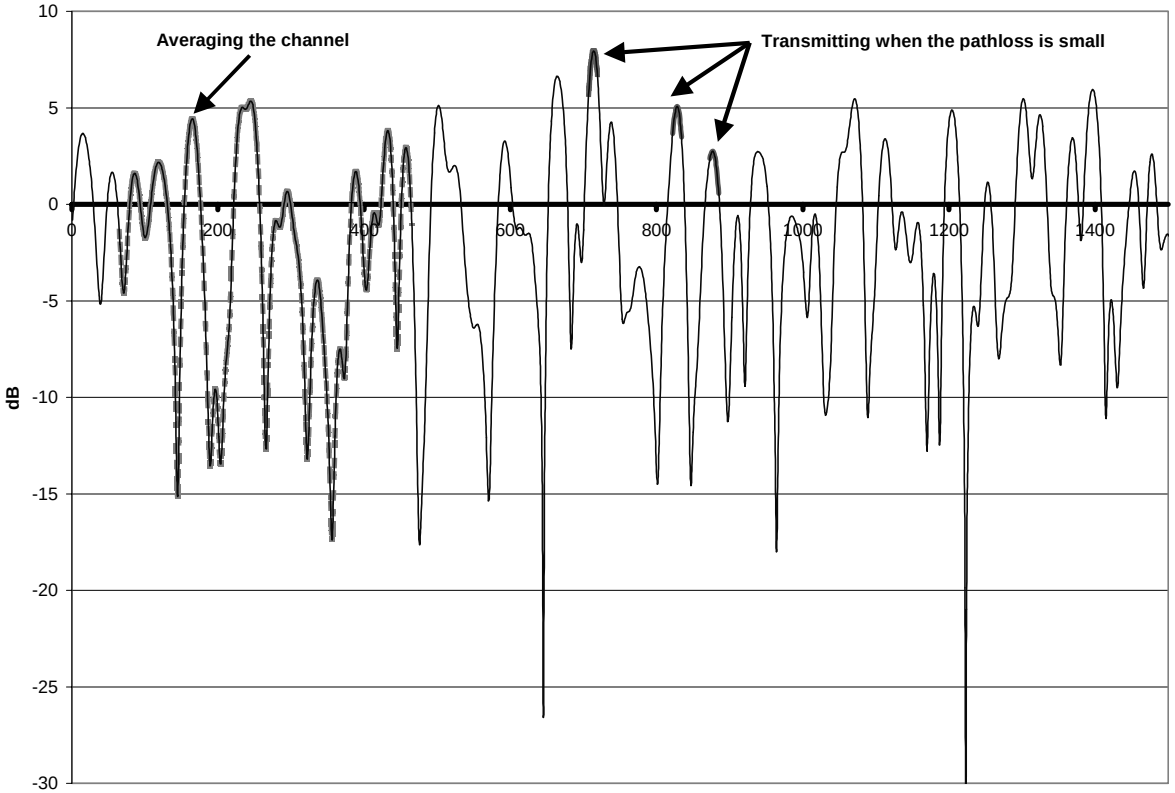


Fig. 2: Trends in microelectronics for wireless terminals

Source: Inst. Fraunhofer
www.ist-wsi.org

Dynamic scheduling to exploit fading (Qualcomm)

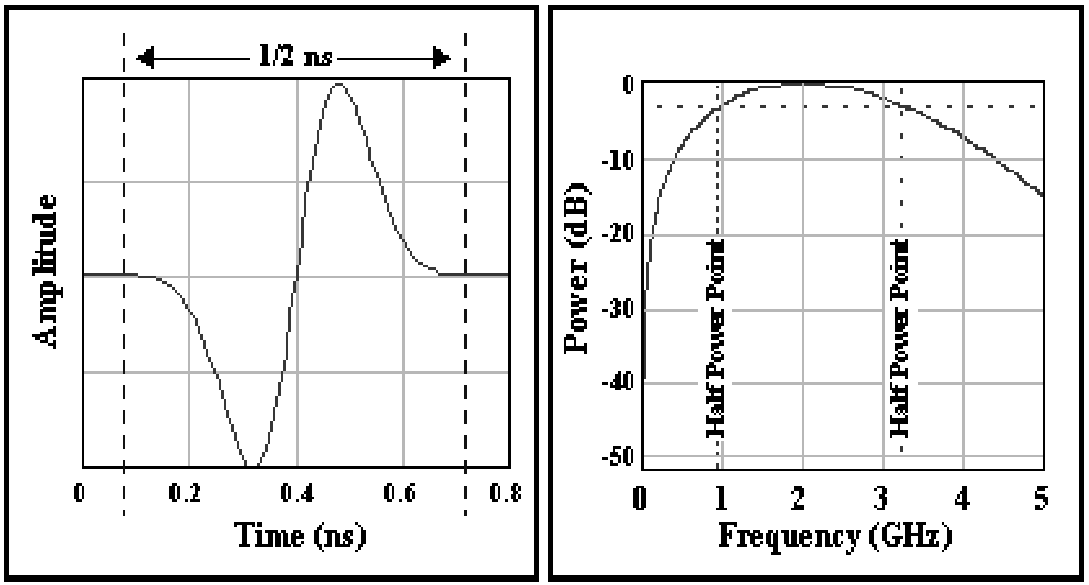


Source: Qualcomm
www.ist-wsi.org

Ultra Wide Band

Source: ***http://www.multispectral.com/presentations.html***

Short pulse wave forms typically created by impulse- or step-excited antennas;
Such monocycles provide wide bandwidth signals with centre frequency and bandwidth depending upon the monocycle's width;

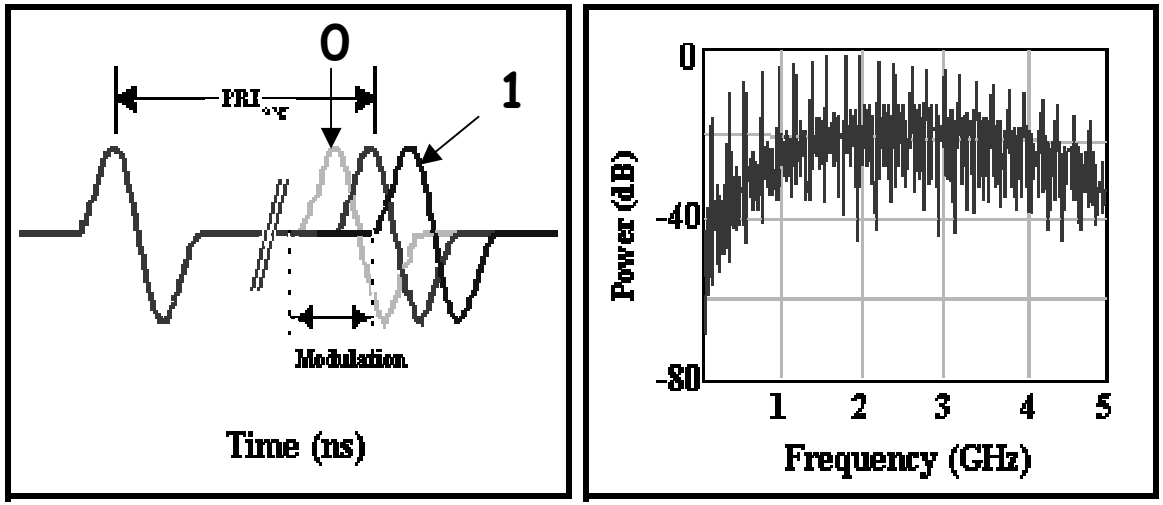


T_s=0.5 nsec f_c =1.25 GHz

UWB in communications

Source: ***http://www.multispectral.com/presentations.html***

In the frequency domain a regular monocycle pulse train produces energy spikes at regular intervals spreading in frequency the low power signal;
For a wireless communication scenario Pulse Position Modulation (PPM) is proposed combined with cross-correlation reception;
PPM distributes the transmitted energy "uniformly" across the available spectrum making the signal less "detectable";



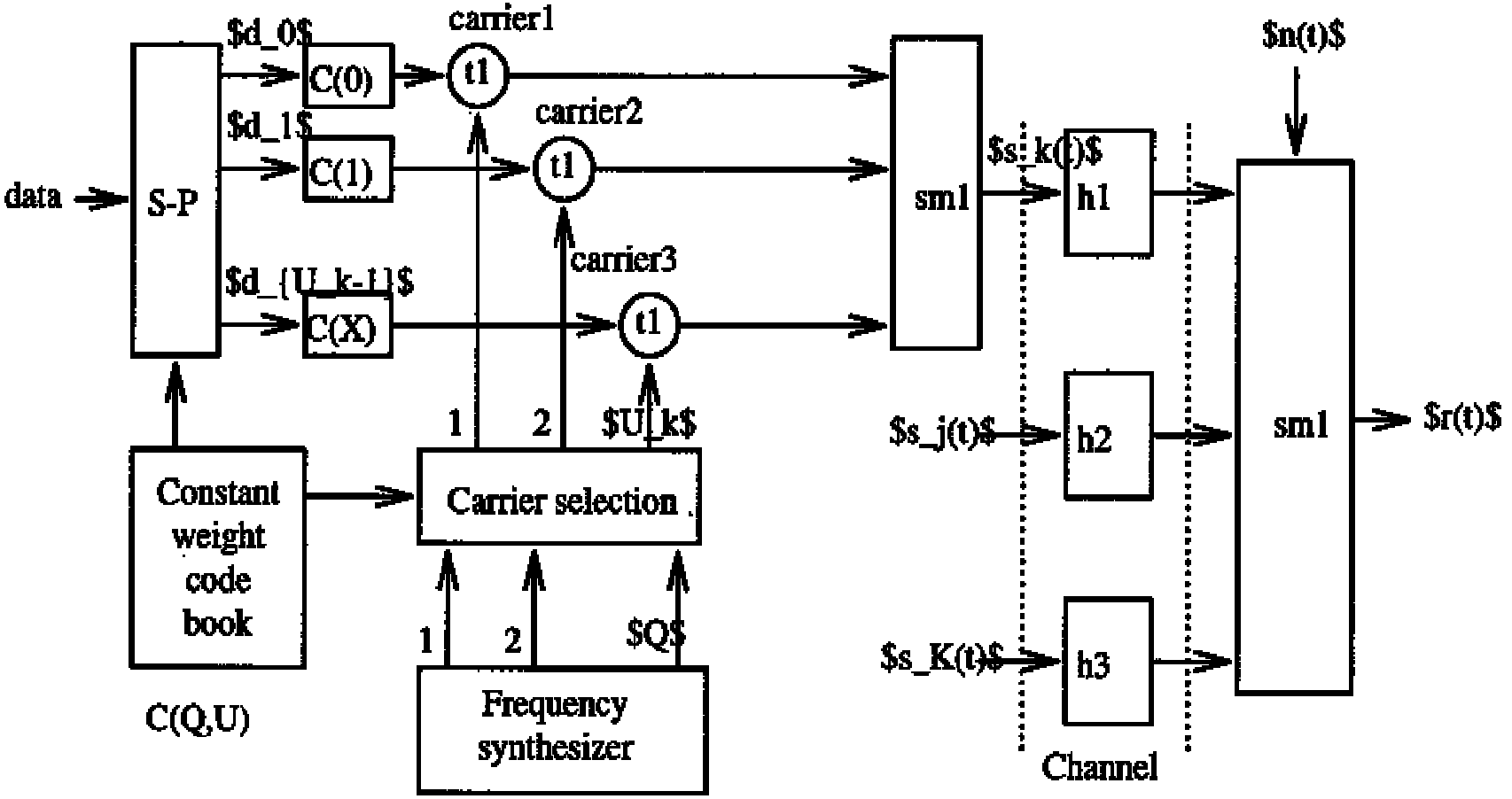
Multicarrier Coded Division Multiple Access

- It’s the combination of two well known techniques for modulation and Multiple Access (MA) :
  - Orthogonal Frequency Division Multiplexing (OFDM): already used in digital broadcasting applications and WLL schemes;
  - Single carrier Code Division Multiple Access (CDMA): already used in 2nd generation cellular systems and being a dominant mode of the UTRA for 3rd generation systems;
- CDMA provides the MA capabilities to the scheme;
- OFDM transforms a high rate serial input sequence into a set of low rate sequences transmitted in parallel (taking advantage of frequency diversity at the same time);
- The result (also known as MT-CDMA, DMT, MC-DS-CDMA) is a very flexible Radio Access (RA) scheme

MC-CDMA

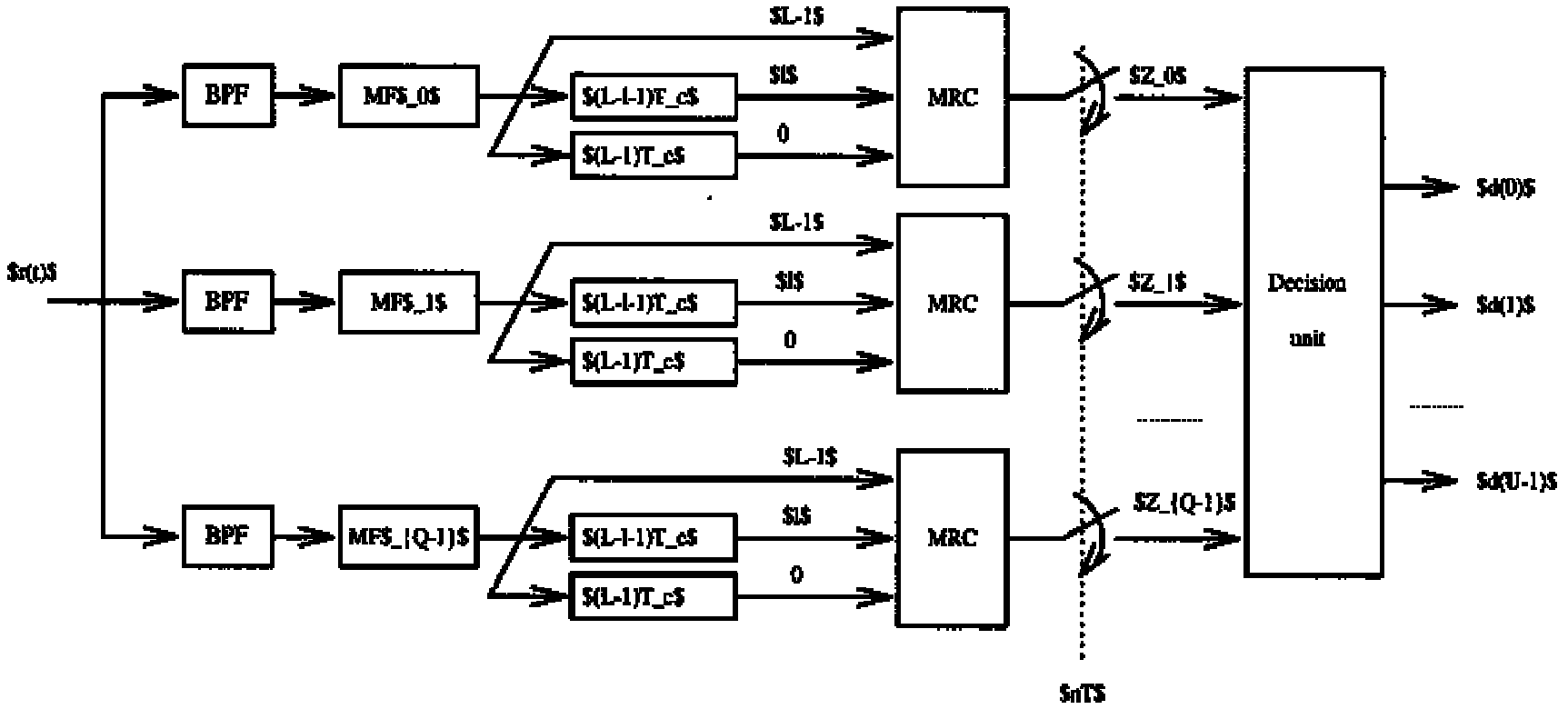
A flexible transmitter proposal

Source: ***Prof. Lajos Hanzo, University of Southampton***
IST TRUST project
http://www-mobile.ecs.soton.ac.uk/index.html



MC-CDMA
A flexible Receiver Design

Source: ***Prof. Lajos Hanzo, University of Southampton***
IST TRUST project
http://www-mobile.ecs.soton.ac.uk/index.html

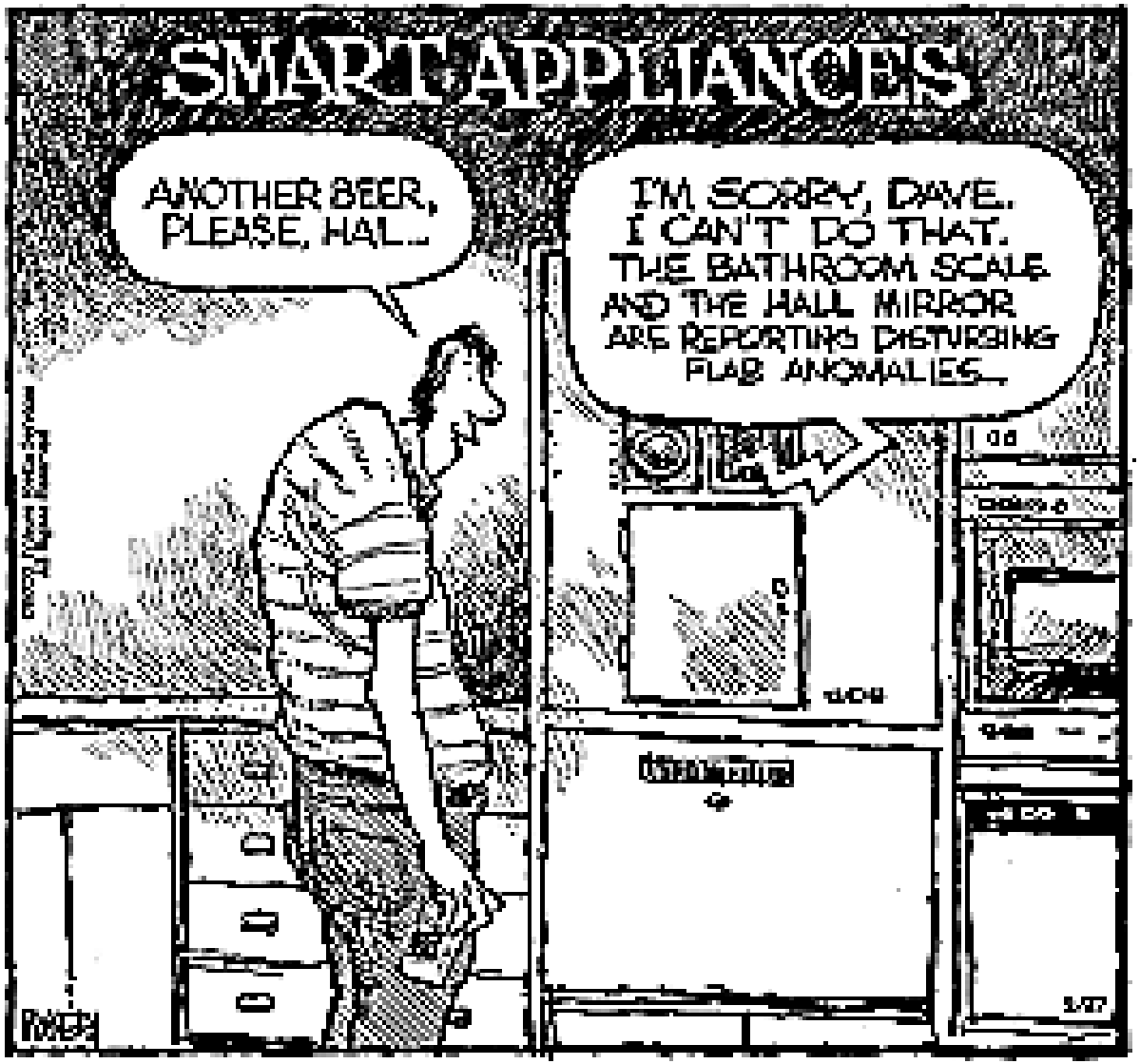


WG4. The new communication environment system: Regulation and Spectrum

- Integration of satellite
- Distributed management of AAA and security
  - use in ad-hoc networking
- Broadband wireless air interface
- PAN and embedded systems
  - info-security, personal safety
- Regulatory and business aspects
- Protocol enhancement for network convergence scenarios
  - Dynamic pricing vs. Loading and top priority services
- Dynamic spectrum management (DSM)
  - Real time spectrum trading
  - Traffic management and mobility issues for DSM

Summary: Challenges

- Do not feel depressed!!. UMTS will succeed
- But we need
  - New planning strategies for multimedia WCDMA
  - Good planning algorithms for TD-CDMA
  - VoIPW needs some work. (QoS issues remain open)
- But just in case, please consider
  - WLAN solutions (Hyperlan, IEEE 802.11 a, MC-CDMA...)
  - New radio alternatives UWB
  - Solutions based on opportunity (HDR Qualcomm)
- Other challenges
  - Self configuring networks
  - New radio interfaces.



Flab: too much soft flesh

Source: J. Dasilva. www.cordis.lu