WiMAX:
IEEE 802.16 - Wireless MANs

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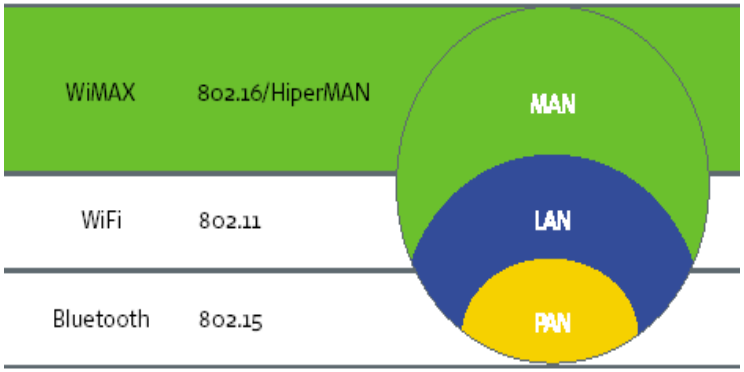
Wireless networks

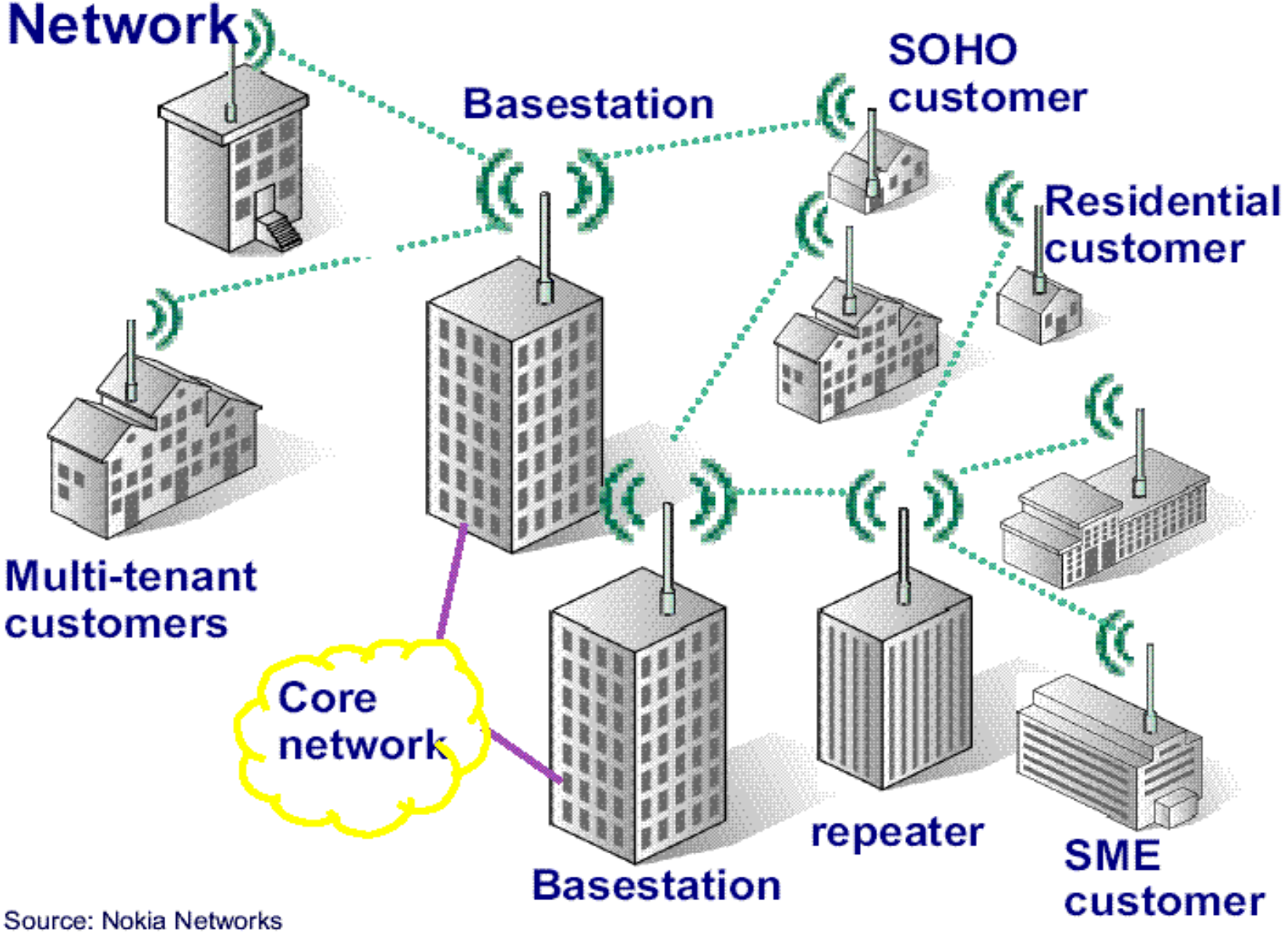
- Wireless PANs (Bluetooth – IEEE 802.15)
  - very low range
  - wireless connection to printers etc
- Wireless LANs (WiFi – IEEE 802.11)
  - infrastructure as well as ad-hoc networks possible
  - home/office networking
- Multihop Ad hoc Networks
  - useful when infrastructure not available, impractical, or expensive
  - military applications, emergencies



Wireless standards and their networking environments

- Wireless MANs (WiMAX-802.16)
  - Similar to cellular networks
  - traditional base station infrastructure systems

WirelessMAN: Wireless Metropolitan Area Network



Source: Nokia Networks

WiMAX

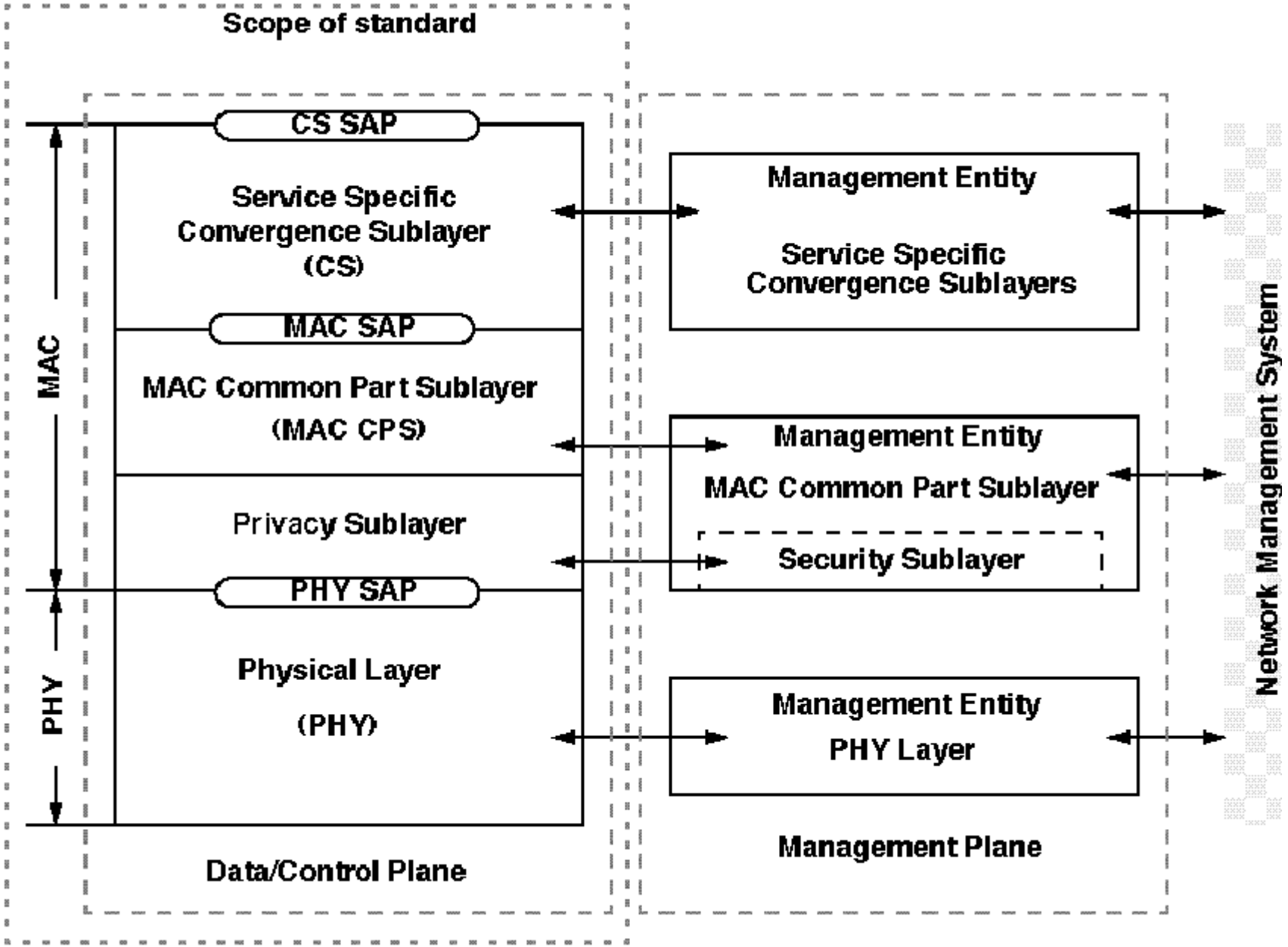
- Goal: Provide high-speed Internet access to home and business subscribers, without wires.
- Base stations (BS) and subscriber stations (SS)
- Centralized access control to prevents collisions
- Supports applications with different QoS requirements
- WiMAX is a subset of IEEE 802.16 standard

IEEE 802.16 standards

- 802.16.1 (10-66 GHz, line-of-sight, up to 134Mbit/s)
- 802.16.2 (minimizing interference between coexisting WMANs)

- 802.16a (2-11 Ghz, Mesh, non-line-of-sight)
- 802.16b (5-6 Ghz)
- 802.16c (detailed system profiles)

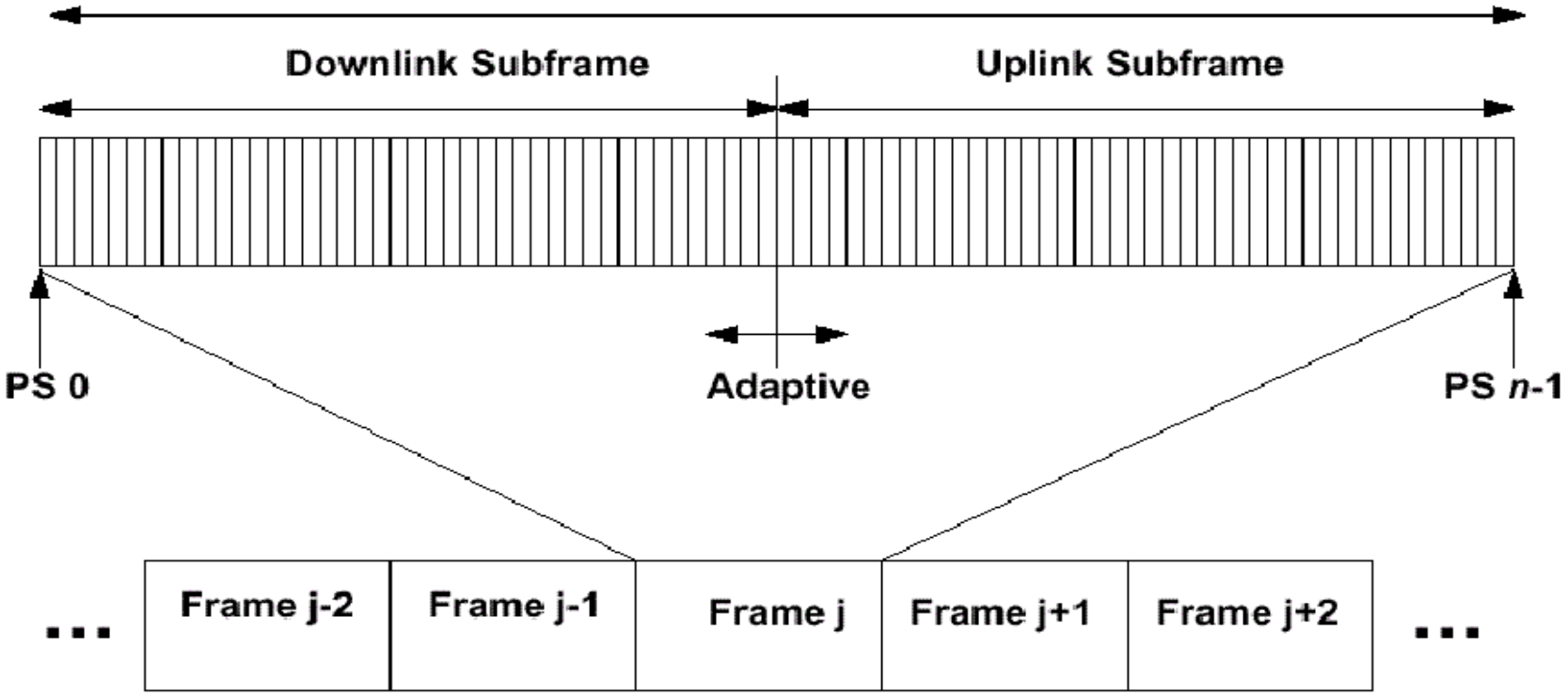
- P802.16e (Mobile Wireless MAN)


Scope of standard
CS SAP
Service Specific
Convergence Sublayer
(CS)
MAC SAP
MAC Common Part Sublayer
(MAC CPS)
Privacy Sublayer
PHY SAP
Physical Layer
(PHY)
MAC
PHY
Data/Control Plane
Management Entity
Service Specific
Convergence Sublayers
Management Entity
MAC Common Part Sublayer
Security Sublayer
Management Entity
PHY Layer
Management Plane
Network Management System

Physical layer

- Allows use of directional antennas
- Allows use of two different duplexing schemes:
  - Frequency Division Duplexing (FDD)
  - Time Division Duplexing (TDD)
- Support for both full and half duplex stations
- Adaptive Data Burst profiles
  - Transmission parameters (e.g. Modulation, FEC) can be modified on a frame-by-frame basis for each SS
  - Profiles are identified by ”Interval Usage Code”

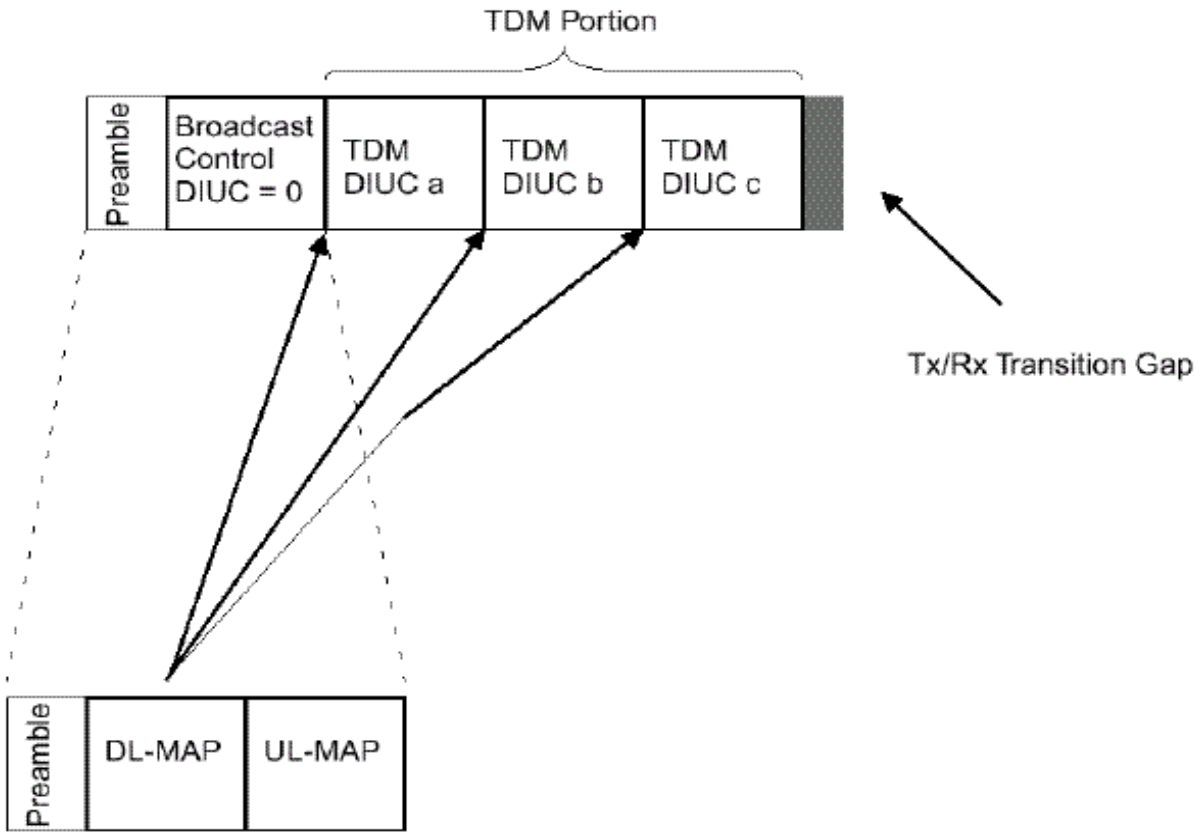
Time Division Duplexing (TDD)



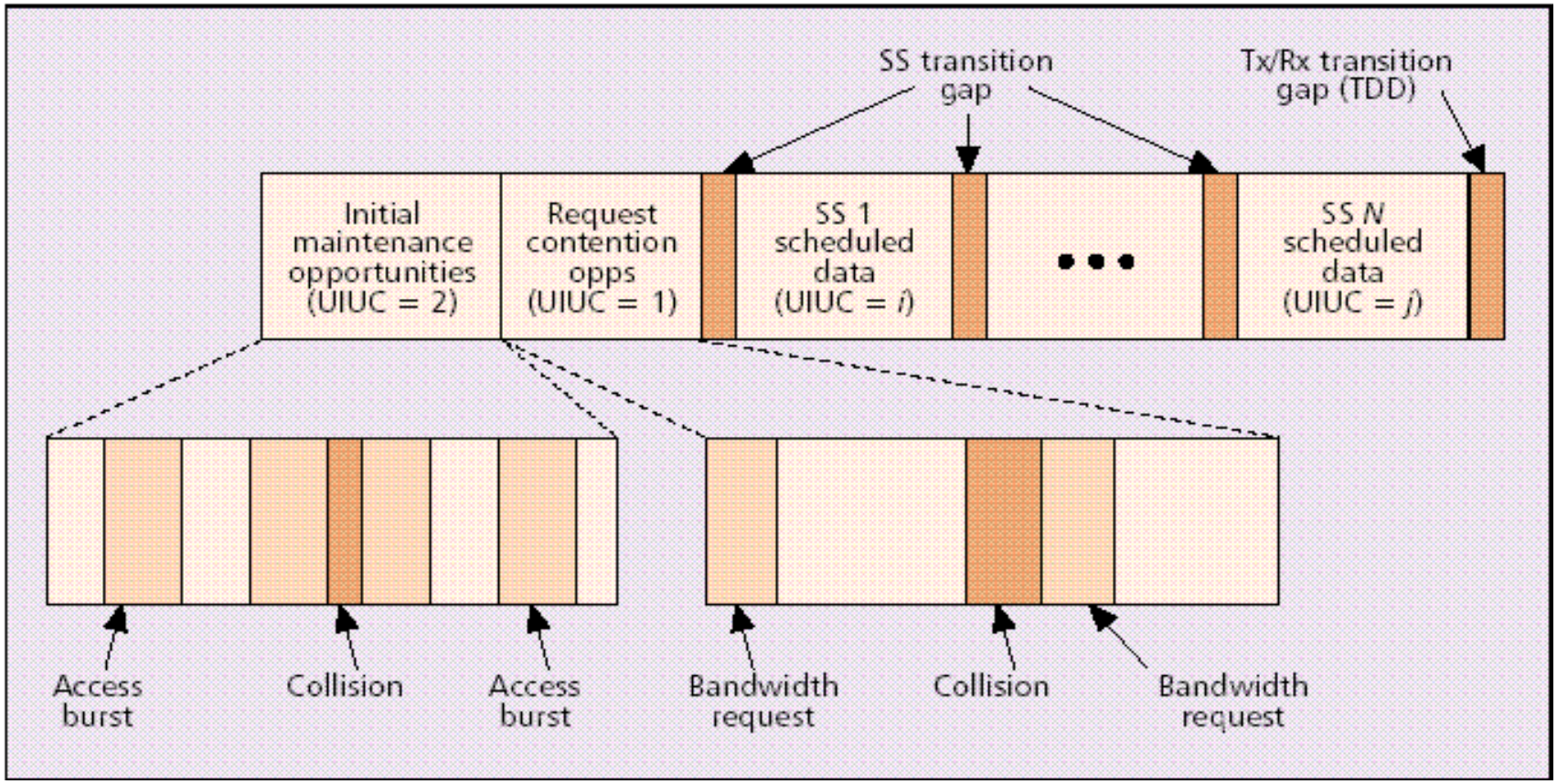
Media Acces Control (MAC)

- Connection oriented
  - Connection ID (CID), Service Flows
- Channel access: decided by BS
  - UL-MAP
    - Defines uplink channel access
    - Defines uplink data burst profiles
  - DL-MAP
    - Defines downlink data burst profiles
  - UL-MAP and DL-MAP are both transmitted in the beginning of each downlink subframe

TDD Downlink subframe



Uplink subframe



Uplink periods

- Initial Maintenance opportunities
  - Ranging - to determine network delay and to request power or profile changes
  - Collisions may occur in this interval
- Request opportunities
  - SSs request bandwith in response to polling from BS
  - Collisions may occur in this interval
- Data grants period
  - SSs transmit data bursts in the intervals granted by the BS
  - Transition gaps between data intervals for synchronization

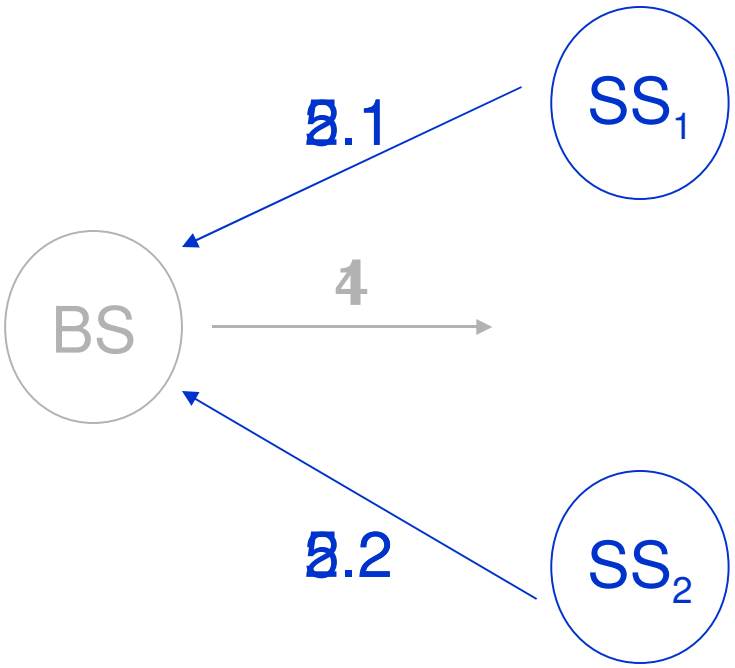
Bandwidth request

- SSs may request bandwidth in 3 ways:
  - Use the ”contention request opportunities” interval upon being polled by the BS
  - Send a standalone MAC message called ”BW request” in an allready granted slot
  - Piggyback a BW request message on a data packet

Bandwidth allocation

- BS grants/allocates bandwidth in one of two modes:
  - Grant Per Subscriber Station (GPSS)
  - Grant Per Connection (GPC)
- Decision based on requested bandwidth and QoS requirements vs available resources
- Grants are notified through the UL-MAP

Bandwidth Request-Grant Protocol



1. BS allocates bandwidth to SSs for transmitting bandwidth request.

2.1 SS_1 transmits bandwidth requests.

2.2 SS_2 transmits bandwidth requests.

5.1 SS_1 transmits data and bandwidth requests.

5.2 SS_2 transmits data and bandwidth requests.

Scheduling services

- Unsolicited Grant Service (UGS)
  - Real-time, periodic fixed size packets (e.g. VoIP)
  - No periodic bandwith requests required
- Real-Time Polling Service (rtPS)
  - Real-time, periodic variable sizes packets (e.g MPEG)
  - BS issues periodic unicast polls
- Non-Real-Time Polling Service (nrtPS)
  - Variable sized packets with loose delay requirements (FTP)
  - BS issues unicast polls regularly (not necessarily periodic)
  - Can also use contention requests and piggybacking
- Best Effort Service
  - Never polled individually
  - Can use contention requests and piggybacking

Example

Total Uplink Bytes = 100

2 SS and 1 BS

SS_1 Demands:

UGS = 20

rtPS = 12

nrtPS = 15

BE = 30

SS_2 Demands:

UGS = 10

rtPS = 10

nrtPS = 15

BE = 20

Total Demand Per Flow:

UGS = 30

rtPS = 22

nrtPS = 30

BE = 50

Flows:	UGS	rtPS	nrtPS	BE
1st Round	40	30	20	10
	30	22	20	10
Excess Bytes = 18				
2nd Round 10+6	30	22	20+12	
	30	22	32	16
Excess Bytes = 2				
3rd Round 16+2	30	22	30	
	30	22	30	18

SS_1 Allocation = 20 +12 + 15 + 9 = 56

SS_2 Allocation = 10 +10 + 15 + 9 = 44

References

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