Handoff Draft Presentation

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Purpose:

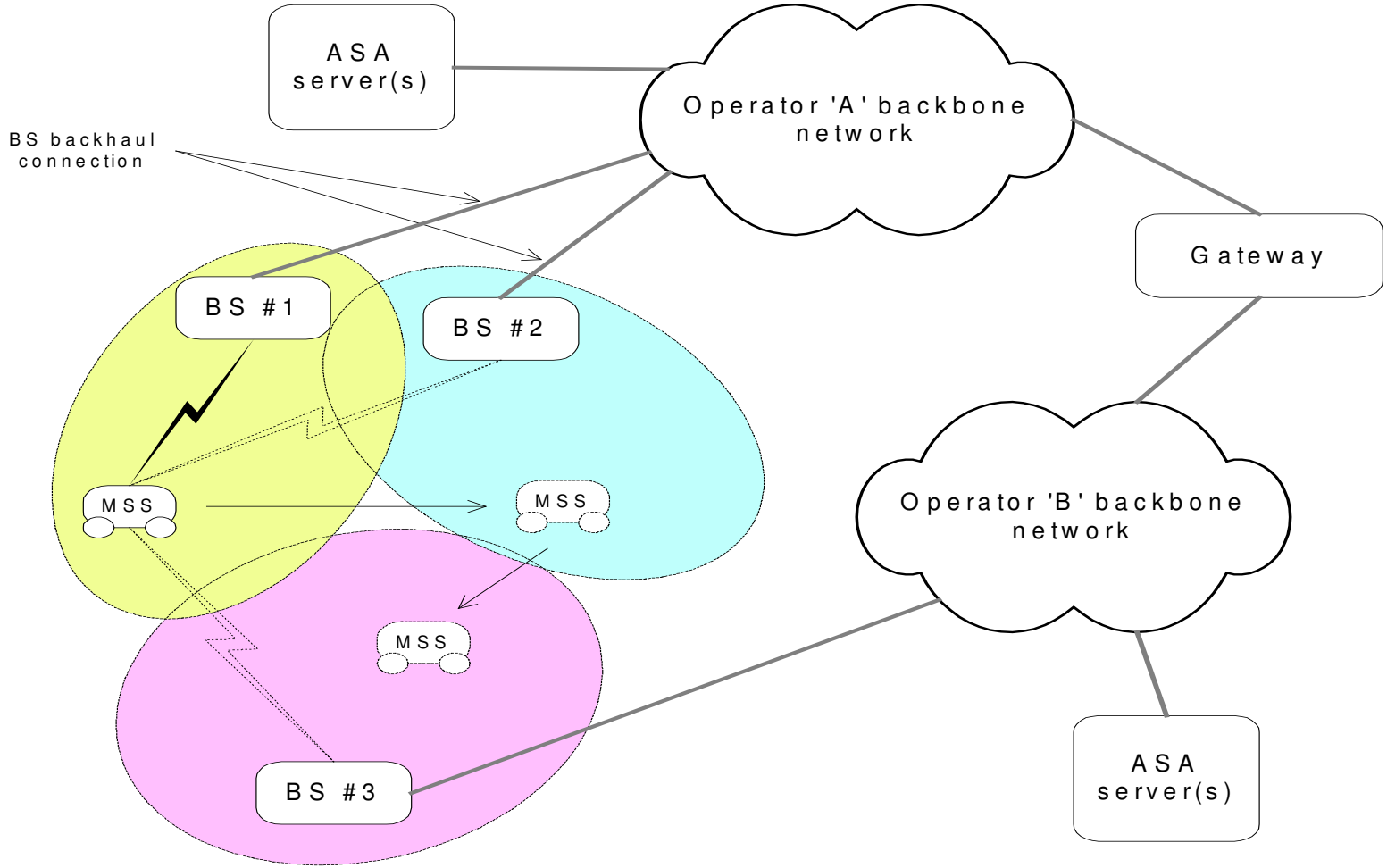
Handoff draft presentation

Handoff procedures for 802.16e

Handoff Ad-Hoc

Network reference model

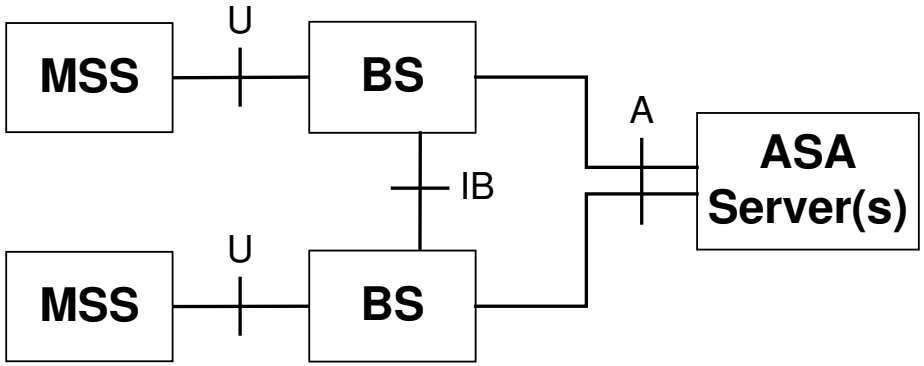
Network reference model



Entities

- MSS - Mobile Subscriber Station, contains MAC (CS), PHY layers
- BS - Base Station Sector, a single MAC entity covers a single air interface instance
- ASA Server(s) - Authentication and Service Authorization Server servicing the whole operator's network. These may be implemented as a centralized or distributed entity

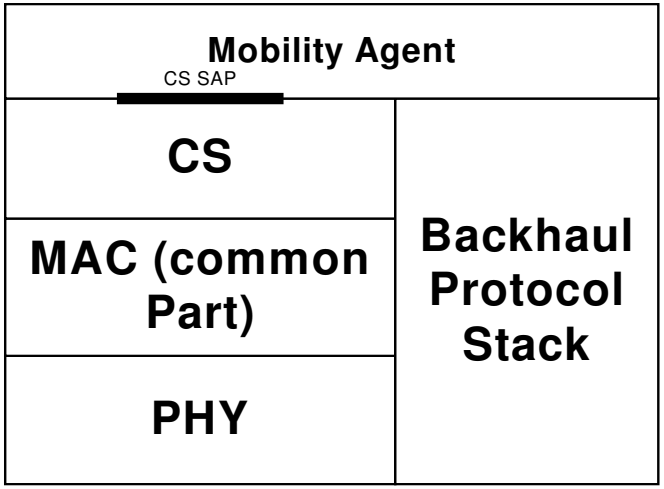
Entities – Control plane



- U - PHY, MAC (including CS) operations, Mobility Sub-layer messages exchange
- IB - BS-to-BS messages (Transport protocol is not specified)
- A - Messages serving MSS authentication and service authorization functions (Transport protocol is not specified)

BS and MSS protocol stack

- MSS protocol stack
  - No difference here compared to IEEE 802.16a standard
- BS protocol stack



Mobility Agent

- MA provides the following functions,
  - Termination of tunnel carrying data to the MSS, including de-capsulation of incoming data units
  - Communication to CS regarding arrival of new MSS to the cell
  - Creation of new connections
  - Creation of new classifier(s) to forward data to the connections
  - Specification of proper QoS per connection
  - After MS departure, deletion of connections and classifiers

MSS Service context

- Network Service
  - Defined as a service provided to the MSS by the network through a single MAC connection with particular connectivity and MAC parameters (including QoS properties)
- MSS Service Context
  - Specifies the set of network services authorized for a given MSS. It is composed of the following elements
    - MSS Service MSS 48-bit MAC address unique identifier
    - Number N of Network Service IEs (NSIEs)
    - N x NSIE
    - Number M of Security Associations IEs (SAIEs)
    - M x SAIE

MAC layer HO procedures

Network topology advertisement

- A BS **shall** broadcast information about the network topology using the NBR-ADV MAC message
  - Information about the PHY settings of the neighbor BS
    - Frequency channel
    - DCD information
    - UCD information
- MSS **may** decode this message to find out information about the parameters of neighbor BS
- Each MSS would thus be able to synchronize quickly with neighbor BS.

MSS scanning of neighbor BS

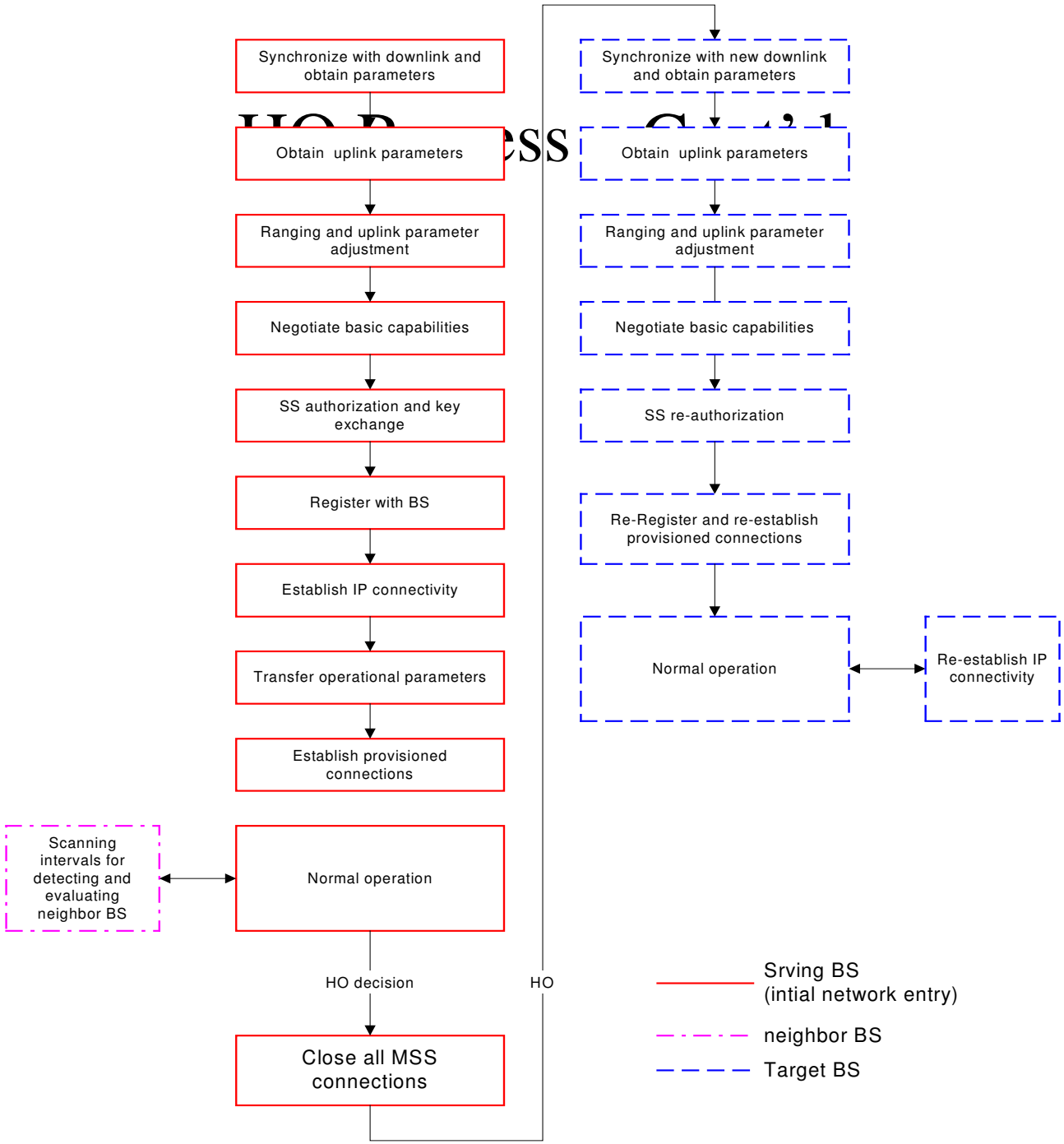
- A BS may allocate time intervals to MSS for the purpose of seeking and monitoring neighbor BS - **scanning interval**
- A MSS may request an allocation of a scanning interval using the SCN-REQ MAC message
  - The MSS indicates the duration of time it requires for the scan
- BS responds with placement of a Scanning_IE in the DL-MAP
  - The Scanning_IE either grants the requesting MSS a scanning interval that is at least as long as requested by that MSS, or deny the request
  - The BS may also place unsolicited Scanning_IE
- Passive scanning

MSS scanning of neighbor BS – Cont'd

- Active scanning
  - A MSS shall use the allocated interval to seek neighbor BS
  - When neighbor BS are identified, estimate the connection quality
  - A MSS may use the interval for UL ranging as well to in a procedure is called **association**.
- When associating with a neighbor BS, two additional stages are performed
  - **association-initial-ranging**
  - **association-pre-registration**
- Association-initial-ranging is performed by transmitting a RNG-REQ MAC message
- Information on Association is reported to the Serving BS

HO Process

- The HO process belongs to the break-before-make type
  - Make-before-break can still be implemented
- HO process consists of the following stages,
  - HO initiation
    - The decision to start the process is taken
  - Termination of service with the serving BS
    - All connections belonging to the MSS are terminated
    - The context associated with connections is discarded (i.e. information in queues, ARQ state-machine, counters, timers, etc.)
  - Network re-entry in target BS
    - The MSS re-enters the network using a fast network entry procedure
    - After network re-entry, connection belonging to the MSS are re-established based on the availability of resources in the target BS


Synchronize with downlink and obtain parameters
Obtain uplink parameters
Ranging and uplink parameter adjustment
Negotiate basic capabilities
SS authorization and key exchange
Register with BS
Establish IP connectivity
Transfer operational parameters
Establish provisioned connections
Scanning intervals for detecting and evaluating neighbor BS
Normal operation
HO decision
Close all MSS connections
HO
Synchronize with new downlink and obtain parameters
Obtain uplink parameters
Ranging and uplink parameter adjustment
Negotiate basic capabilities
SS re-authorization
Re-Register and re-establish provisioned connections
Normal operation
Re-establish IP connectivity
Srving BS (intial network entry)
neighbor BS
Target BS

HO initiation

- Either a MSS or a BS may initiate a HO
  - HO is initiated by transmitting the HO-REQ MAC message
  - In most situations the MSS will be the initiator of the HO
  - A BS may be the initiator of a HO to facilitate load sharing among BS
- When HO-REQ is sent by a MSS,
  - MSS may indicate possible target BS (from signal quality point of view)
  - MSS may include an indication of the estimated time for HO
- When sent by a BS
  - BS may indicate the recommended target BS (based on QoS capability)
  - BS may include an indication of the estimated time for HO
- At the BS side, before sending or after receiving a HO-

HO initiation – Cont'd

- After receiving HO-REQ message,
  - Receiving party shall respond with a HO-RSP MAC message
- When sent by a BS,
  - the HO-RSP message may indicate a recommended target BS
  - The HO-RSP message may also includes an estimation of the time when the HO would take.
- The MSS, may ignore BS recommendation
  - This includes staying with its serving BS, i.e. skipping the HO
  - MSS risks receiving a degraded level of service

Termination with serving BS

- After the HO-REQ/RSP handshake is completed, the MSS may begin the actual HO by closing all connections to the serving BS. This mass destruction act is done by sending a DEL-ALL MAC message
- Upon reception of a DEL-ALL MAC message,
  - BS may close all connections and discard MAC state machines and MPDUs associated with the MSS
  - BS does not HAVE to close or discard anything, this enables a make-before-break HO

Drops and corrupted HO attempts

- A drop is defined as the situation where a MSS has stopped communication with its serving BS (either in the downlink, or in the uplink) before the normal HO sequence has been completed.
- A MSS can detect a drop by,
  - Failure to demodulate the downlink
  - Exceeding the RNG-REQ retries limit allowed for the periodic ranging mechanism
- A BS can detect a drop by,
  - exceeding the RNG-REQ retries limit allowed for the periodic ranging mechanism
- When the MSS has detected a drop, it shall attempt network re-entry with its preferred target BS
- When the BS has detected a drop, it shall react as if a

Re-entry with target BS

- Target BS as well as all neighbor BS are aware of the HO in progress (except in a drop situation)
- Step 1 - Synchronize with downlink and obtain parameters
  - Immediate for MSS that have used the scanning interval to synchronize with target BS and have decoded the NBR-ADV message
  - Defaults to initial network entry procedure for otherwise
- Step 2 - Obtain uplink parameters
  - Immediate for MSS that have decoded the NBR-ADV message
  - Defaults to initial network entry procedure for otherwise

Re-entry with target BS – Cont'd

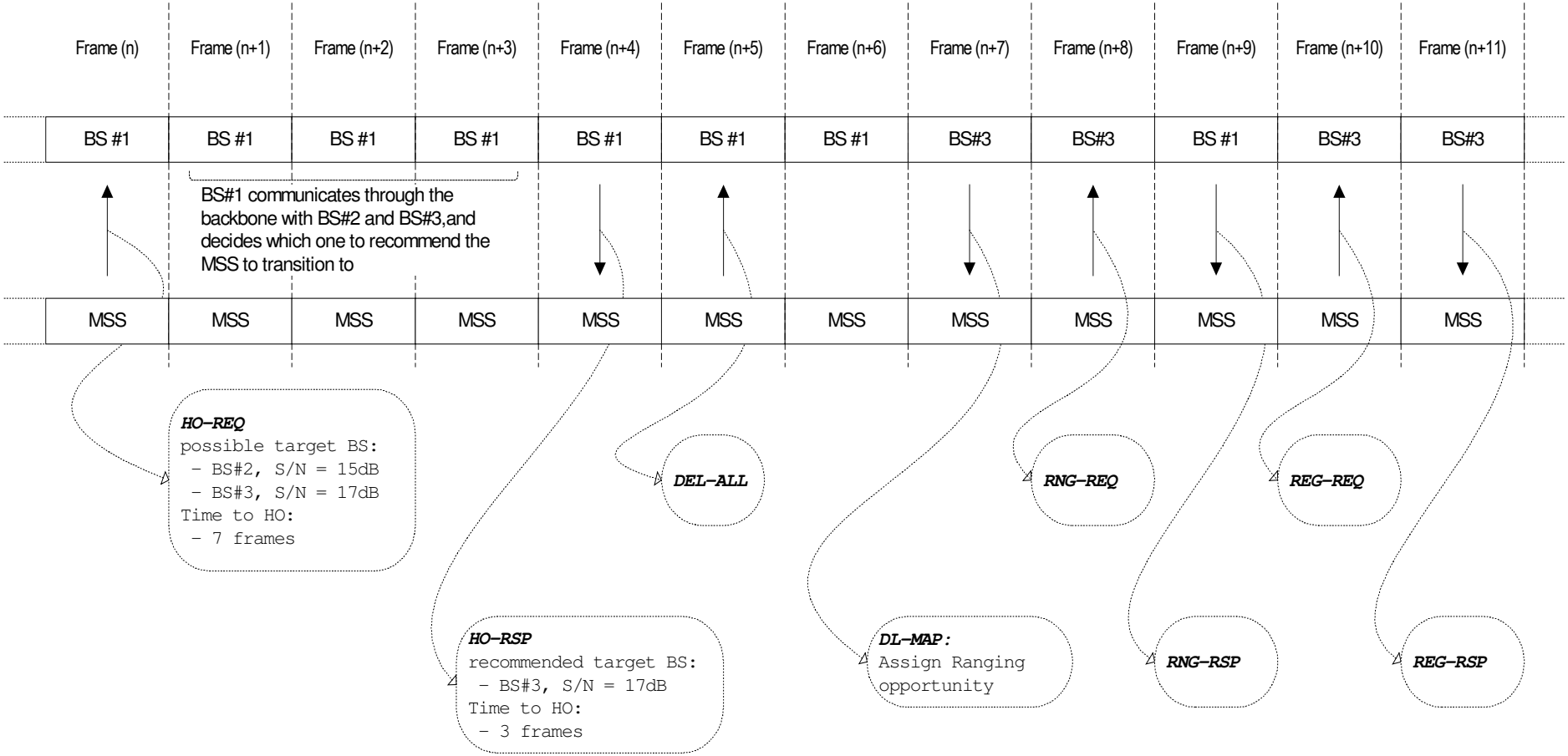
- Step 3 - Ranging and uplink parameters adjustment
  - Immediate for MSS that have used their scanning interval to do UL ranging with target BS
  - Defaults to initial network entry procedure for otherwise
  - Ranging opportunity may be allocated individually based on a MSS 48-bit MAC address (no contention)
    - 48-bit MAC address identifier is forwarded to the target BS via the backbone network
    - Defaults to contention based method when 48-bit MAC address identifier is not available
- Step 4 - Negotiate basic capabilities
  - This stage is identical to the one performed during initial network entry

Re-entry with target BS – Cont'd

- Step 5 - MSS re-authorization
  - MSS performs the re-authorization part of the PKM protocol used at initial network entry
  - Security context it is transferred from the old BS via backbone
- Step 6 - Re-register and re-establish connections
  - MSS re-registers with the BS
  - MSS receives on the registration response a conversion table that maps the connections it had with to a new set of connections
  - MSS postpones the **establish-IP-connectivity** stage
  - MSS skips **transfer-operational-parameters** and the **time-of-day establishment** stage

Re-entry with target BS – Cont'd

- Step 7 - Commence normal operation
  - Normal operation commences
  - MSS re-establishes its IP connectivity



HO completion

- No current text – should add text if make-before-break HO is to be supported

MAC messages for HO

Neighbor Advertisement message

Syntax	Size	Notes
NBR-ADV_Message_Format() {		
Management Message Type = ?	8 bits	
N_NEIGHBORS	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
Configuration Change Count	8 bits	
Physical Frequency	16 bits	
TLV Encoded Neighbor information	Variable	TLV specific
}		
}		

- Following TLV parameters may be included,
  - DCD_settings for the advertised BS downlink channel
  - UCD_settings for the advertised BS uplink channel

Scanning Interval Allocation Request

Syntax	Size	Notes
SCN-REQ_Message_Format() {		
Management Message Type = ?	8 bits	
Scan Duration	20 bits	For SCa PHY, units are mini-slots. For OFDM/OFDMA PHY, units are OFDM symbols
}		

- Scan duration is specified by the MSS
  - According to PHY capabilities

Scanning Information Element

For SCa PHY:		
Syntax	**Size**	**Notes**
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	22 bits	Offset (in units of mini-slots) to the start of the scanning interval from the mini-slot boundary specified by the downlink Allocation_Start_Time
Scan Duration	22 bits	Duration (in units of mini-slots) where the MSS may scan for neighbor BS.
}		

For OFDM PHY:		
Syntax	**Size**	**Notes**
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	18 bits	Indicates the scanning interval start time, in units of OFDM symbol duration, relative to the start of the first symbol of the PHY PDU (including preamble) where the DL-MAP message is transmitted.
Scan Duration	18 bits	Duration (in units of OFDM symbols) where the MSS may scan for neighbor BS.
}		

For OFDMA PHY:		
Syntax	**Size**	**Notes**
Scanning_IE {		
CID	16 bits	MSS basic CID
Scan Start	18 bits	The offset of the OFDM symbol in which the scanning interval starts. Measured in OFDM symbols from the time specified by the Allocation_Start_time field in the DL-MAP
Scan Duration	18 bits	Duration (in units of OFDM symbols) where the MSS may scan for neighbor BS.
}		

Ranging Request/Response message

- A MSS may use the RNG-REQ message in its scanning interval for associating with a neighbor BS. Parameters are,
  - **Downlink Channel ID**
  - **SS MAC Address**
  - **CID at MAC Header** = Initial Ranging CID
  - **MSS Association Channel ID =** An identifier of the downlink channel on which the MSS is currently registered
- When a BS sends a RNG-RSP message in response to a RNG-REQ message containing a **MSS Association Channel ID**, BS response may include,
  - **Service Level Prediction – L**evel of service the MSS can expect,
    - 0 = No service possible for this MSS
    - 1 = Service requested (as determined by the 48-bit MSS MAC

HO Request message

Syntax	Size	Notes
HO-REQ_Message_Format() {		
Management Message Type = ?	8 bits	
Estimated HO time	8 bits	
N_Recommended	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
BS S/(N+I)	8 bits	This parameter exists only when the message is sent by the MSS
}		
}		

- Either a MSS or a BS may transmit an HO-REQ message when either wants to initiate an HO
- The message shall be transmitted on the basic CID

HO Response message

Syntax	Size	Notes
HO-RSP_Message_Format() {		
Management Message Type = ?	8 bits	
Estimated HO time	8 bits	
N_Recommended	8 bits	
For (j=0 ; j<N_NEIGHBORS ; j++) {		
Neighbor BS-ID	48 bits	
BS rating	8 bits	This parameter exists only when the message is sent by the BS
}		
}		

- Either a MSS or a BS shall transmit an HO-RSP message upon reception of HO-REQ message
- The message shall be transmitted on the basic CID

Delete All Connections message

Syntax	Size	Notes
DEL-ALL_Message_Format() {		
Management Message Type = ?	8 bits	
TLV Encoded Information	Variable	TLV specific
}		

- If Privacy is enabled, the DEL-ALL message shall include the following TLV value,
  - **HMAC Tuple** (see 11.4.10 in IEEE 802.16-2001) – The HMAC Tuple Attribute contains a keyed Message digest (to authenticate the sender)

Fast UL ranging IE

For OFDM PHY:		
Syntax	**Size**	**Notes**
`Fast_UL_ranging_IE {`		
MAC address	48 bits	MSS MAC address as provided on the RNG_REQ message on initial system entry
UIUC	4 bits	UIUC ≠ 15. UIUC ≠ 4. A four-bit code used to define the type of uplink access and the burst type associated with that access.
Duration	12 bits	The Duration indicates the length, in units of OFDM symbols, of the allocation. The start time of the first allocation shall be the Allocation Start Time given in the UL-MAP message.
Reserved	4 bits	
}		

- Example above is for OFDM PHY

REG-RSP TLVs for connection re-establishment

- The following TLVs shall be included in the REG-RSP for MSS recognized by the BS through their 48-bit MAC address in HO,
  - **CID_update**
    - The CID_update is a TLV value that provides a shorthand method for renewing a connection used in the previous serving BS
    - The TLV specifies a CID in the new serving BS that shall replace a CID used in the previous serving BS
    - All the service flows and parameters associated with the old CID remain unchanged
  - **Connection_Info**
    - The Connection_Info is a compound TLV value that encapsulates the **Service Flow Parameters** and the **CS Parameter Encodings** TLVs allowed on the DSA-RSP
    - TLV enables the new serving BS to renew a connection used in the previous serving BS, but with different QoS settings

Backbone network HO procedures

Backbone network services

Service	Possible methods for providing service	Comments
Backhaul for traffic	-	Transport protocol is not specified
Provide a BS with the identity of its neighbors	1. Get info from ASA server 2. Configuration (network management)	Options (1) and (2) are really the same, the only difference is where the configuration is done
Provide a BS with the identity of the ASA server	1. ASA server publishes its presence 2. Configuration (network management)	Message format and transport protocol need to be specified for interoperability
Advertise the fact that a certain MSS has registered with a certain BS	1. BS notifies ASA server 2. BS notifies neighbor BS	Message format and transport protocol need to be specified for interoperability
Provide a BS information about a certain MSS	1. ASA server provides information 2. Serving BS provides information (or network management if serving BS cannot be found)	Message format and transport protocol need to be specified for interoperability
Information exchange during HO	1. ASA server is in the middle 2. BS to BS direct exchange	Message format and transport protocol need to be specified for interoperability

- IT is possible to exchange information between BS directly or through the ASA server
- Protocol used for information exchange on the backbone can regard the ASA server as another BS
- No special message will be required with regards to the ASA server

I-am-host-of message

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS on initial network entry
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

- Sent by a BS to notify other BS (or the ASA server) that a certain MSS is registered with it
- The message shall be sent upon MSS registration, and periodically
- The message might trigger a neighbor BS to request more information on the MSS (from sender BS, or from ASA

MSS-info-request message

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num Records	16-bit	Number of SS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the *I-am-host-of* message)
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

- Message may be sent from one BS to another (or to the ASA server) to request information about a MSS
- Typically the message will be sent,
  - As a reaction to reception of an *I-am-host-of* message
  - In cases where a MSS is trying to re-enter the network after a HO

MSS-info-response message

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num Records	16-bit	Number of SS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the *I-am-host-of* message)
N_NSIE		Number of Network Service Information Elements
For (k=0; k<N_NSIE; k++) {		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a DSA-REQ MAC message
}		
N_SAIE		Number of Security Association Information Elements
For (k=0; k<N_SAIE; k++) {		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a PKM-xxx MAC messages
}		
Field Size	16-bit	Size of TLV encoded information field below
TLV encoded information	Variable	TLV information as allowed on a SBC-REQ MAC message
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

- Message may be sent from one BS to another (or ASA server)
- Typically the sent in response to a *MSS-info-request*

HO-notification message

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the *I-am-host-of* message)
Estimated Time to HO	16-bit	In milliseconds, relative to the time stamp
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

- Sent by a BS to advertise a MSS intention to perform HO
- Typically sent to all neighbor BS
- Serves to alert the neighbor BS that a HO event is going to happen

HO-notification-response message

Field	Size	Notes
Message Type = ?	8-bit	
Sender BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Target BS-ID	48-bit	Base station unique identifier (Same number as that broadcasted on the DL-MAP message)
Time Stamp	32-bit	Number of milliseconds since midnight GMT (set to 0xffffffff to ignore)
Num Records	16-bit	Number of MSS identity records
For (j=0; j<Num Records; j++) {		
MSS unique identifier	48-bit	48-bit unique identifier used by MSS (as provided by the MSS or by the *I-am-host-of* message)
QoS Estimate	8-bit	TBD
}		
Security field	TBD	A means to authenticate this message
CRC field	32-bit	IEEE CRC-32

- Sent from one BS to another BS, typically in response to a *HO-notification* message
- Serves to provide the BS that sent the *HO-notification* message with information about the level of service the MSS could expect if it transitions to this BS

Backbone network protocol

- Should we define the protocol the BS use to communicate through the backbone?
- To ensure interoperability between BS from different manufacturers the format of this communication should be standardized (at least as a recommendation)
- Consider using UDP as the transport protocol
- Resource reservation and QoS over the backbone may be left un-addressed.

Convergence sub-layer HO procedures

Supported convergence sub-layer

- No text in this section

SAP for higher layer protocols

- Defines the services between the MAC and higher layers for supporting the HO process
- Higher layers may use information provided by the MAC layer HO process to optimize their HO process
- Information is defined as set of indications provided by the MAC layer to the higher layers,
  - **MSS Movement** - Occurs at the MSS, indication that the MSS has registered to a new Target BS
  - **Serving BS Pre-HO** - Occurs at the Serving BS, indication that a MAC layer HO of a certain MSS is about to take place
  - **Target BS Pre-Ho** - Occurs at the Target BS, indication that a MAC layer HO of a certain MSS is about to take place
  - **BS Post-HO** - Occurs at the Target BS or MSS, indication that a MAC layer HO between the MSS and the Target BS has been completed

Setup and negotiations

Setup and negotiations

- No text in this section
- This section should discuss the following
  - Setup and negotiation procedures related to the HO
  - PHY dependent parameters and associated handshake
  - The model for coexistence of fixed and mobile-SS on the same air-interface instance