

Radio Network Architecture Evolution

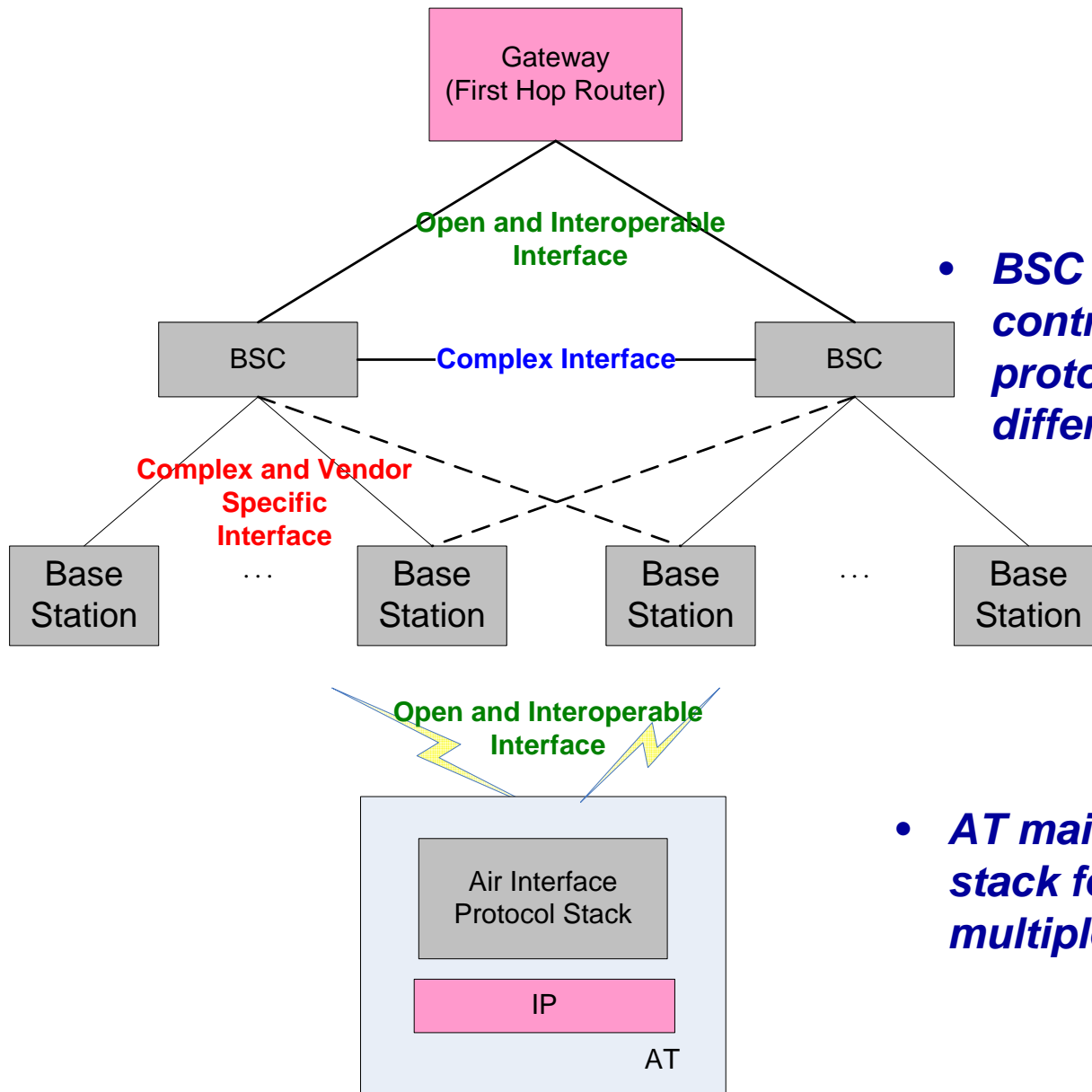
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- ***Wireless wide area network design aims to deliver several desirable features***
 - High data rates
 - Seamless mobility
 - QoS support
 - Scalability
 - Interoperability of equipment from different vendors
 - Efficient frequency reuse-1 deployment
 - Frequency reuse-1 is optimal in terms of spectral efficiency
 - Frequency reuse-1 leads to simpler deployment because it does not require frequency planning
 - Eliminating the need to do frequency planning is especially important in dense eBS deployments

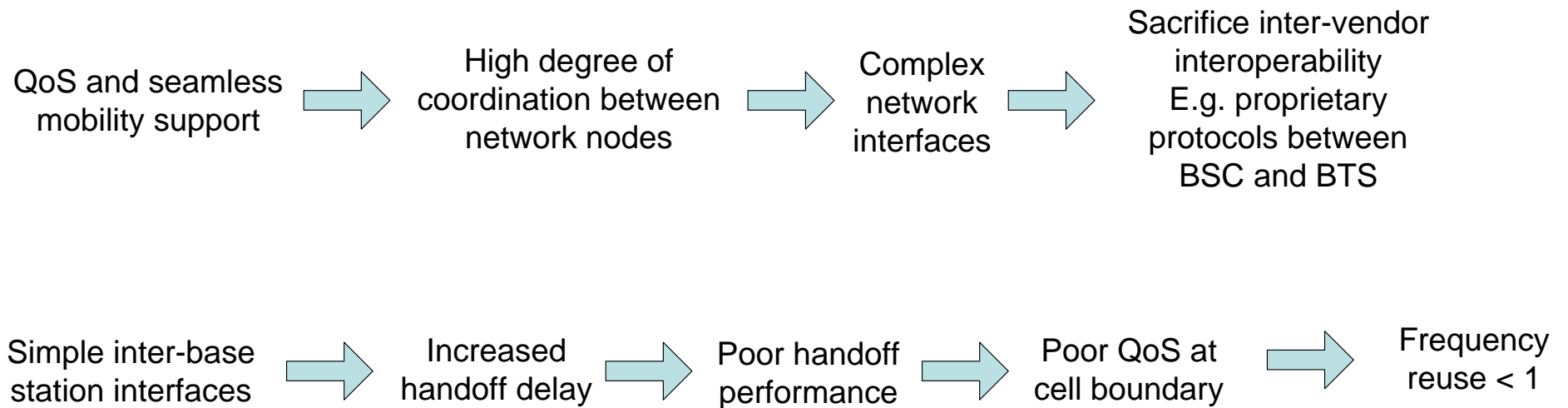
It is often assumed that all of the above cannot be achieved simultaneously

Traditional Wireless Network Architecture



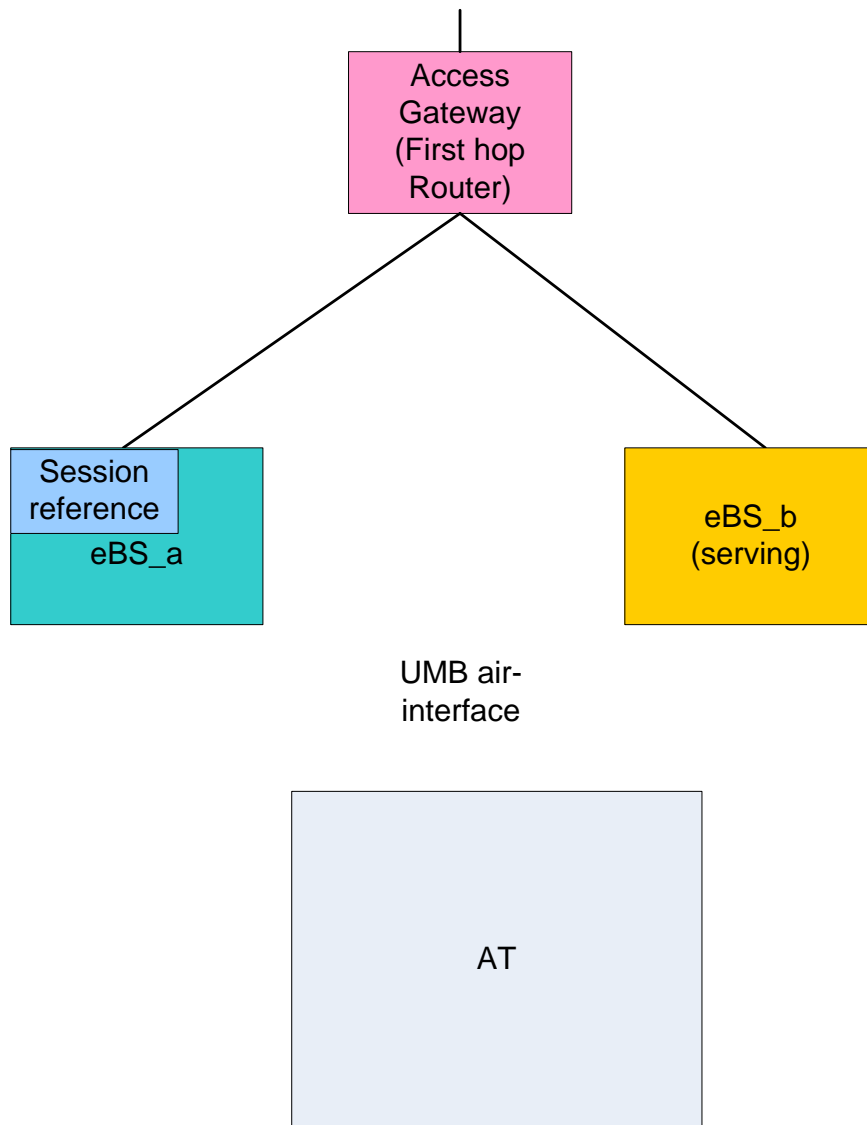
- **BSC - Centralized control/coordination entity keeps protocol state coordinated across different base stations**

- **AT maintains one air interface stack for communication with multiple base stations**



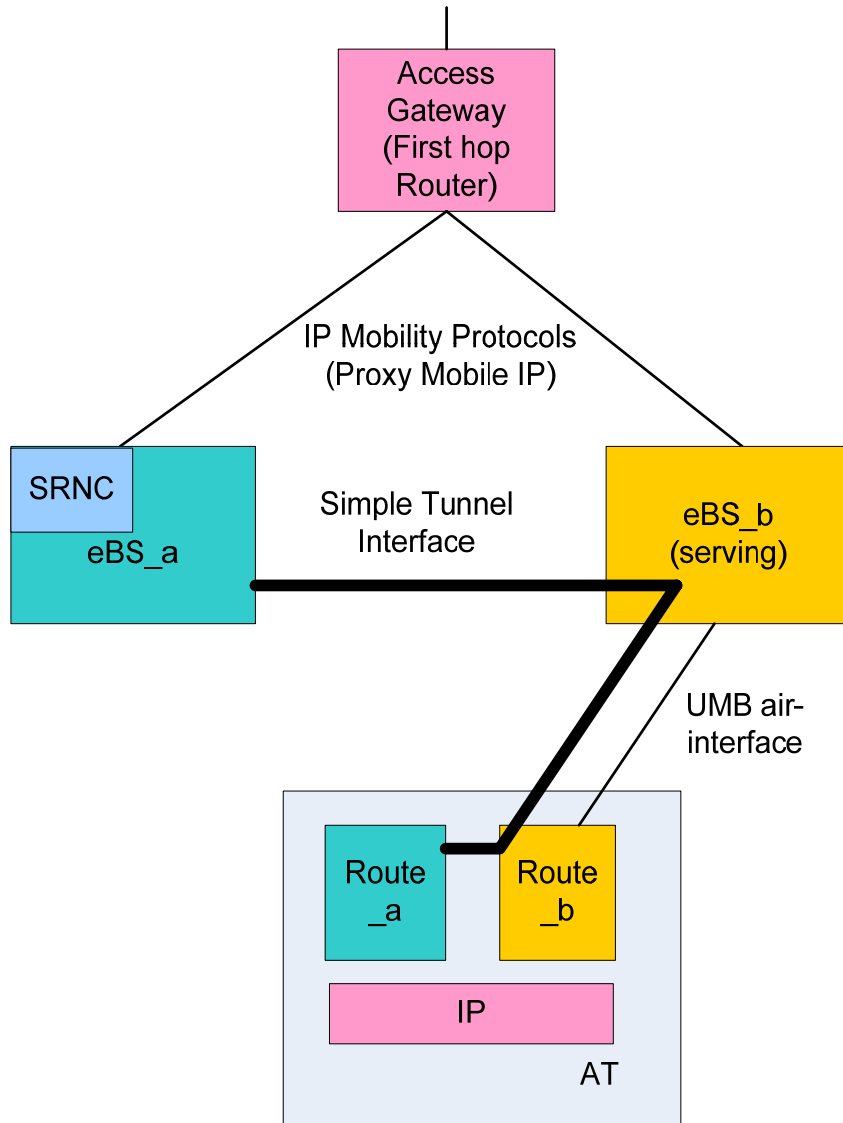
- ***Do we have to make these trade-offs?***
- ***A radio network can deliver all desirable properties simultaneously***
 - This talk describes Ultra Mobile Broadband* (UMB) radio network as an example of a system that achieves this

* Ultra Mobile Broadband and UMB are registered trademarks of the CDMA Development Group (CDG)



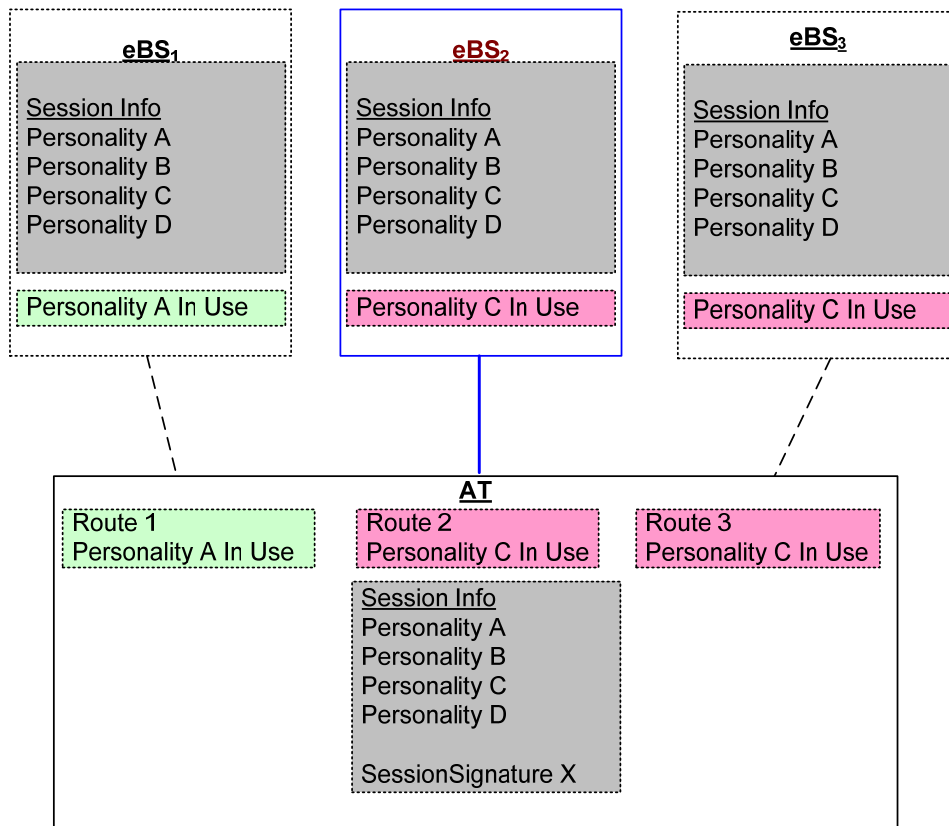
- **Access Terminal (AT)**
 - Provides IP data connectivity to the user.
- **Evolved Base Station (eBS)**
 - Provides a ‘layer 2’ (data link layer) point of attachment for the AT.
 - May also act as the ‘layer 1’ (physical layer) point of attachment on the forward link, or reverse link, or both.
- **Access Gateway (AGW)**
 - Provides the ‘layer 3’, i.e. network layer or Internet Protocol (IP) point of attachment for the AT.
- **Session Reference**
 - Stores the radio session negotiated with the AT
 - Session reference function can be in one of the eBSs or in a centralized entity

AT maintains a separate protocol stack for each eBS



- **AT maintains a separate air interface protocol stack associated with each eBS**
 - Each instance of the protocol stack is called a Route.
 - The set of eBSs that have a Route with the AT is called the Route Set.
- **Each eBS maintains independent connection state for its Route to the AT**
 - E.g. RLP state
 - E.g. header compression state
 - E.g. security keys
- **No coordination of connection state across eBSs leads to a controller-less network**
 - AT plays the role of the centralized controller
- **Simpler network interfaces**

Each Route can choose its own Personality



- **Personality**
 - Set of protocols and their attributes for use by the protocol stack between the AT and eBS.
- **Session**
 - Storage of one or more Personalities.
- **Each Route can choose its own Personality**
 - eBSs with differing Personality preferences can exist in the AT's Route Set simultaneously
 - Mobility is supported even if eBSs are not well coordinated in their configurations or capabilities
 - Allows gradual technology upgrade
- **All eBSs in the Route Set share a common session**
 - Personality negotiated by one eBS may be used by another eBS without re-negotiation
 - Speeds up addition of new eBS to Route Set
- **SRNC maintains AT's session information and provides the session to other eBSs.**
 - SRNC functionality can be in one of the eBSs or can be centralized

- **Layer 1 connectivity**

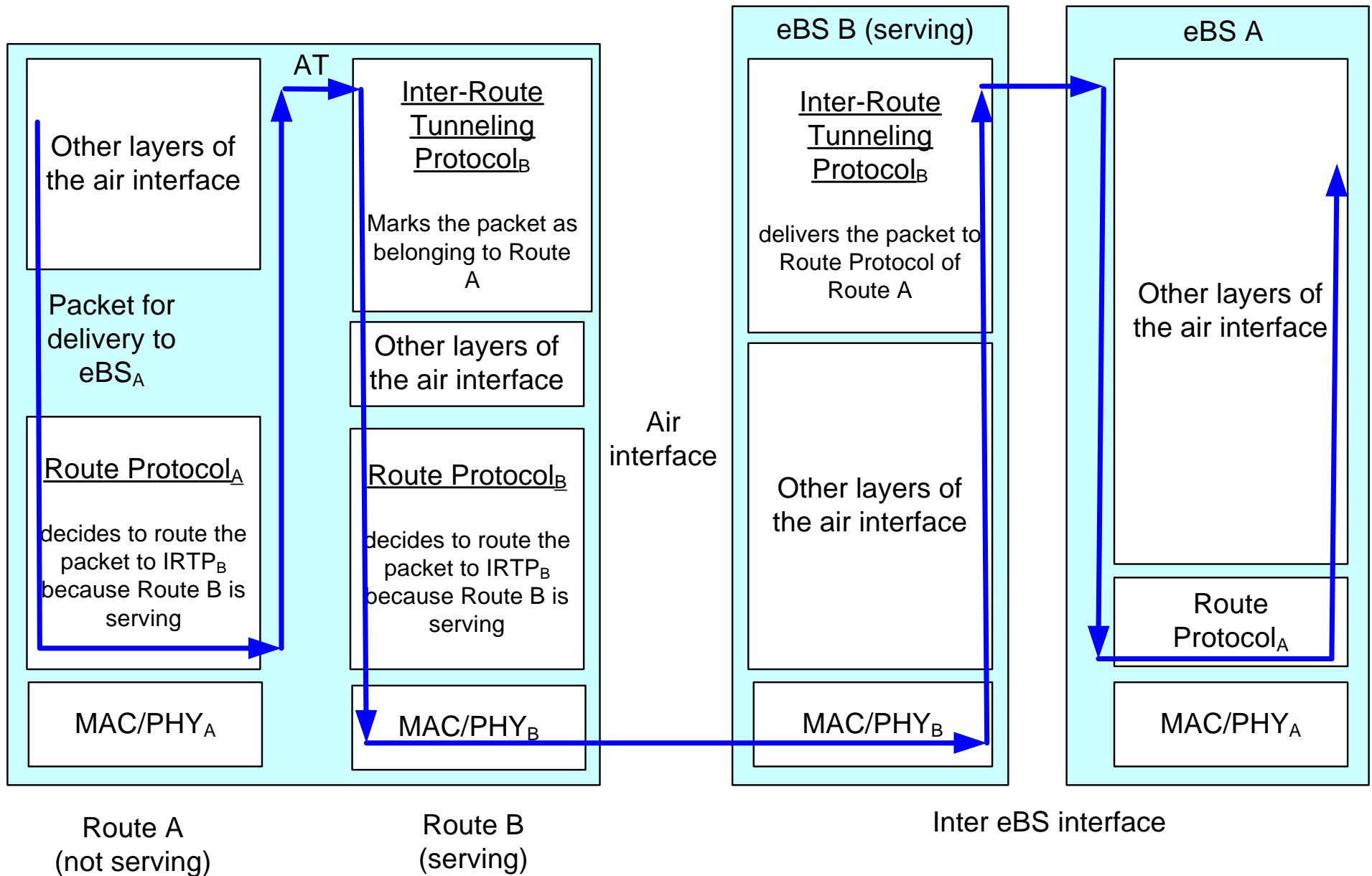
- One eBSs in the Route Set has layer 1 connectivity to the AT on the forward link a time (FLSE)
- One eBS in the Route Set has layer 1 connectivity on the reverse link at a time (RLSE)
- FLSE and RLSE functions may be served by the different eBSs
 - Best eBS can be chosen independently on each link
- AT chooses the FLSE and RLSE
- Physical layer channels support fast switching of layer 1 connectivity as channel conditions change
- QoS can be supported without resorting to frequency reuse less than one, which is used to reduce the need for handoff

- **Layer 2 connectivity**

- AT has layer 2 connectivity to each eBS in the Route Set
- An eBS is added to the Route Set when signal strength exceeds a threshold
- Protocols run end to end between an eBS and the AT
- Signaling messages are tunneled through the serving eBS
- Encryption and integrity protection is applied end to end
- eBS which acts as a tunnel does not interpret the tunneled messages
- No protocol conversion between eBSs

- ***When the AT switches from one eBS to another, it uses the Route associated with the new serving eBS to transfer packets***
 - Since the target eBS was already set up to become the serving eBS when it was added to the Route Set, and no connection state (such as RLP state or ROHC state) is transferred between source and target serving eBSs
 - Layer 1 switch can be executed very quickly while maintaining a simple inter-eBS interface
- ***Undelivered packets fragments at the source eBS are tunneled through the target serving eBS using a layer 2 tunnel***
 - Target eBS carries the packets over the air on behalf of the source Route
 - Target eBS does not interpret the packets
- ***Undelivered full IP packets buffered at the source eBS are delivered to the target eBS through a layer 3 tunnel***
 - Such packets are served to the AT using the Route associated with the target eBS
- ***Contrast with a traditional network where a centralized controller must retrieve packets from the source eBS and deliver them to a target eBS***

Tunneling support in a multi-Route air interface



- ***AGW acts as the Layer 3 attachment point for the AT***
 - AGW sends packets destined to the AT to one of the eBSs, which is performing the function of a Data Attachment Point (DAP)
- ***If DAP is different from FLSE, then the DAP forwards packet to the FLSE in a layer 3 tunnel***
 - To avoid triangular routing, it is desirable that FLSE and DAP should be collocated
 - To avoid too many binding updates, DAP eBS should not be moved at every layer 1 handoff
 - E.g. when AT ping-pongs between two eBSs
- ***AT chooses when DAP based on channel conditions and using attributes negotiated with eBS***
- ***Decoupling of the DAP move (layer 3 handoff) from a layer 1 handoff***
 - Allows layer 1 handoff to happen more frequently than DAP move
 - Removes DAP handoff from the critical path of the layer 1 handoff timeline.

- ***Each eBS in the Active Set uses a separate data Route***
 - No need to transfer RLP and header compression state between eBSs
- ***Traffic flowing between an eBS and the AT can be tunneled through the serving eBS***
 - Support fast and seamless re-pointing between cells
- ***Each eBS in the Active Set could use a separate Personality***
 - Seamless handoff across air interface revision boundaries
- ***Protocols between an eBS and the AT can be tunneled through the serving eBS***
 - The eBS which acts as a tunnel does not interpret the tunneled messages
 - No protocol conversion between eBSs
- ***There is no entity in the network that maintains Connection state of all eBSs in the Active Set***
 - No need to synchronize relatively fast changing state across eBSs
- ***Seamless mobility, QoS, and frequency reuse-1 deployment can be achieved simultaneously with simple inter-vendor-interoperable network interfaces***