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Ethernet & Wireless LAN are going mobile

Wireless Mobility in IEEE802

Maximilian Riegel, 2004-01-27
Siemens ICM Networks

'Ethernet & Wireless LAN go mobile'

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- Recently the IEEE802, the organization which created Ethernet and the most successful Wireless LAN, established two new groups for standardization of mobile broadband wireless access radio interface specifications. While the task group IEEE P802.16e will work on MAC layer enhancements for mobility support within the IEEE802.16a specification for fixed wireless access, the new working group IEEE P802.20 has started to define the MAC and PHY of a mobile broadband wireless access interface from ground up.

- The initiation of these new IEEE802 activities has caused remarkable publicity and a extremely high attendance in the meetings. The presentation will provide insights into the technical scope, into organizational matters and some 'historic' issues of these groups following an overview about the IEEE802 standardization and its particularities.

Motivation:
IEEE802 goes mobile...

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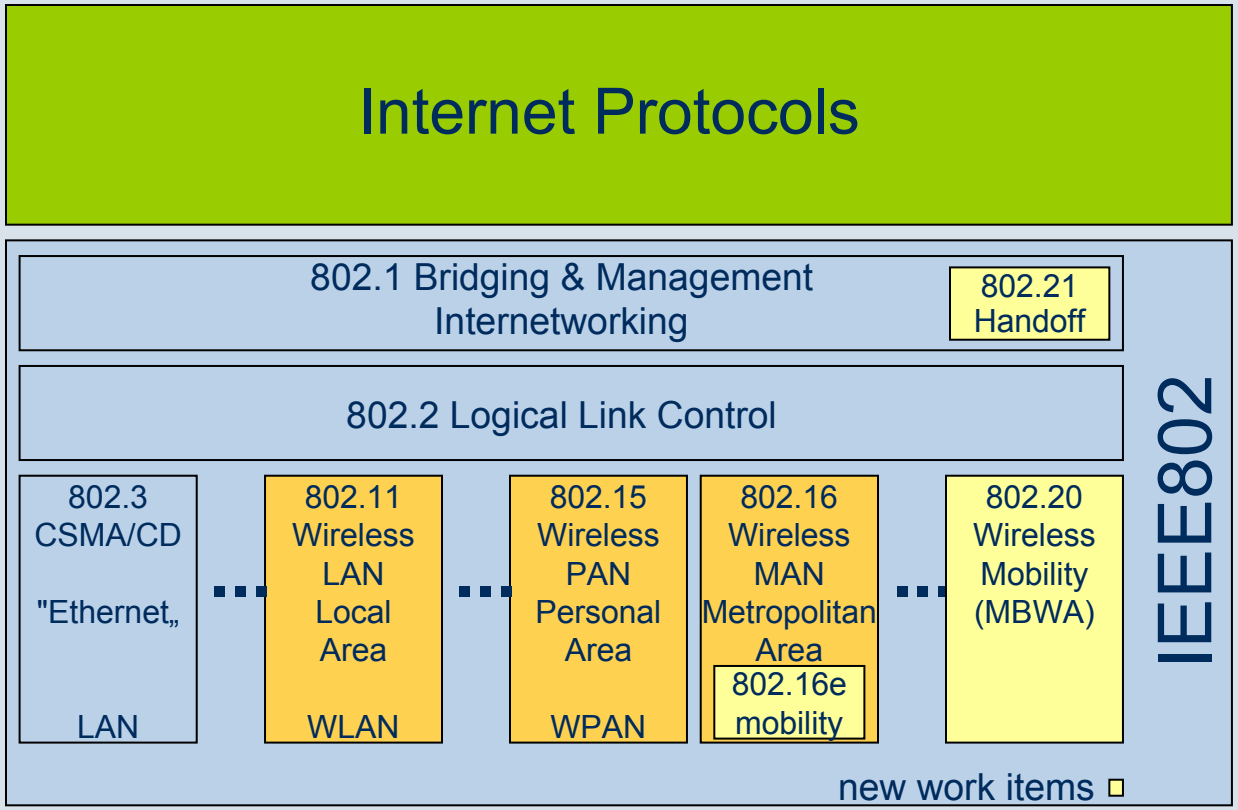

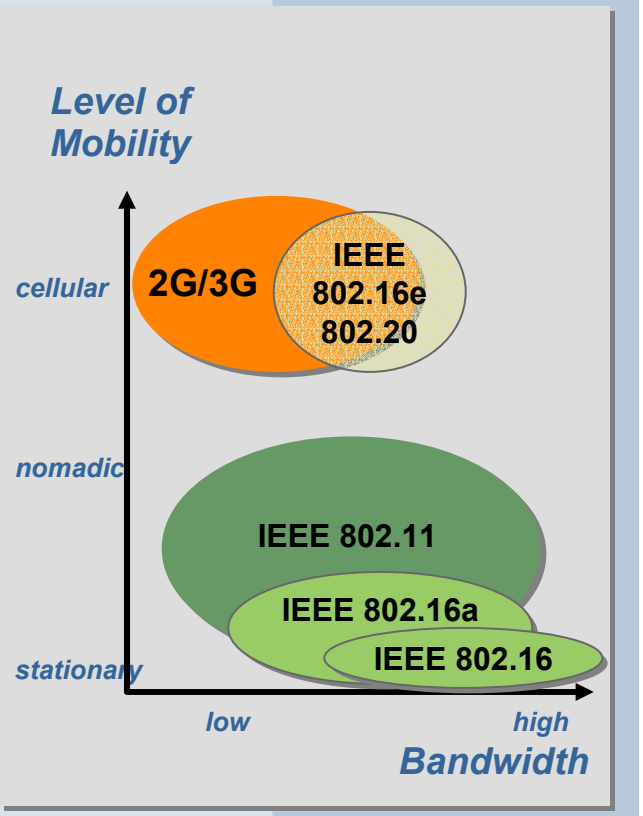

- IEEE802 provides a complete set of standards for carrying IP
- IEEE802 defines only the Physical and Link Layer of a network
- IEEE802 just recently started activities for mobile Internet access

Further motivation: Money makes the world go round...

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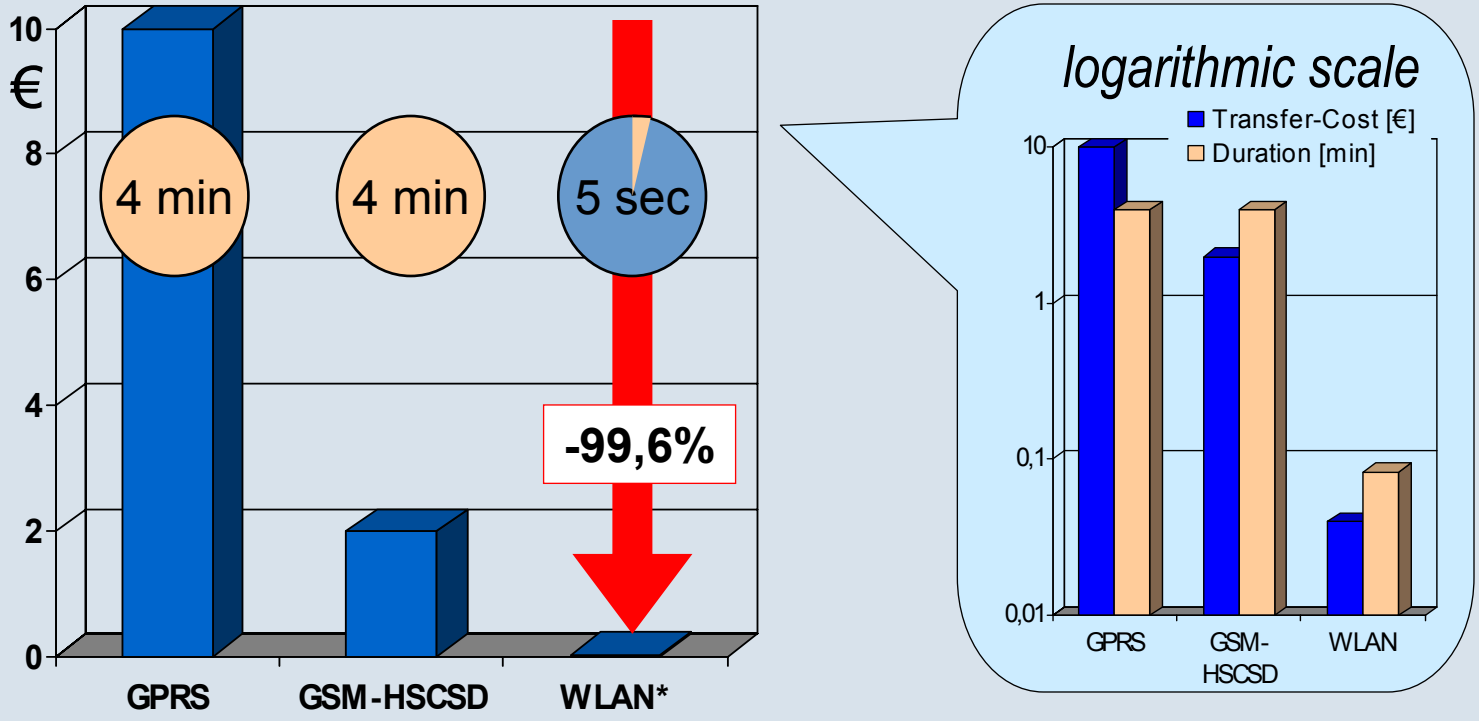
"Traditional mobile networks are much more expensive than WLAN IEEE802.11"

Transfer cost/duration of an 1 Mbytes .ppt/.doc/.xls File...



*** based on current IP volume prices of 40€ /GByte. Time based pricing results in similar costs,**

Overview

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- **Where IEEE802 fits in...**
- **The history of IEEE P802**
- **Organiational structure of the IEEE P802 LMSC**
- **Some rules for participation**
- **The way to 'Wireless Mobility' in IEEE P802**
- **Unique identity of 802.16e, 802.20 and 3G**
- **IEEE P802.20: procedural and technical issues**
  - initial plan and its failing due to blocking membership
  - inofficial technical discussions
- **IEEE P802.16e: Mobility Enhancements to IEEE802.16a**
  - the evolving market
  - driving force behind: Intel, Korean HPi
- **The market for IEEE802.16e & IEEE802.20**
  - UMTS HSDPA provides comparable performance

Network standardization in protocols: IEEE802 & IETF

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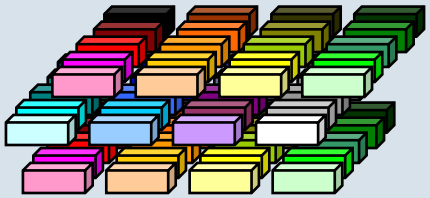
Protocol

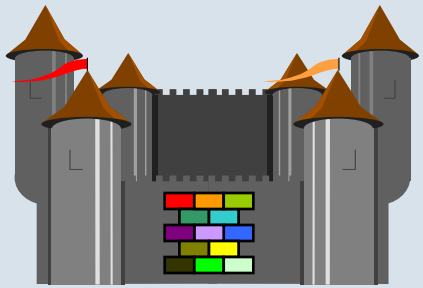
IETF, IEEE802



- General building blocks
- Single protocol functions
- Adoption open to market
- Contribution by individuals

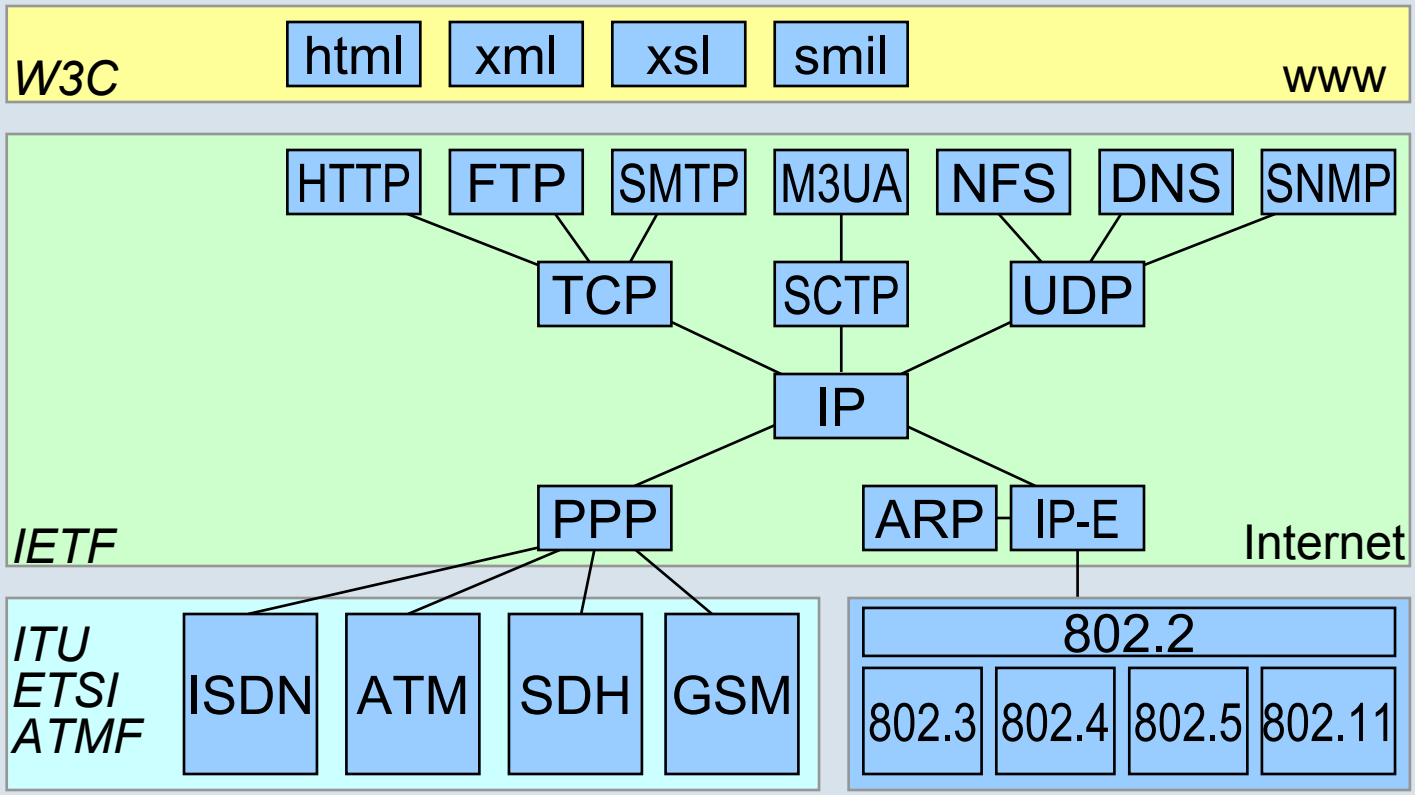
Architecture

3GPP/3GPP2



- Network architecture
- Specification of a network
- Often compulsory
- Corporate membership

- the other leg of the Internet



Application

Transport

Network

Link

Physical

- IEEE Project 802 develops LAN and MAN standards,
  - Only Link and Physical Layer of the OSI reference model
- Some standards published by ISO as international standards
- International participation, some meetings held outside the U.S.

The beginning of IEEE P802...

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- **First meeting of the IEEE Computer Society "Local Network Standards Committee", Project 802, in Febr. 1980.**
  - The project number 802 was simply the next number in the sequence.
  - Later renamed to "LMSC": LAN/MAN Standardization Committee
- **Work was on one LAN standard, with 1 to 20 MHz, divided into:**
  - Higher Level Interface (HILI).
  - Media Access Control (MAC), and
  - Physical layer (PHY),

  Access method similar to Ethernet, as well as the bus topology.
- **End of 1980: token access method was added.**
  - a year later three MACs: CSMA/CD, Token Bus, and Token Ring.
- **Further MAC and PHY groups addded, e.g. 802.11, 802.15, 802.16**
- **Unifying themes of IEEE P802**
  - common upper interface to the Logical Link Control (LLC) sublayer,
  - common data framing elements

IEEE P802: Active Groups

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- **802.1: High Level Interface (HILI) Working Group**
  - Chairman - Tony Jeffree (tony@jeffree.co.uk)
- **802.3: CSMA/CD Working Group**
  - Chairman – Bob Grow (bob.grow@intel.com)
- **802.11: Wireless LAN (WLAN) Working Group**
  - Chairman - Stuart Kerry (stuart.kerry@philips.com)
- **802.15: Wireless Personal Area Network (WPAN) Working Group**
  - Chairman - Bob Heile (bheile@ieee.org)
- **802.16: Broadband Wireless Access (BBWA) Working Group**
  - Chairman - Roger Marks (r.b.marks@ieee.org)
- **802.17: Resilient Packet Ring (RPR)**
  - Chairman - Mike Takefman (tak@cisco.com)
- **802.18: *Radio Regulatory Technical Advisory Group***
  - Chairman – Carl Stevenson (carl.stevenson@ieee.org)
- **802.19: *Coexistence Technical Advisory Group***
  - Chairman – Jim Lansford (jim.lansford@mobilian.com)
- **802.20: Mobile Wireless Access Working Group**
  - Chairman – Jerry Upton (jerry.upton@ieee.org)

IEEE 802 Organization
Sponsor Executive Committee members

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P802.1 High Level Interface (HILI) Tony Jeffree	P802.2 Logical Link Control Dave Carlson*	P802.3 CSMA/CD Bob Grow
P802.4 Token Bus Paul Eastman*	P802.5 Token Ring Robert D. Love*	R802.6 Metropolitan Area Network James Mollenauer**
P802.7 Broadband TAG Robert Russell**	P802.8 Fiber Optic TAG J. Paul Benson**	P802.9 Integrated Services LAN Dhadesugoor Vaman*
P802.10 Interoperable LAN Security Kenneth G. Alonge*	P802.11 Wireless Local Area Network Stuart J. Kerry	P802.12 Demand Priority Patricia Thaler*
P802.14 Cable-TV Based Broadband Robert Russell*	P802.15 Wireless Personal Area Netw Bob Heile	P802.16 Broadband Wireless Access Dr. Roger Marks
P802.17 Resilient Packet Ring Mike Takefman	P802.18 Radio Regulatory TAG Carl Stevenson	P802.19 Coexistence TAG Jim Lansford
P802.20 Mobile Broadband Wireless Jerry Upton	P802.21 Handoff D.J. Johnson	

Chair Paul Nikolich
Vice Chair Mat Sherman
Vice Chair Geoff Thompson
Treasurer Bill Quackenbush
Recording Secretary Bob O'Hara
Executive Secretary Buzz Rigsbee

* - Denotes Hibernating (Inactive) Working Group
** - Denotes disbanded working group

IEEE P802 Process

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- **Membership**
  - **Individuals (engineers)**
    - *other Telecom standardization bodies, e.g. ITU, 3GPP: Governmental Representatives, Companies*
- **Process**
  - Call for Contributions
    - Specific topics for discussion at next meeting
  - Receive and post written contributions
  - Discuss and debate at meeting
    - Create draft by 75% vote
  - Working Group Ballot
    - Ballot Responses: "Approve" or "Disapprove": indicate what needs to be changed
    - Comments have to be resolved by working group
  - IEEE "Sponsor Ballot“
    - same as above, but with more open group

IEEE P802 Membership

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- **Membership can be acchieved by**
  - participating in the initial meeting of the working group
  - participating at two out of the last four plenary sessions in the meetings of the working group
    - One interim meeting may be substituted for one of the two plenary sessions
    - Participation is defined as at least 75% presence at a meeting.
- **Membership starts at the third plenary session attended by the participant.**
- **Membership belongs to the individual, not an organization, and may not be transferred.**
- **Membership privileges may be revoked if any one of the following occurs:**
  - Failure to respond and vote on 2 out of 3 consecutive mandatory working group letter ballots
  - Failure to participate in 2 out of 4 consecutive plenary sessions. (Note: one interim can be substituted for one plenary session)

IEEE802 goes mobile: 802.20 (MBWA) and 802.16e

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- **March 2002: BOF held in P802.16 on mobile extensions**
- **July 2002: SG for mobile extensions failed in P802.16**
- **IEEE802 SEC sets up the MBWA ECSG on mobile radio interface**
  - supported by Flarion and Arraycomm
- **P802.16 sets up a SG for mobile extensions of 802.16a**
  - supported by InterDigital, Wi-Lan, Alvarion
- **November 2002: SEC approves both SGs driven by chair**
  - lobbying against: Nokia, Ericsson, Siemens
  - lobbying in favour: Cisco, Motorola
- **First activities on January 03 Interim to complete PARs**

802.20 and 802.16e (Unique Identities-1) Claiming 'Two Markets – Two Projects'

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Dimension	802.16e	MBWA (802.20)	3G
Technology	■Extensions to 802.16a MAC & PHY	■New PHY & MAC optimized for packet data and adaptive Antennas	■W-CDMA, cdma2000
	■Optimized for and backwards compatible with fixed stations	■Optimized for full mobility	■Evolving of GSM or IS-41
	■Licensed bands 2-6 GHz	■Licensed bands < 3.5 GHz	■Licensed bands < 2.7 GHz
	■Typ. Channel BW >5 MHz	■Typ. Channel BW < 5 MHz	■Typ. Channel BW < 5 MHz
	■Packet oriented architecture	■Packet oriented architecture	■Circuit oriented architecture – evolving to packet on the downlink
	■Channelization and control for multimedia services with QoS	■Channelization and control for mobile multimedia services. Mobile-IP Based	■Channelization and control optimized for mobile voice services. MAP/SS7 based
	■High efficiency data uplinks and downlinks	■High efficiency data uplinks and downlinks	■Medium efficiency data downlinks, low efficiency uplinks
	■Low Latency architecture	■Low latency data architecture	■High latency data arch.

802.20 and 802.16e (Unique Identities-2) Claiming 'Two Markets – Two Projects'

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Dimension	802.16e	MBWA (802.20)	3G
End-user	■High data rate fixed wireless user with adjunct mobility service ■Symmetric data services ■End-user devices for fixed subscribers (CPE) and PC Cards for mobile devices ■Support of low-latency data and real time voice services	■Fully mobile, high throughput data user ■Symmetric data services ■End-user devices initially PC Card enabled data devices ■Support of low-latency data services	■Voice user requiring data services ■Highly asymmetric data services ■End user devices initially data enabled handsets ■Lack of support for low latency services
Service Provider	■Evolving off Fixed Wireless service providers and WISPs adding mobility as enhance-ment to service offering ■Local/Regional mobility and roaming support	■Wireless Data Service provider – Greenfield start or evolving Cellular carrier ■Global mobility and roaming support	■Cellular voice service provider evolving to data support ■Global mobility and roaming support

IEEE802 activities on mobile standards

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- **IEEE 802.20 Mobile Broadband Wireless Access**
  - Mobile Broadband Wireless Access Network Operating in Licensed Frequency Bands and Supporting Mobility at Vehicular Speeds

- **IEEE 802.16 Broadband Wireless Access**
  - Active Projects:
  - 802.16d: Revision of 2-11 GHz profile incl. mobility extensions of PHY
  - 802.16e: Mobile Wireless MAN project

- **IEEE 802.21 Handoff**
  - Optimisation of handoff between networks of different media types or networks of the same media type but of different operational entities.

802.20 - Draft Project Development Timeline from January '03

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ECSG Approval of PAR/5C	Sep. 2002
Submission of PAR/5C to LMSC Executive Committee	Oct. 7, 2002
Conditional Submission of PAR/5C to NesCom	Oct. 31, 2002
First MBWA Technical Meeting (WG #0)	Nov 10-14, 2002
Approval of PAR/5C by LMSC Executive Committee	Nov 15, 2002
Approval of PAR by IEEE-SA Board	Dec 12, 2002
First Meeting of MBWA WG (WG #0)	Jan 13-17, 2003
Initial Membership Meeting	Mar 10-14, 2003
WG Letter Ballot	Nov/Dec, 2003
LMSC Sponsor Ballot	May/Jul, 2004
Sponsor Confirmation Ballot	Aug., 2004
Submission to RevCom	Oct. 31, 2004
IEEE-SA Approval	Dec. 10, 2004

Understanding the 802.20 PAR

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- **PAR was written with inputs from Flarion and Arraycomm**
- **Try to distinguish itself with 802.16e (fixed wireless access enhanced by mobility)**
- **PAR should be used as guideline only**
  - Evaluation matrix will be determine for proposal selection
  - Proposal merging is common in IEEE
  - Mandatory and optional modes are available
  - There can be multiple specifications to address each requirement in the PAR, i.e., one for FDD and one for TDD
- **IEEE working group cannot work beyond scope of PAR; otherwise, new PAR is needed**

802.20 Requirements from PAR

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Characteristic	Target Value
Mobility	Vehicular mobility classes up to 250 km/hr (as defined in ITU-R M.1034-1)
Sustained spectral efficiency	> 1 b/s/Hz/cell
Peak user data rate (Downlink (DL))	> 1 Mbps*
Peak user data rate (Uplink (UL))	> 300 Kbps*
Peak aggregate data rate per cell (DL)	> 4 Mbps*
Peak aggregate data rate per cell (UL)	> 800 Kbps*
Airlink MAC frame RTT	<10 ms
Bandwidth	e.g., 1.25 MHz, 5 MHz
Cell Sizes	Appropriate for ubiquitous metropolitan area networks and capable of reusing existing infrastructure.
Spectrum (Maximum operating frequency)	< 3.5 GHz
Spectrum (Frequency Arrangements)	Supports FDD (Frequency Division Duplexing) and TDD (Time Division Duplexing) frequency arrangements
Spectrum Allocations	Licensed spectrum allocated to the Mobile Service
Security Support	AES (Advanced Encryption Standard)

Sprint's wish list:

- up to 120 km/hr
- 2 b/s/Hz/Cell
- 1 Mbps/512 kbps
- 256/128 kpbs

- higher than 5 MHz
- link budget > 160 dB

- 2.5 GHz

802.20 Initial Membership & Votes

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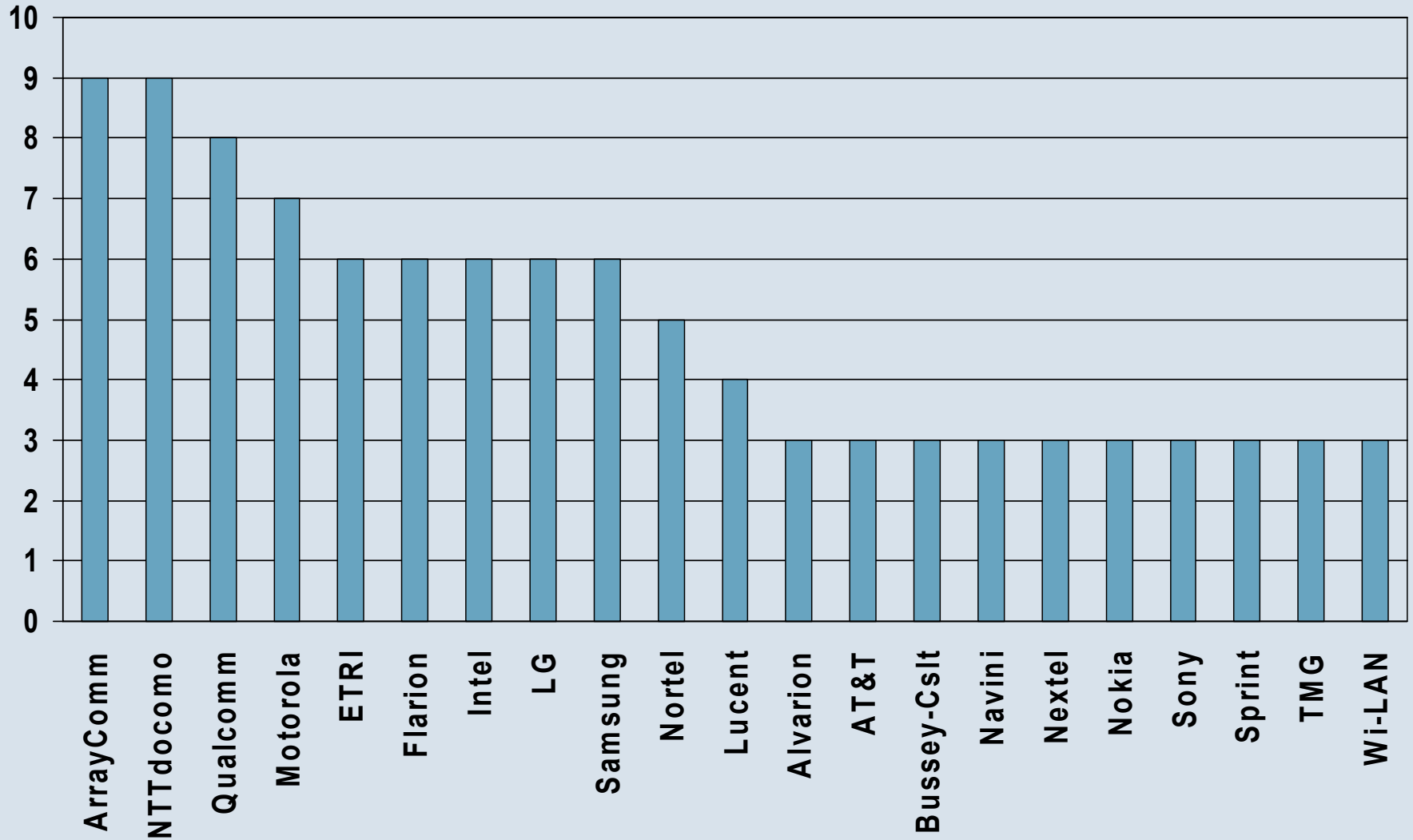

IEEE802.20: Political fights from the beginning

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- **Proponents: Flarion, Arraycomm, Nextel**
  "Please rubberstamp our proposals"
- **Opponents: Qualcomm, Lucent, 3G vendors**
  "Go away!"
  - 802.20 is aiming to compete especially with 1X-EVDO
- **Bystanders: Motorola, Navini, Sprint**
  "We want something different"

- **None of the parties have reached sufficient majority to start productive work in the WG**

IEEE 802.20 Participation

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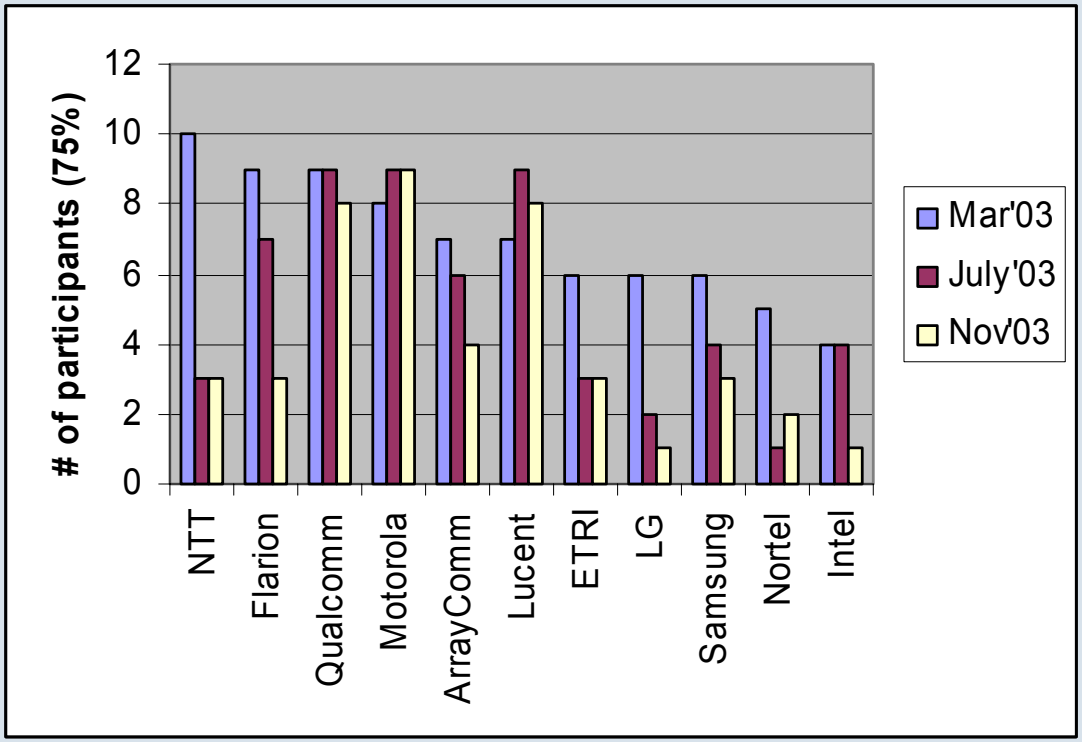
- **Companies (except Lucent, Qualcomm and Motorola) have reduced the number of delegates**
  - Political debates (boring for most people)
  - IEEE rules allow temporary absence of participation
  - Rotating new faces to increase the number of voters



Current work in IEEE802.20

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- **Still working on the prerequisites for standardization**
- **Requirements document**
  - Agreement on bandwidth definition, block assignment (1.25 to 20 MHz FDD and 2.5 to 40 MHz TDD)
  - Unsolved issues: Spectral efficiency (definition and number), frame error rate requirement
- **Evaluation criteria document (depends on requirements)**
  - Derived from 3GPP2 documents
  - Agreement on fairness criteria
  - Discussion on application specific (VoIP) evaluation
    - Example: 2 SY needed to evaluate 1X-EV-DV
- **Traffic and channel modeling document**
  - Derived from 3GPP2 documents (VoIP. Gaming, web browsing)
  - No further discussion in the meeting

802.20: Status/Results from IEEE802 Interim meeting in January 2004

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- **About 80 people with about 40 voters were present**
  - there has been no quorum (no binding decision)
- **No NTTDoCoMo participation**
  - except for Gang Wu (vice-Chair)
- **There are still monitoring participants from Japan and Korea**
- **Continuing interest from operators (T-Mobile, Vodafone, Cingular, Sprint, Nextel, France Telecom)**
- **Lucent is still delaying progress by endless discussions**
- **Nextel and Sprint is trying to form operator alliance but DoCoMo is not interested**
- **Outlook**
  - Future will mainly depend of officer election in March
  - In the best case, the 1st draft may be available in first half of 2005

802.20 Vote distribution by company

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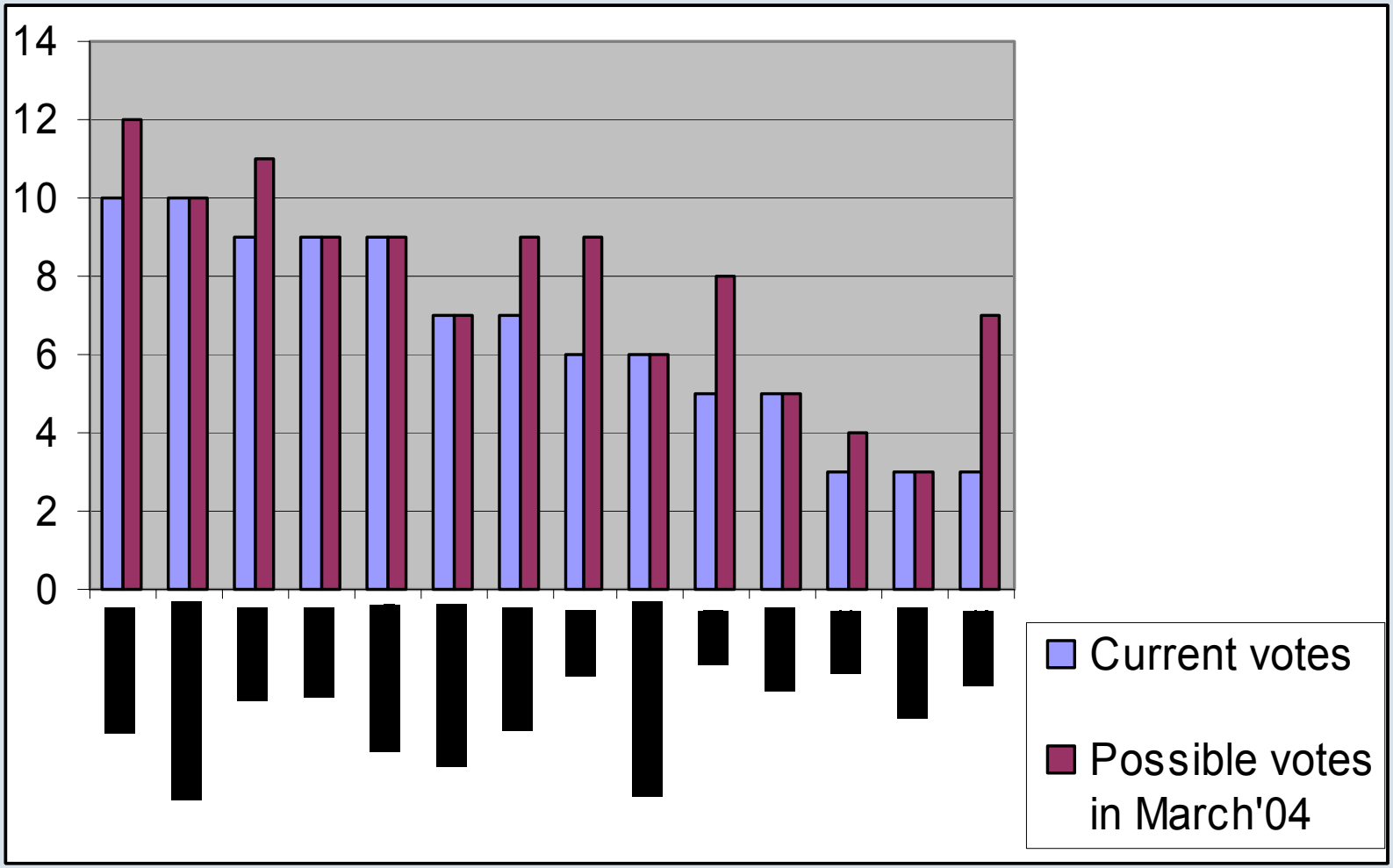

An essential change may be quite unlikely in March ’04.

Comparison between 802.20 and 802.16e

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	IEEE 802.20	IEEE 802.16e
Estimated IEEE standard approval	2005 - 2006	2004 (802.16-rev 2003) → 2005 (802.16e)
Licensed frequency	Below 3.5 GHz	2 - 6 GHz
Bandwidth (TDD/FDD)	1.25 – 40 MHz	1.5 – 24, 1.75 – 28, 2.5 – 15 MHz
Spectral efficiency	> 2 bps/Hz/Sector DL	Not specified
# of simul. Sessions	> 100	Not specified
Data rate per user	> 1 Mbps DL > 300 kbps UL	>1 Mbps (4-24 Mbps in 6 MHz BW)
Mobility support	Up to 250 km/h	Target at 150 km/h
QoS	IETF	Connection-oriented
Latency	< 10 ms (RTT)	Not Specified
Cell deployment	Hierarchy, P2MP, Mesh	Hierarchy, P2MP
Handover	Soft and hard	Soft and hard mobileIPv4
Backward compatibility	None	802.16a

Ongoing discussions

IEEE802 activities on mobile standards

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- **IEEE 802.20 Mobile Broadband Wireless Access**
  - Mobile Broadband Wireless Access Network Operating in Licensed Frequency Bands and Supporting Mobility at Vehicular Speeds

- **IEEE 802.16 Broadband Wireless Access**
  - Active Projects:
  - 802.16d: Revision of 2-11 GHz profile incl. mobility extensions of PHY
  - 802.16e: Mobile Wireless MAN project

- **IEEE 802.21 Handoff**
  - Optimisation of handoff between networks of different media types or networks of the same media type but of different operational entities.

IEEE 802.16 Standards Family

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	802.16	802.16a	802.16e
Completed	December 2001	January 2003 (802.16a)	Estimate mid '04
Spectrum	10 - 66 GHz	< 11 GHz	< 6 GHz
Channel Conditions	Line of Sight Only	Non Line of Sight	Non Line of Sight
Bit Rate	32 – 134 Mbps in 28MHz channel bandwidth	Up to 75 Mbps in 20MHz channel bandwidth	Up to 15 Mbps in 5MHz channel bandwidth
Modulation	QPSK, 16QAM and 64QAM	OFDM 256 sub-carriers QPSK, 16QAM, 64QAM	Same as 802.16a
Mobility	Fixed	Fixed, Portable	Nomadic Mobility
Channel Bandwidths	20, 25 and 28 MHz	Scalable 1.5 to 20 MHz	Same as 802.16a with UL sub-channels
Typical Cell Radius	2-5 km	7 to 10 km Max range 50 km	2-5 km

IEEE802.16/WiMAX Market Evolution
Fixed Outdoor in '04

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802.16a
Non Line of Sight
Point to Multi-point

Point to Point
BACKHAUL

802.16a

Solution
Fixed location
Outdoor installed
Applications
E1/T1 level service
Backhaul for Hotspots
Residential BBA

FRACTIONAL E1/T1
for SMALL BUSINESS

E1/T1+ LEVEL
SERVICE ENTERPRISE

Internet Backbone

IEEE802.16/WiMAX Market Evolution
Consumer Indoor in '05

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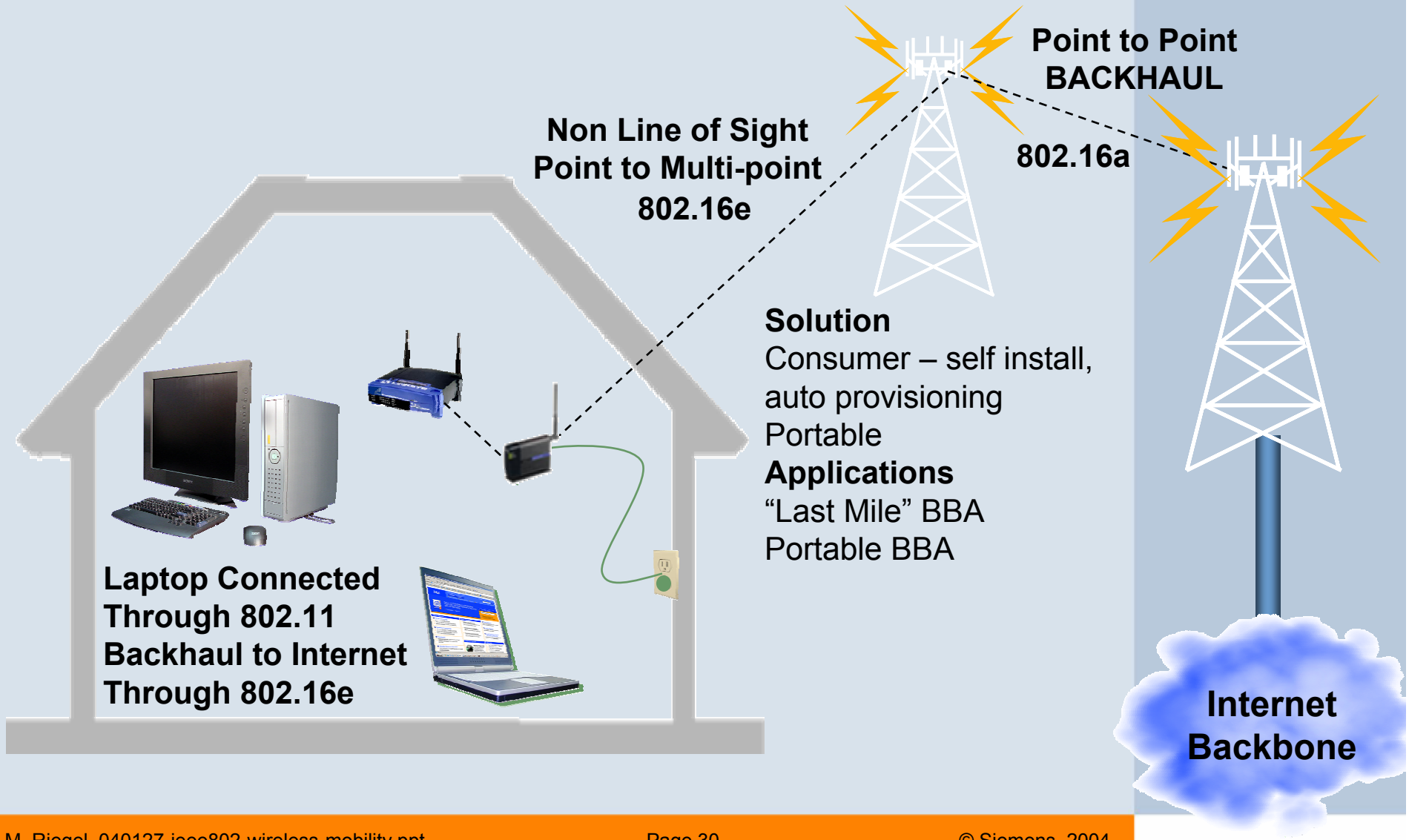

IEEE802.16/WiMAX Market Evolution
Mobile Consumer in '06

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Non Line of Sight
Point to Multi-point

802.16e

Point to Point
BACKHAUL

802.16a

802.16e
802.11 indoors
Always Best Connected

Solution

- Native in Mobile PC
- Roam at varying speeds

Applications

- "Mobile" BBA for consumers
- Simple Network Selection

Internet Backbone

Comparison: IEEE802.16 and IEEE802.11 Standards

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	802.11	802.16	Technical
Range	■Optimized for 100 meters	■Optimized for last mile, outdoor ■Typical cell size of 7-10 km ■Up to 50 km range	■802.16 PHY tolerates 10x more multi-path delay spreads than 802.11
Coverage	■Assumes indoor environments and users within 100m of each other	■Assumes outdoor environments (trees, buildings, users spread out over distance) ■Standard support for advanced antenna techniques & mesh	■Base station coordinates subscriber transmits -> no “hidden node” problem in 16
Scalability	■Channel bandwidth is wide (20 MHz) and fixed -> fine for indoor networks	■Channel b/w is flexible from 1.5 MHz to 20 MHz ■Easier cell planning for both licensed and license exempt	■Only 3 non-overlapping 802.11b channels; 5 for 802.11a ■802.16: limited only by available spectrum
Bit rate	■2.7 bps/Hz peak data rate ■Up to 54 Mbps in 20 MHz channel	■3.8 bps/Hz peak data rate; Up to 75 Mbps in a 20 MHz ■5 bps/Hz bit rate; 100 Mbps in 20 MHz channel	■802.16: 256 OFDM ■802.11: 64 OFDM
QoS	■No QoS support today -> 802.11e working to standardize	■QoS designed in for voice, video and differentiated services	■802.11: contention-based MAC (CSMA) ■802.16: grant request MAC

802.16: Status/Results from IEEE802 Interim meeting in January 2004

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- **About 150 participants**
  - remarkable increase since last meeting
  - currently 63 voting member, about 30 present on the meeting
- **Apparently broad interest in 802.16d/e**
  - caused by WiMAX and Korean interest
  - Samsung and Intel are now heavily driving completion
  - Extremely high participation from Korea
    - especially in TGe more than 50% coming from Korea
  - Many participants from Intel, mostly in TGd
- **Nokia, Qualcomm showed up (again)**
  - many other companies started monitoring
- **A liaison letter was received from Korean TTA PG05 (HPi Standardization Project) asking for cooperation on the mobile WMAN specification**
  - Intel actively promoted the use of WiMAX instead of home-grown HPi in Korea beginning of December ’03.

Participation in 802.16 by company

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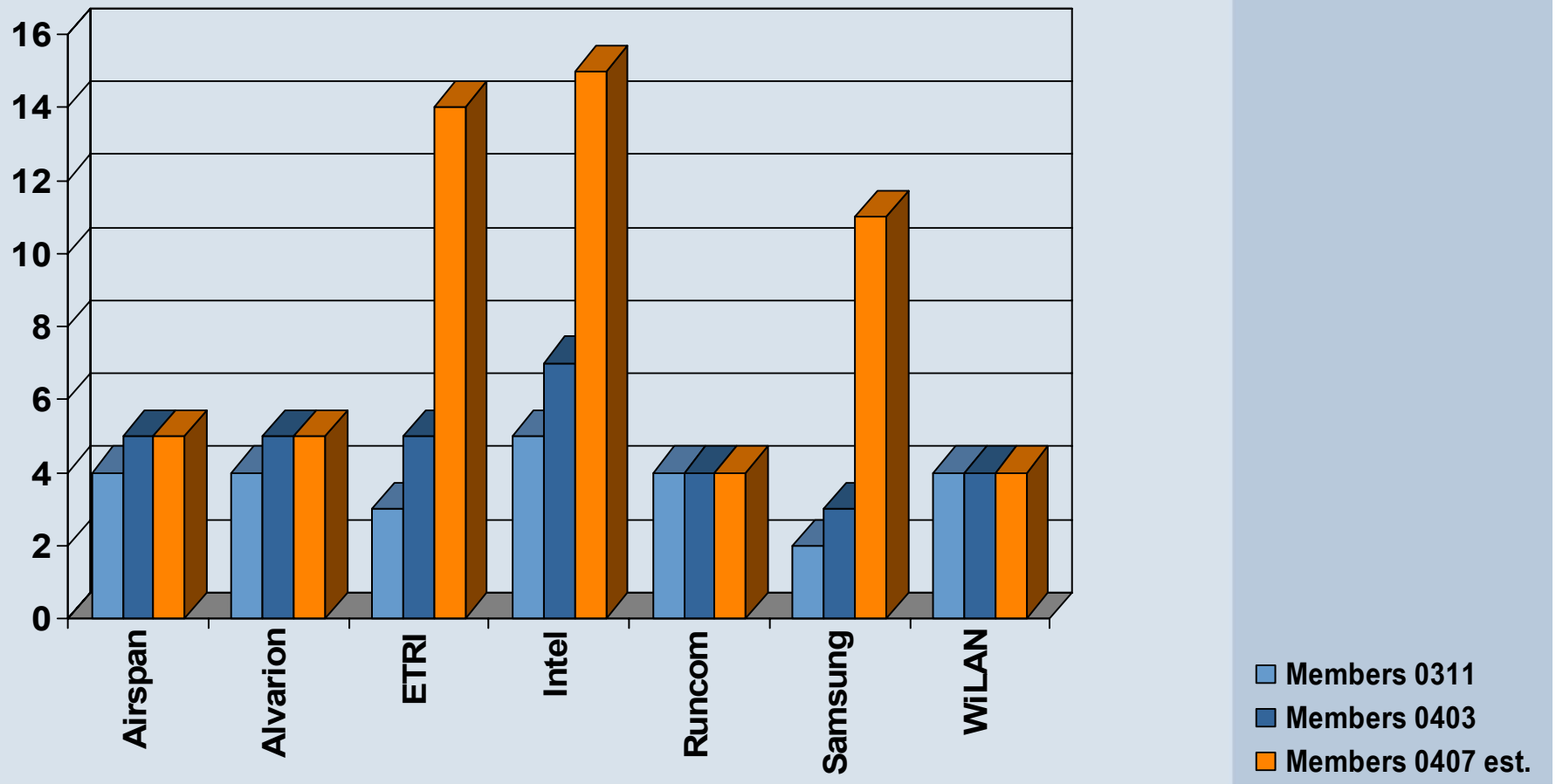
- Intel, ETRI and Samsung have increased their participation.



The Korean HPi (High-speed Portable internet) Project

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HPI Project

• Project name	HPI system development
• Sponsor	Samsung, HTI, KT, KTF, SKT
• term	2003. 1. 1. ~ 2005. 12. 31.
• Final Goal	Portable internet RTT spec. and system development.
• Detail Goal	- Portable internet RTT spec. - Portable internet system development. . Access Point(AP), Access Terminal(AT), Packet Access Router(PAR) - Portable internet modem development. . Modem for AP and AT

Co-operation

ETRI: HPI requirements spec. and prototype system development.
Samsung: Commercial system development.
Tel. co.: Support requirements spec.

HPi Physical Layer Specification

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Frequency Band	2.300GHz ~2.400GHz
Channel Bandwidth	10MHz
Multiple Access	OFDMA-TDD
Modulation	QPSK, (8PSK), 16QAM, 64QAM
Channel Coding	CTC (Convolution Turbo Code)
Frame Length	5msec
Maximum Data Rate	30Mbps (without SA/MIMO)
	50Mbps (with SA/MIMO)
AP Synchronization	GPS
Cell Coverage	Urban ~1Km
	Suburban ~5Km

Where is this hype coming from?

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Approaching the potential market...

The future of broadband Internet access

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- **Today broadband Internet access is provided by DSL or cable modems**
  - cable modems less important in many countries
- **Currently wire line DSL penetration is heavily growing worldwide**
  - has reached nearly 10% of all households in Germany
- **Expectation:**
  market penetration may reach ~ 35% in 2008
  - only some countries subsidizing broadband access may go higher
- **But Internet penetration of households may grow beyond 80%**
  - some US cities have already reached this level

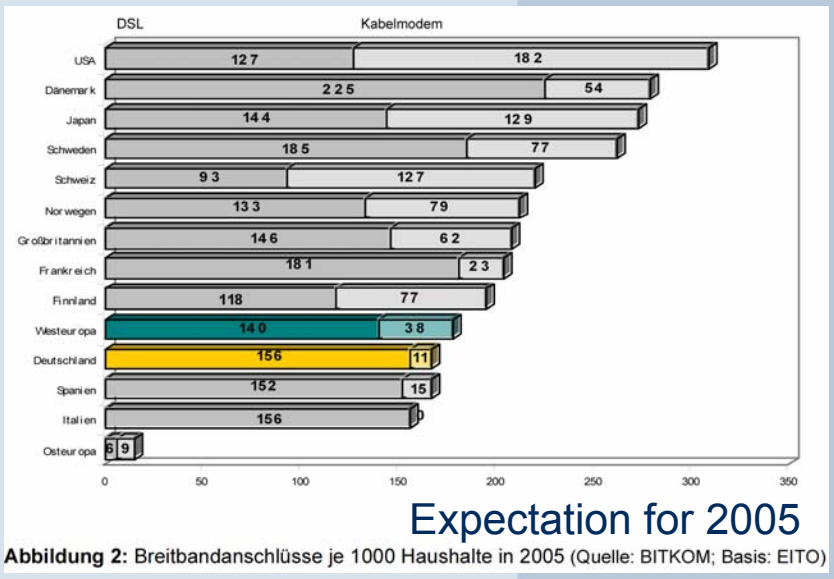

Abbildung 2: Breitbandanschlüsse je 1000 Haushalte in 2005 (Quelle: BITKOM; Basis: EITO)

Is there a business to serve some of the other 50% of all households with broadband Internet access?

The weaker sides of wire line DSL

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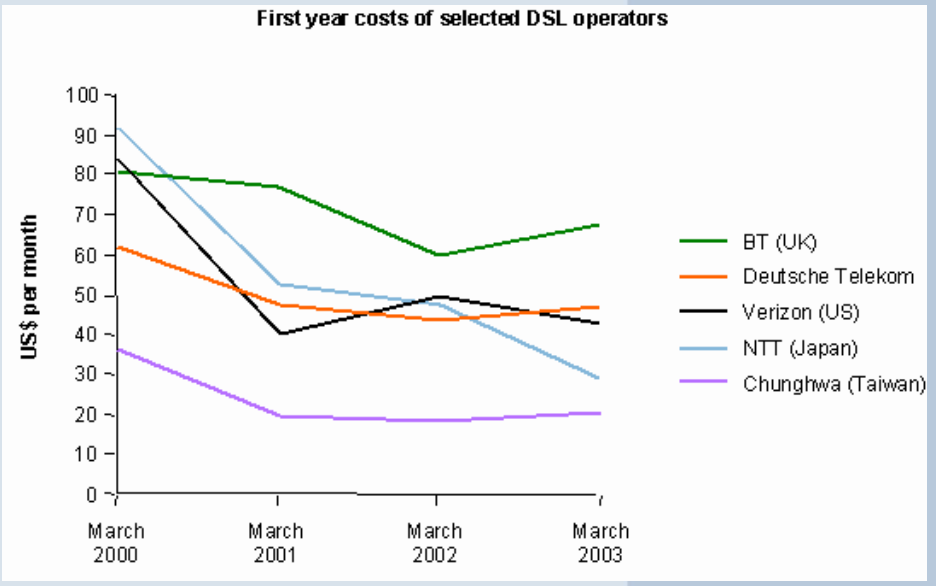
- **It is quite expensive, if customers...**
  - have switched to mobiles for all their telephony (!), (> 30€/month just for DSL)
  - have only a single POTS line, (> 20€/month add-on for DSL)
  - are often moving, (~ 100€/installation)



... especially if they live in small households

- 1-2 user/household and “casual” Internet usage

- **Expensive and cumbersome in-house networking**
  - Needs a technician for installations and maintenance

Often a wireless DSL technology may provide a cheaper and more user-friendly solution?

There is a huge market aside of UMTS
(Do not touch UMTS business!)

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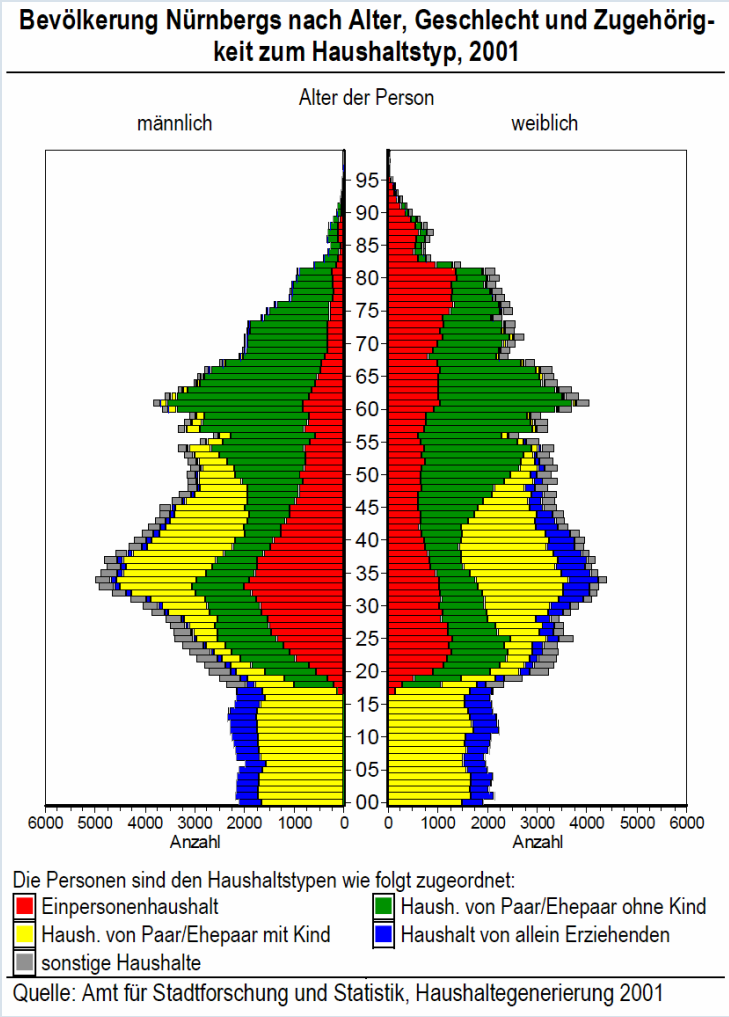

- **Small households (red and green areas)**
  - Nearly 80% of all households in dense urban areas have 1-2 people
  - Nearly all people above 55yrs are living in small households
- **Casual Internet users**
  - see next slide.

Do not address:

- **Families**
  - The youngsters are eating too much
- **Business users**
  - They may be willing to pay much more for their Internet service (UMTS business!)

Key figures of a wireless DSL system

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- **Bandwidth per user (DL): 1 Mbit/s (like wireline DSL)**
- **Maximum number of customers per 'base-station':**
  - assuming an aggregate DL capacity of 10 Mbit/s per base-station
  - a multiplexing factor of 40
    (statistical multiplexing gain when combining the traffic of several users)
    - usual figures for wireline DSL: 30 - 150
    - according to traffic statistics from Korean DSL users:
      20 000 DSL customers are producing a peak data rate of 500 Mbit/s

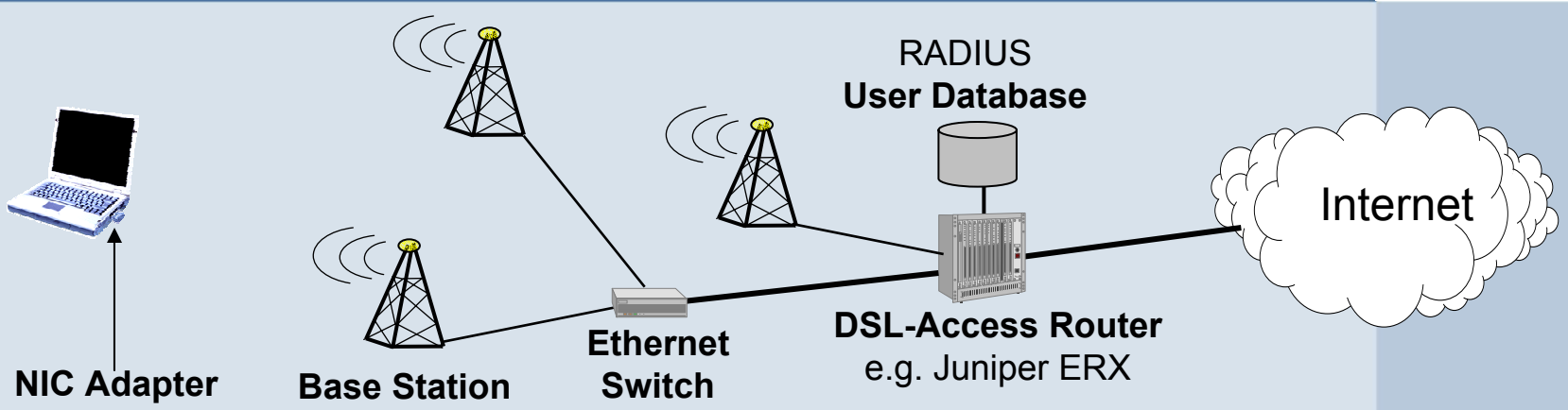
⇒ **each base-station may serve at least 400 customers (even more when going for the 'casual-user')**

- **necessary cell size:**
  - assuming a density of 1200 households/km^2 (urban area)
  - 15% penetration for wireless DSL

⇒ **Cell size: about 1,7 km (diameter)**

The figures are fitting exactly into Sprint's requirements for IEEE802.20!

The wireless DSL network



- **Simplified, cost effective ISP-like network architecture**
  - Base stations, Ethernet switches, DSL access router, RADIUS server
- **Extremely cost-effective customer management by use of RADIUS**
  - adding a user means just adding an entry in the user database
    - no dedicated ports, no dedicated wires needed, no in-home installations
  - very well suited for serving a huge number of 'casual-users'
- **Radio technology may be IEEE802.16 (WiMAX), IEEE802.20 or Flarion (OFDM) or IPWireless (TDD) or WCDMA HSDPA(?)**
  - Rest of the network is off the shelf

Telecommunication Market Segmentation
WiMAX is addressing a new market!

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	"Integrated Services Digital Network"	*"Digital Subscriber Line"*
fixed	PSTN, N-ISDN, B-ISDN, ATM	ADSL, SDSL, VDSL, CableModem
mobile	GSM, UMTS	IEEE802.20, IEEE802.16e WiMAX

- Voice, realtime messaging, realtime streaming
- Defined, guaranteed QoS
- Precious bandwidth
- Services tied to the network
- Detailed accounting, charging and billing

- Web, e-mail, streaming, file download, (VoIP)
- Best effort, diffserv enabled
- Cheap bandwidth
- Access to services anywhere in the Internet
- Simple billing, often flat-rate

The end

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- Thank you for your attention.
- Questions and comments?
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