



Future Directions

HIPERLAN, Wireless ATM, and FPLM TS

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Purpose To Increase Awareness

June 15, 1998

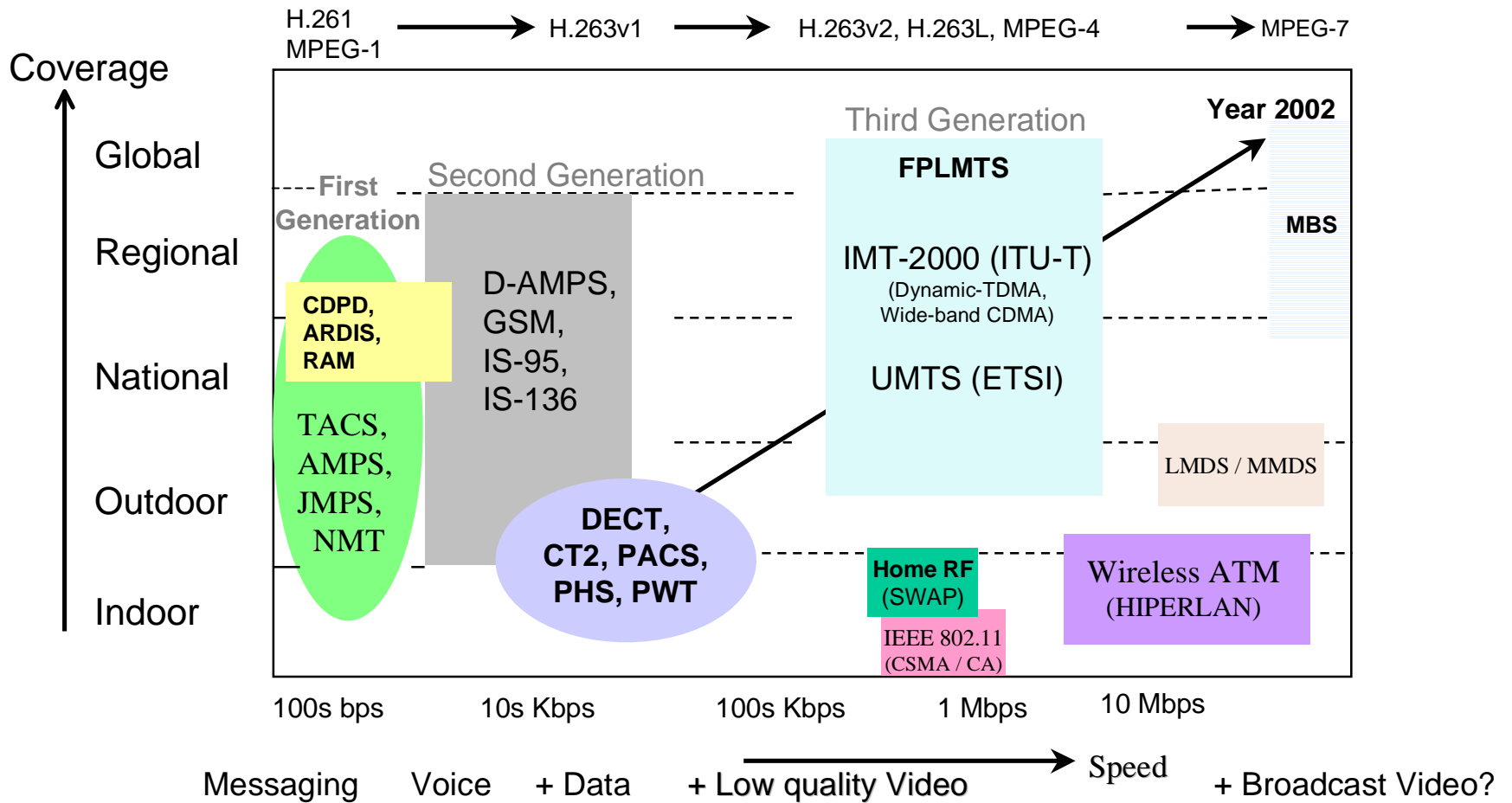
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Outline

- Perspective on Standards and Functionality
 - HIPERLAN
 - Description, history
 - Architecture, PHY, MAC
 - Wireless ATM
 - Charter, evolution, history
 - Concepts, Architecture, Functions, Standardization
 - UMT
 - Scope, History
 - OnTheMove
-
- Local Area Connectivity
- Wide Area Connectivity

Standard's Activity -- Past, Present, and Future



Latest from the FCC (Translation - more standards !)

- FCC recently allocated the 5.15 - 5.35 GHz and 5.725 - 5.825 GHz for unlicensed broadband services (U-NII - Unlicensed-National Information Infrastructure)
- Highlights
 - Three 100 MHz bands available for broadband wireless in a technology neutral way
 - Band 1 (5.15 - 5.25 GHz) @ 200 mW EIRP (WLAN ~ 100 m)
 - Band 2 (5.25 - 5.35 GHz) @ 1 W EIRP (outdoor microcell ~ 500m)
 - Band 3 (5.725 - 5.825 GHz) @ 4 W EIRP (community networks ~ 1 Km)
- Rules permit immediate use, without specifying
 - Channelization, Spectrum Etiquette, spectral efficiency, etc.
 - => potential for interference problems, inefficient usage, etc.

Architectural Trends

PRESENT

- Mostly homogeneous traffic - voice (circuit switched), data (packet switched)
- Limited coverage
- Custom wireless network API
- Vertical protocol stack built on radio air interface
- Single hop networks
- Low usage per subscriber
- Low bit-rates
- Poor cost / performance ratio
- Insecure



FUTURE

- Mostly heterogeneous traffic - voice + data + video, (packet switched)
- Ubiquitous
- Generic network API
- Fixed network protocols with radio and mobile plug-ins
- Multi-hop self configuring networks
- High usage
- High bit-rates
- Mass market cost/performance
- Secure

General Comments on the design of MAC protocols for Wireless Communications

Q: Why not use MAC such as Ethernet in Wireless communications ?

A: Media dependent difference between wired LAN and wireless LAN

- Inability to listen while sending
- “*mute-deaf-time*” -- turnaround time between Rx/Tx has significant effect on the design of the MAC layer
- Hidden terminal vulnerability
- Exposed terminal

HIPERLAN (HIgh PERFORMANCE LAN)

by ETSI BRAN WG

(European Telecommunications Standard Institute
Broadband Radio Access Networks Working Group)

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HIPERLAN: History

- **HI**gh **PE**formance **R**adio **L**AN
 - Motivation - *Faster is better*
 - Interoperability standard that specifies common air interface MAC and PHY layers in the OSI model
 - Family of standard being developed in Europe by ETSI for high speed, RF connectivity
- History
 - BRAN (formally known as RES10) started work on standard -- early 1992
 - CEPT allocated spectrum -- early 1993
 - Complete draft standard -- early 1993
 - ETSI published final standard -- late 1995

HIPERLAN Family (ETSI BRAN)

HIPERLAN Type 1 Wireless LAN	HIPERLAN Type 2 Wireless ATM <i>Indoor access</i>	HIPERLAN Type 3 Wireless ATM <i>Remote Access</i>	HIPERLAN Type 4 Wireless ATM <i>Interconnect</i>
MAC	DLC	DLC	DLC
PHY	PHY	PHY	PHY
(5 GHz)	(5 GHz)	(5 GHz)	(17 GHz)
20 + Mbps	20 +Mbps	20 + Mbps	150 + Mbps

HIPERLAN I: Design Goals

- + Operational Spectrum -- 5.15-5.3 GHz (and 17.1 - 17.3 GHz)
- + Data rates -- 10-20 Mbps
- + Radio Range -- 50 m (short, mostly indoor)
- + Mobility -- < 10 m/sec (low)
- + Communications -- Packet oriented
 - without infra-structure (ad hoc, peer-to-peer), and
 - with infra-structure (centralized, mobile to base-station)
- + Simultaneous support for isochronous and asynchronous traffic
 - 25 audio connections @ 32 Kbps, 10 msec latency (ADPCM)
 - 1 video connection @ 2 Mbps, 100 msec latency
 - File transfer of data @ 13.4 Mbps, immediate access
- + Power saving mode
- + Explicit support for multi-hop networking
- + QoS is based on “*best effort with priority and packet lifetime*”

HIPERLAN I: System Architecture

Lookup	Routing Info. Exchange	Power Saving	User Data Transfer Priority mechanism
Channel Access (EY-NPMA)			
Physical Layer			

Lookup -

For operation of multiple HIPERLAN in close proximity.
Each HIPERLAN has a unique ID.

Routing Info. -

For extending the range of HIPERLAN, contains routes
for multi-hop operation.

Power Saving -

For periodic wake up

Priority Mechanism -

For QoS support

HIPERLAN I: PHY Specification

Select one of five independent channels

Low transmission rate -- acknowledgment packets and packet header

- Rate -- 1.470588 Mbps
- Modulation -- FSK, freq. Dev = 368 KHz
- Transmit power -- +10, +20, +30 dBm
- Receive sensitivity -- -50, -60, -70 dBm

High transmission rate -- data packets

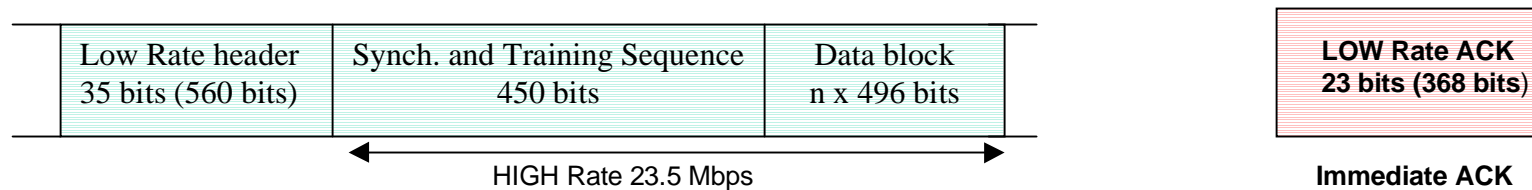
- Rate -- 23.5294 Mbps
- Modulation -- Differential GMSK
- FEC -- BCH (31,26)
- Packet failure rate -- 0.01 (4160 data bits)

HIPERLAN I: PHY Specification

Rx/Tx turnaround time < 5 micro-seconds

Power saving

- Low rate headers,
 - If packet is not destined for receiver, do not power up equalizer circuitry
- negotiate wake-up patterns through bi-lateral agreement



HIPERLAN I: MAC Specification

- Fully distributed MAC
- Permits multi-hop relaying via neighbors based on LBT
- EY-NPMA - Elimination Yield Non-preemptive Multiple Access
 - Three phases for access mechanism
 - *Priority Resolution* -- Listen before talk
 - *Elimination* -- contention resolution using talk-listen
 - *Yield Phase*

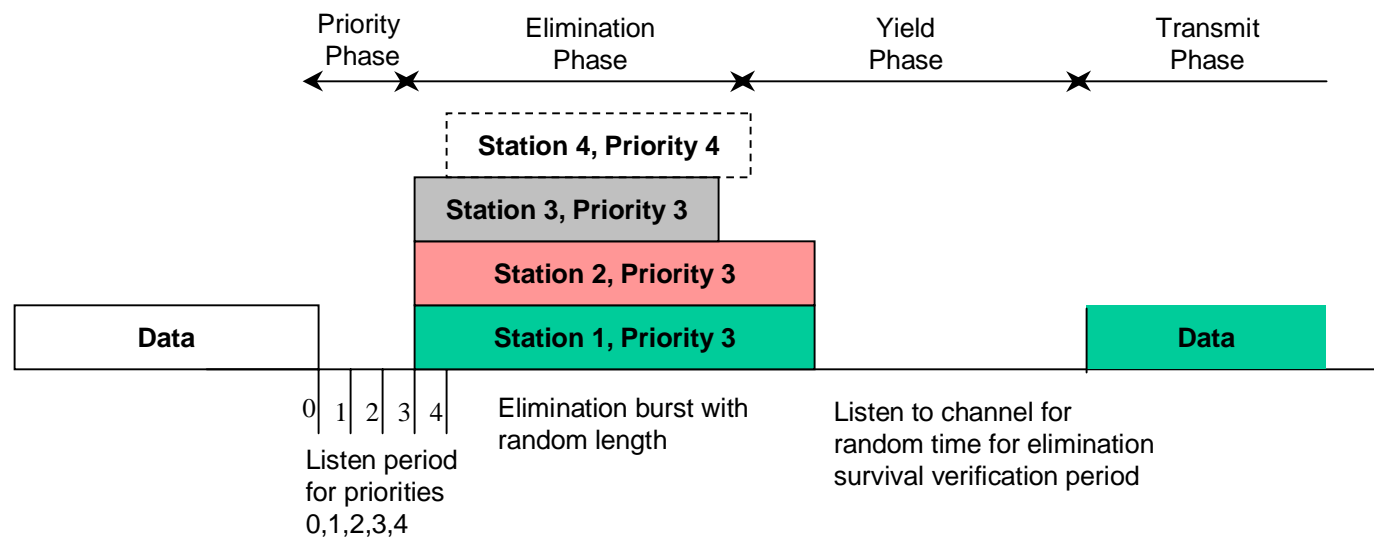
HIPERLAN I: Priority Classes

- 2 User priorities are mapped into 5 MAC-layer priorities
- Priority is assigned dynamically as a function of lifetime and user priority

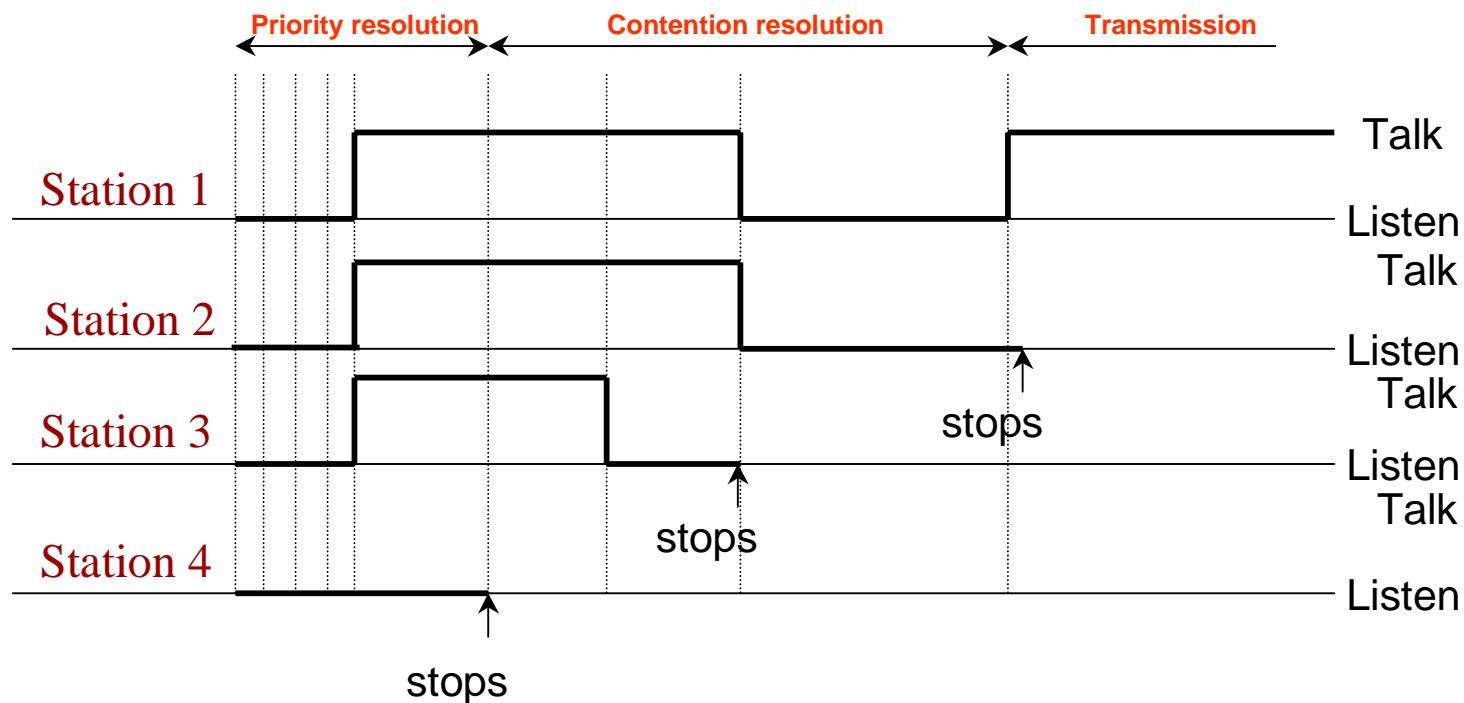
Normalized Residual Lifetime msec	High User Defined Priority	Low User defined priority
NRL < 10	0 (highest)	1
10 < NRL < 20	1	2
20 < NRL < 40	2	3
40 < NRL < 80	3	4
80 < NRL	4 (lowest)	4 (lowest)

- In each access cycle only packets with the same access priority compete for the channel
- If lifetime expires, packet is discarded in the MAC
- Either best effort latency for isochronous traffic OR best effort integrity for asynchronous traffic
- For multi-hop networks, use NRMT (Normalized residual MSDU lifetime)
 - $NRMT = \text{residual lifetime} / \text{distance between source and destination hops}$

HIPERLAN I: EY-NMPA Access Scheme



HIPERLAN I: EY-NPMA Operation



Prioritization - 1 to 5 slots of 168 bits (talk)

Contention -- Elimination 0 to 12 slots of 212 bits (talk)

HIPERLAN I: EY-NPMA

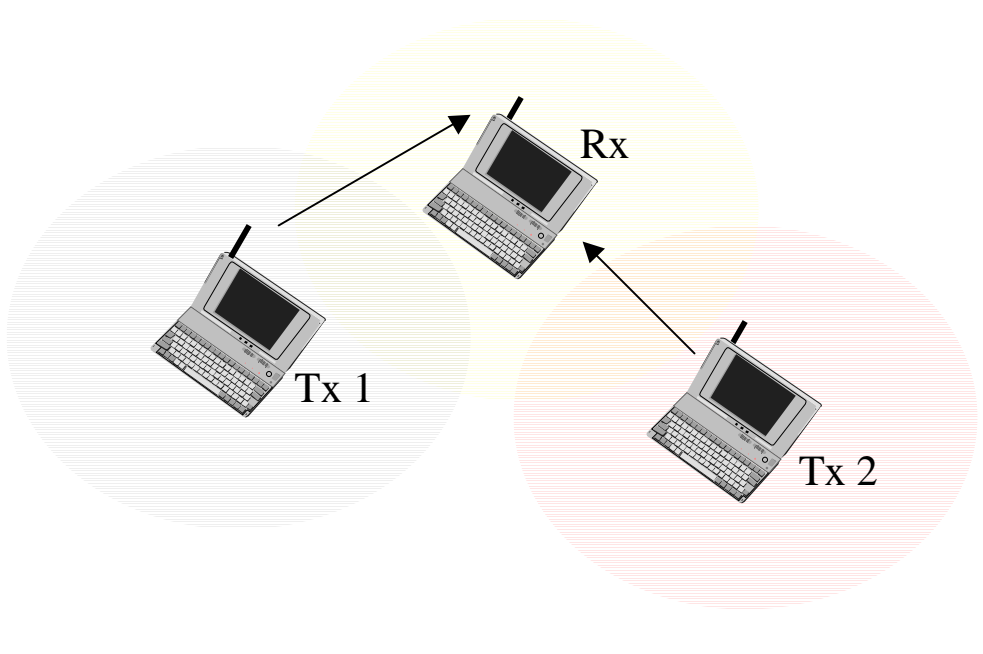
Features:

- No preemption by frames with higher priority after priority resolution
- Performance is independent of availability of network infra-structure
- Fair contention resolution of frames with same priority
- Requires minimum number of Rx/Tx transmission turnarounds
 - Simulation indicate it results in a winning station with a probability of 97.8 %

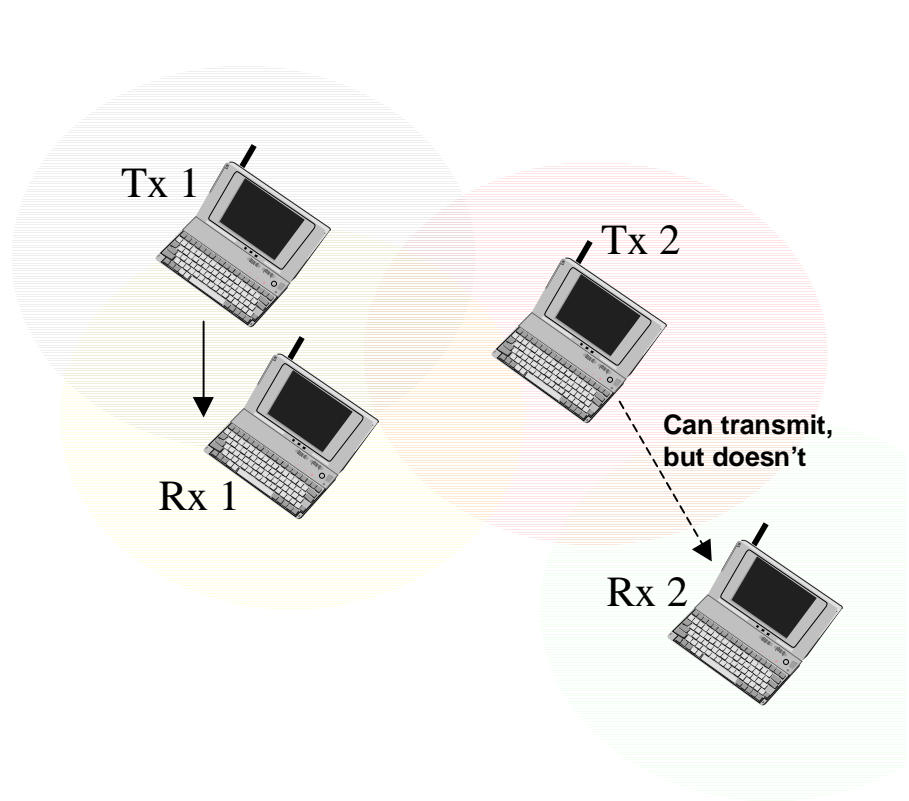
Quirks:

- antenna diversity possible, but must use same antenna for correct MAC operation
- no maximum lifetime can produce large delays
- too many high priority users can effect time-bounded isochronous traffic

Throughput is effected by -- Hidden & Exposed Terminals



RTS/CTS - with intended transmission duration



HIPERLAN I: Documented Research Testbed

Two European collaborative projects

- LAURA - not fully standards compliant
- HIPERON - fully standards compliant
 - ASIC designed
 - RF MCM with GaAS and Si by GPS
 - Modem, CODEC, D/A, A/D by Apple
 - MAC controller by ARM

HIPERLAN II: WATM ++

- ETSI “BRAN” group is now working on a generic radio layer capable of supporting multiple higher layers, including IP and WATM

Charter

- Specify radio access (PHY and MAC) for 5 GHz band (US U-NII)
- Specify data-link control (e.g. FEC with Selective-ARQ)
- Will support QoS through bandwidth reservations and delay guarantees
- Will support Handovers
- Might support ATM size cells

Timeline

- Initial draft -- late 1999

WATM

(Wireless Asynchronous Transfer Mode)

by ATM Forum

<http://www.atmforum.com>

Wireless ATM: Motivation

ATM technology offers speed, scalability, multimedia integration, and uniform API features with good cost performance

Established in June 1996, WG meets every 2 months

Charter -- to develop specifications for

- protocol extensions required to support mobility within an ATM infrastructure
- radio access technology necessary for seamless delivery of ATM services to mobile terminals

Wireless ATM WG

Charter

“The Wireless ATM (WATM) working group will develop a set of specifications intended to facilitate the use of ATM technology for a broad range of wireless network access scenarios, both private and public. This specification will include both *mobile ATM* extensions for mobility support within an ATM network as well as *radio access layer* for ATM-based wireless access. The WATM specifications are intended for use in networks involving terminal mobility and/or radio access, and will be designed for compatibility with ATM equipment adhering to the (then) current ATM Forum specification. Explicit liaison arrangements will be established with relevant standards bodies.”

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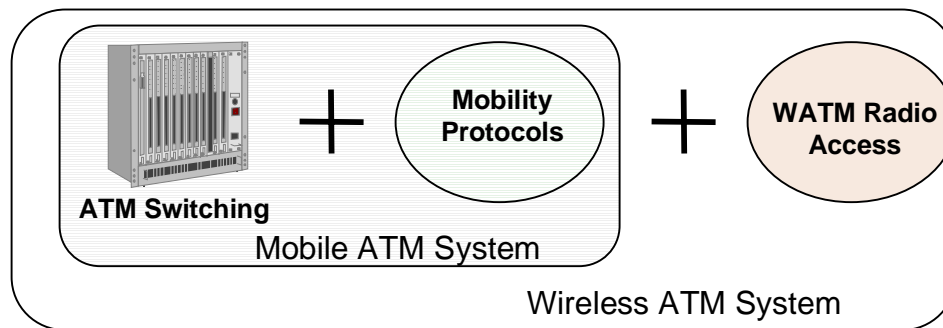
WATM: Projected Evolution

Phase 0 - Fixed RF access to ATM networks

Phase 1 - Add support for end system mobility

Phase 2 - Add support for mobile ATM switches (mobile networks)

Phase 3 - Add support for ad hoc ATM networking



Wireless ATM systems can be constructed via hardware/software plug-ins to existing ATM switches

Initial Requirements (July 1997)

- + Operational Spectrum -- 5 GHz U-NII
- + Data Rate -- 25 Mbps
- + Range -- 30 to 50 meters (indoor); 200-300 meters (outdoors)
- + Bit error rate (with error correction): 10^{-4} at 99.9% availability
- + Transmit Power -- 100 - 200 mW
- + MAC architecture -- centralized control
- + MAC addressing -- IEEE 48 bit addressing
- + Access scheme -- TDMA/TDD with dynamic slot allocation
- + ARQ mandatory at DLC layer

WATM: Initial Work Items + Technical Scope

Mobile ATM (*“M” UNI / NNI specification*)

- Handoff control (signaling NNI extensions etc.)
- Location management for mobile terminal
- Routing considerations for mobile connections
- Traffic / QoS control for mobile connections
- Wireless Network Management

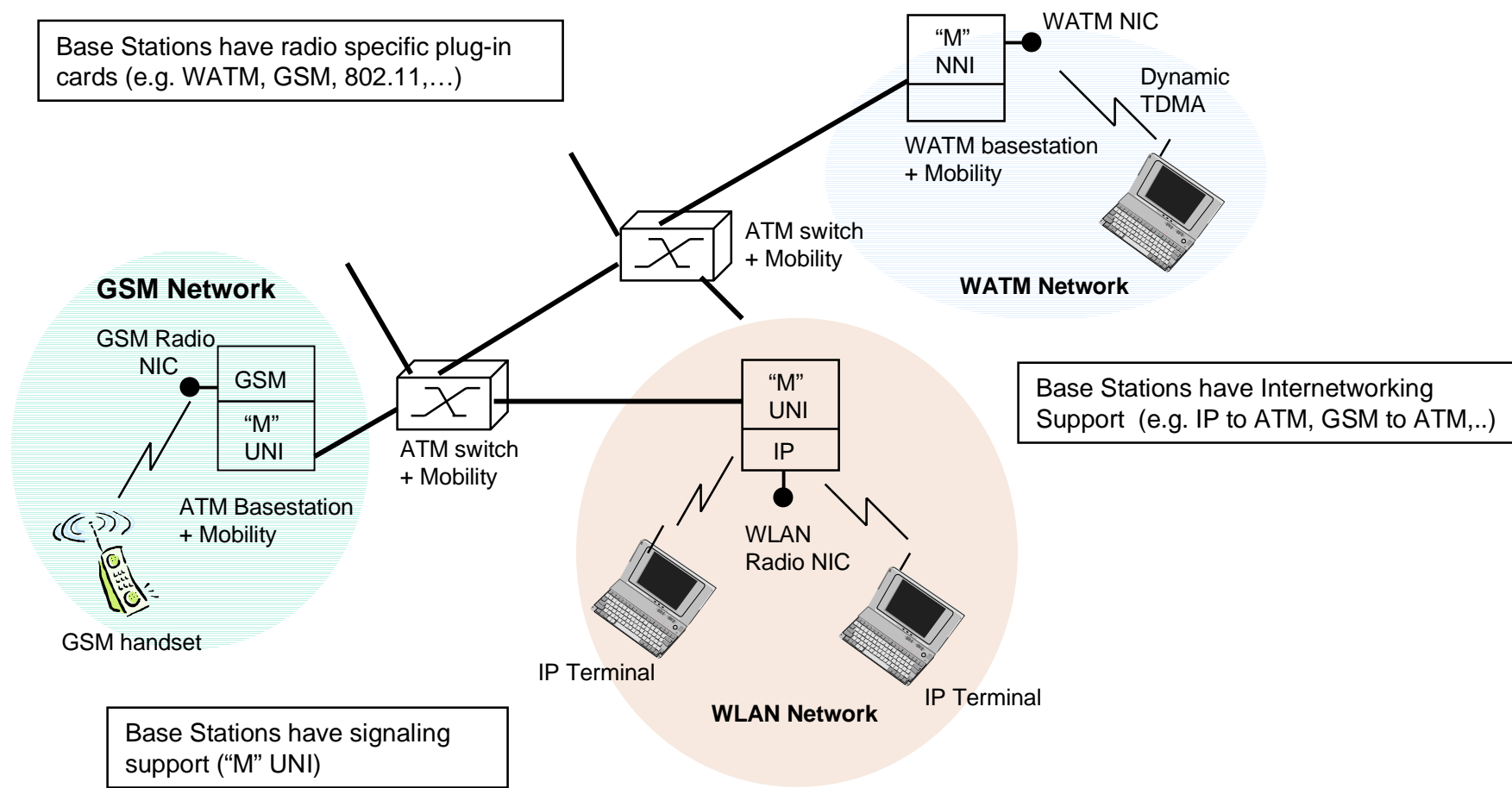
Radio Access Layer (*“W” UNI specification*)

- Physical layer
- Medium access control for wireless channels (with QoS etc.)
- Data link control for wireless channel errors
- Wireless control protocol for radio resource management

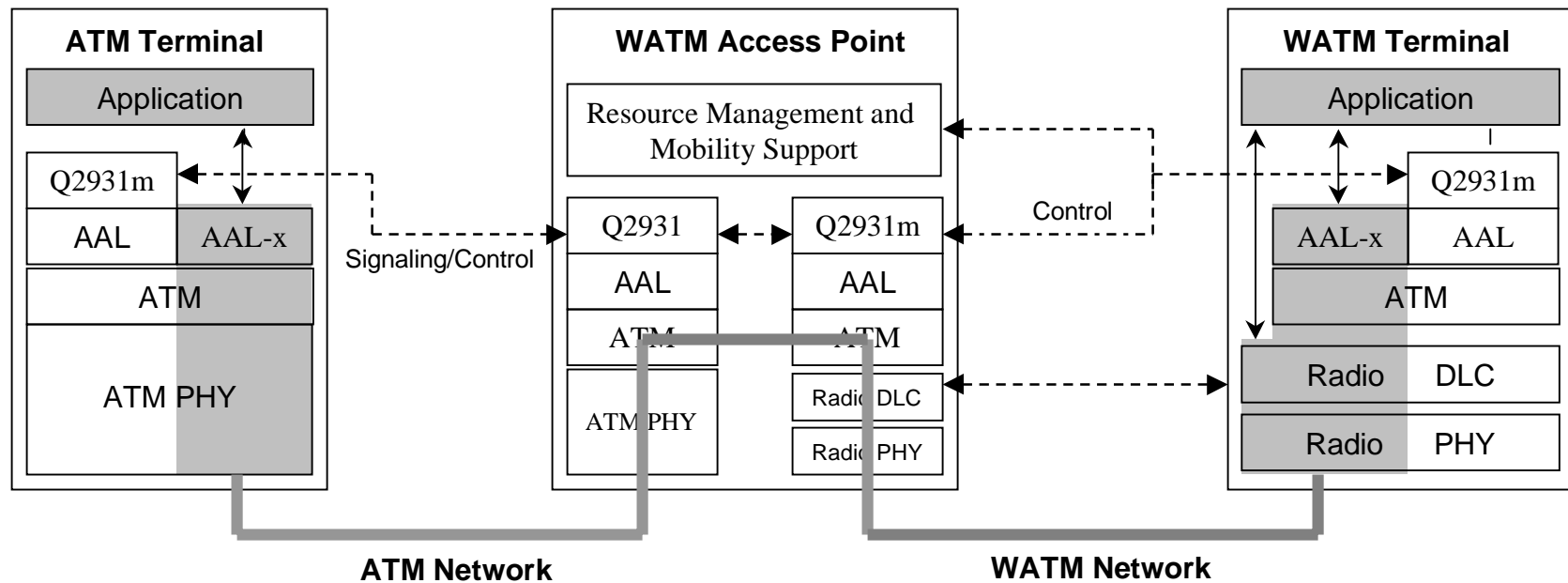
WATM: Service Scenarios

- Providing mobility support in IP
 - ATM connection appears as a “tunnel” to IP
 - mobility of tunnel endpoint oblivious to IP
- Mobile Telephony (*geographic span from local to wide-area*)
 - ATM base station terminate GSM radio protocol
 - Translates GSM call setup to “M” UNI signaling
 - “Bridges” GSM air interface and ATM data path
- Wireless ATM systems (*multimedia transport with QoS*)
 - End-to-End ATM connection to mobile endpoints
 - Broadband wireless access (~ 25 Mbps)

WATM: Functional Components



WATM: Protocol Architecture (native mode)



Approach: Make ATM networking layer mobility aware

WATM: Protocol Architecture

Wireless/Mobility protocols incorporated into standard ATM stack

- ATM cell as basic unit in both wireless and backbone
- standard ATM services at transport interface
- custom medium access, data link control for wireless segment
- mobility extensions to ATM signaling: handoff, location management

WATM: Areas of Activity

Location Management Area

The ability to determine, topologically the current location of the mobile terminal

Issues being tackled

- Location-independent terminal addressing
- Distributed location servers
- Location management integrated with ATM signaling

Mobility Management Area

The ability, of the network, to maintain an active connection as the mobile terminal moves through the infra-structure

Issues being tackled

- Signaling mechanisms for Handover (debate still going on whether to manage this at ATM or radio layer)
- QoS Renegotiations and routing

WATM: Sample MAC (D-TDMA)

- Multi-service dynamic TDM/TDMA protocol with QoS control
 - share available bandwidth efficiently among multiple users
 - support standard ATM traffic classes: CBR, VBR, ABR, UBR
 - satisfy QoS requirements
 - maintain high utilization of radio link

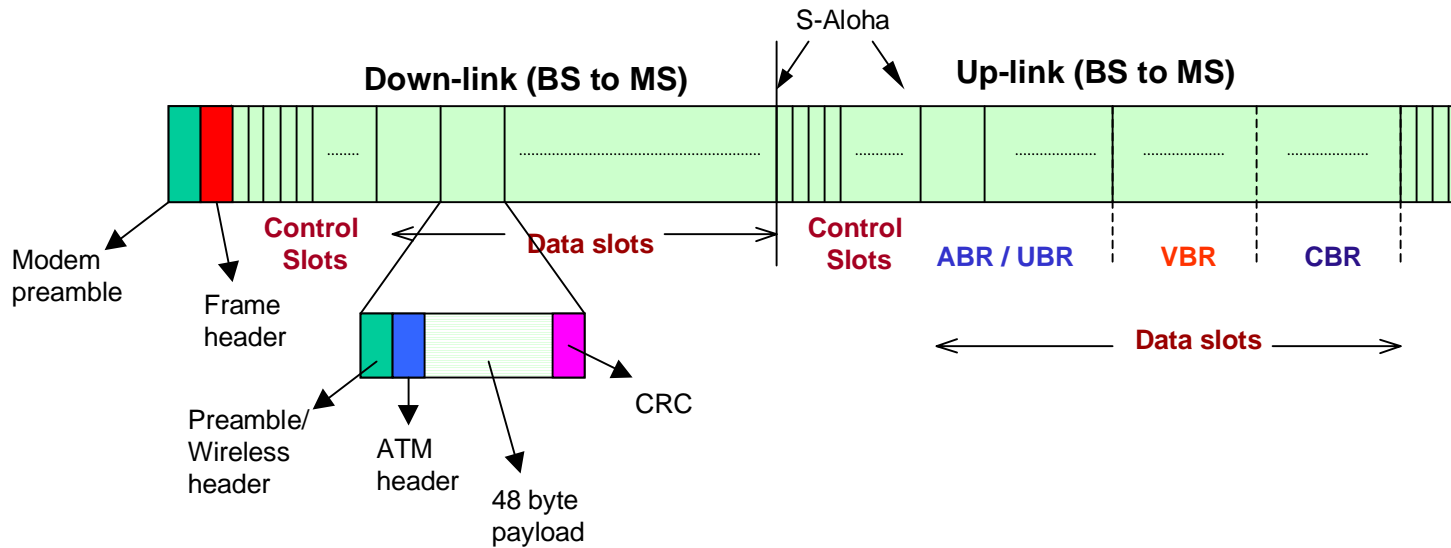


Figure 2: Frame and Slot structure for D-TDMA

WATM: Standard Status - Revision 1.0

- Current WATM WG focus is on mobility protocols:
 - ongoing efforts on handoff and location management protocols specs
 - baseline text for “M” spec expected -- late 1998
- Possible parallel liaison on radio PHY/MAC with ETSI BRAN, MMAC (Japan) and ITU-T
 - ETSI BRAN standard radio will be just one specific instance of ATM radio layer
 - Focus on micro-cellular 5 GHz band (US U-NII & Europe HIPERLAN-II)
- Open Issues:
 - US FCC U-NII action on 5 GHz spectrum etiquette, etc.
 - Relation of WATM to UMTS, FPLMTS?
 - Integration /interoperability with IP/RSVP, Differentiated Services. etc.?
 - Security, authentication,

WATM: Documented A/D Projects

United States

- SUN & Lucent -- MII (Multimedia Information Infrastructure)
- NEC -- WATMnet (2.4 GHz band)
 - Demonstrate 8 Mbps wireless ATM in the ISM band
- AT&T -- SWAN

Europe

- EC/ACTS -- Magic WAND (5 GHz band)
 - Demonstrate 20 Mbps wireless ATM using a cellular MAC from UMTS
- EC/ACTS -- MEDIAN (60 GHz band)
 - Demonstrate 155 Mbps wireless ATM in the 60 GHz band

Japan

- NTT's -- AWA (17 GHz band)
 - Demonstrate public multi-media services based on ATM and cellular radio subsystem

U.K.

- Olivetti

UMTS

(Universal Mobile Telecommunications Systems)

by ETSI

Third generation cellular mobile radio system

UMTS & MBS: Goals

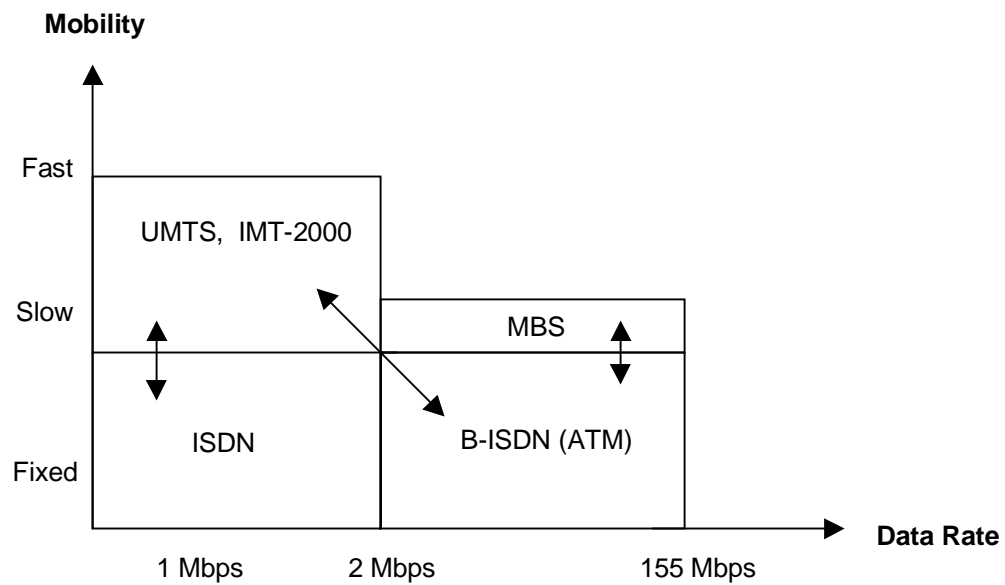
UMTS (*Universal Mobile Telecommunications System*)

- Global wireless communications at rates up to 2 Mbps
- Support multi-rate services (voice, data, video)
- Operate in multi-cell environment (macro, micro, pico cells)
- Operate in multi-operator environment (public and private)
- Maximize spectrum efficiency

MBS (*Mobile Broadband System*)

- millimeter wave air interface -- 40 to 60 GHz frequency band
- Broadband wireless services up to 155 Mbps
- Transparent extension to B-ISDN, based on ATM technology
- Standardization activities have not yet commenced

Relationship between UMTS, IMT-2000, MBS



UMTS: Approach

Core network -- evolve GSM infra-structure towards UMTS

Radio interface -- brand new air interface for UMTS Terrestrial Radio Access

- Candidates were
 - Wideband CDMA, Wideband TDMA, TD/CDMA, OFDMA, ODMA
- Selected (March 1998)
 - Wideband CDMA for FDD mode
 - TD/CDMA for TDD mode

Bulk of Activities being carried out within EC/ACTS

- Advanced Communications Technology and Services Framework
 - Pre-competitive research & Technological development Initiatives
 - 150 sub-projects

ACTS: Projects

- Magic WAND -- Wireless ATM demonstrator
- AWACS -- Wireless Access Communication System
- MEDIAN -- Wireless broadband for CPN/LAN for professional and residential multimedia (60 GHz band)
- SAMBA -- System for Advanced Mobile Broadband applications
- RAINBOW -- UMTS demonstrator
- OnTheMove -- Investigating mobile multimedia services for UMTS.

ACTS OnTheMove: History and Goals

Timeline

- September 1995 -- September 1998

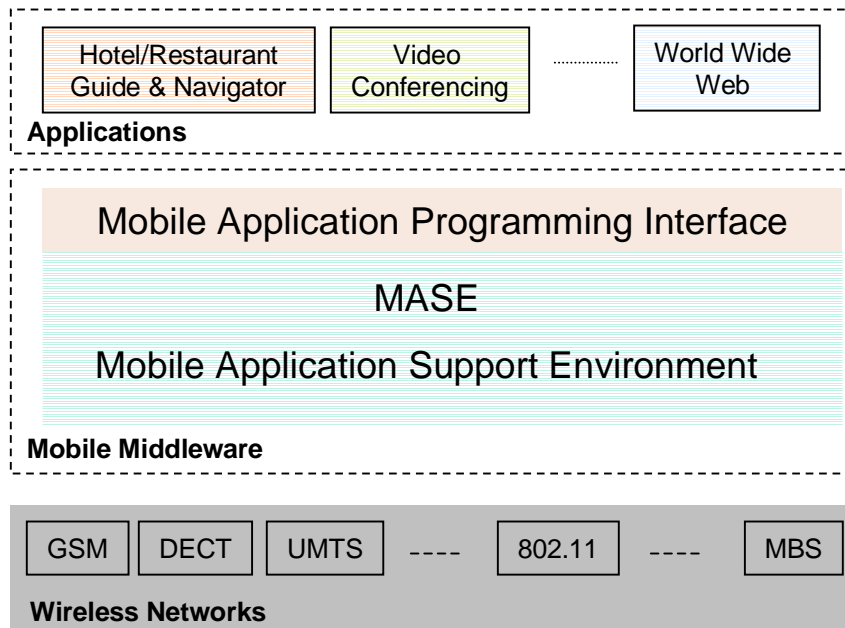
Consortium:

- Siemens, Ericsson, IBM, Sony, BT,....

Project Objectives:

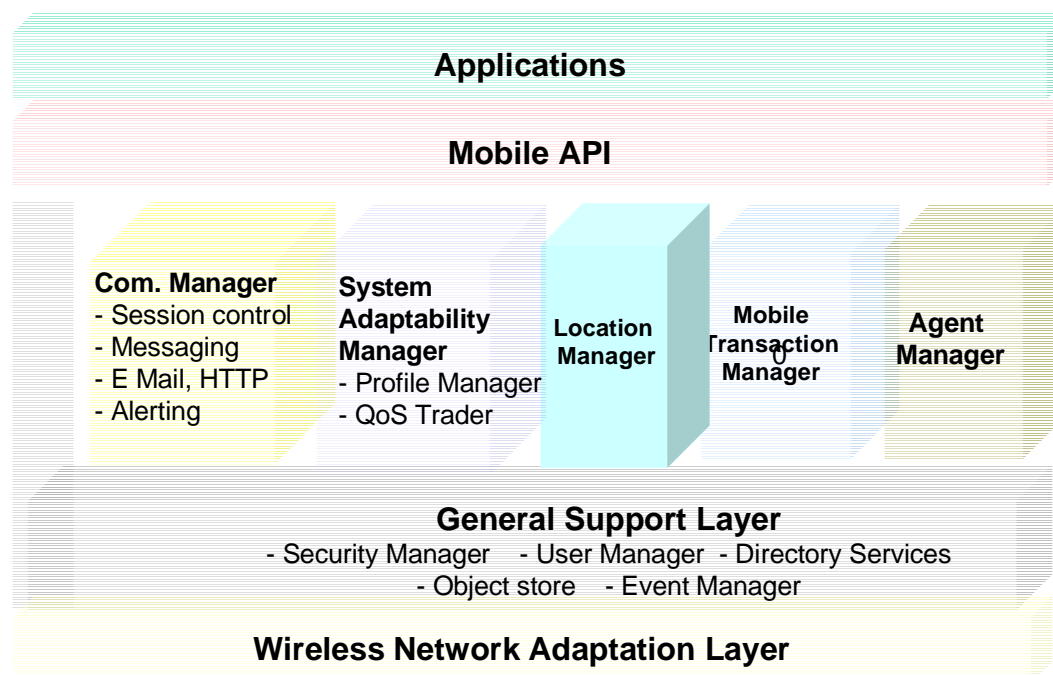
- Specification for an application level interface (Mobile-API) for mobile multimedia
- Develop a scalable support environment (MASE) for multimedia services over a range of wireless technologies
- Validate the Mobile-API and MASE through field trials of multimedia applications
- To understand what users and service providers expect from these applications
- To promote adoption of Mobile-API by computer industry

ACTS OnTheMove: Framework



Implemented as a Class Library
for UNIX, Windows 95, Windows NT

ACTS OnTheMove: MASE Internals



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Thanks!

Contact for more info - *bahl@microsoft.com*