Competence Center for
Advanced Network Technologies and Systems

GMD FOKUS

Mobility Management

Related Activities within the ATM-Sat Project

Presentation to Industry Representatives and Interested Scientists

http://www.fokus.gmd.de
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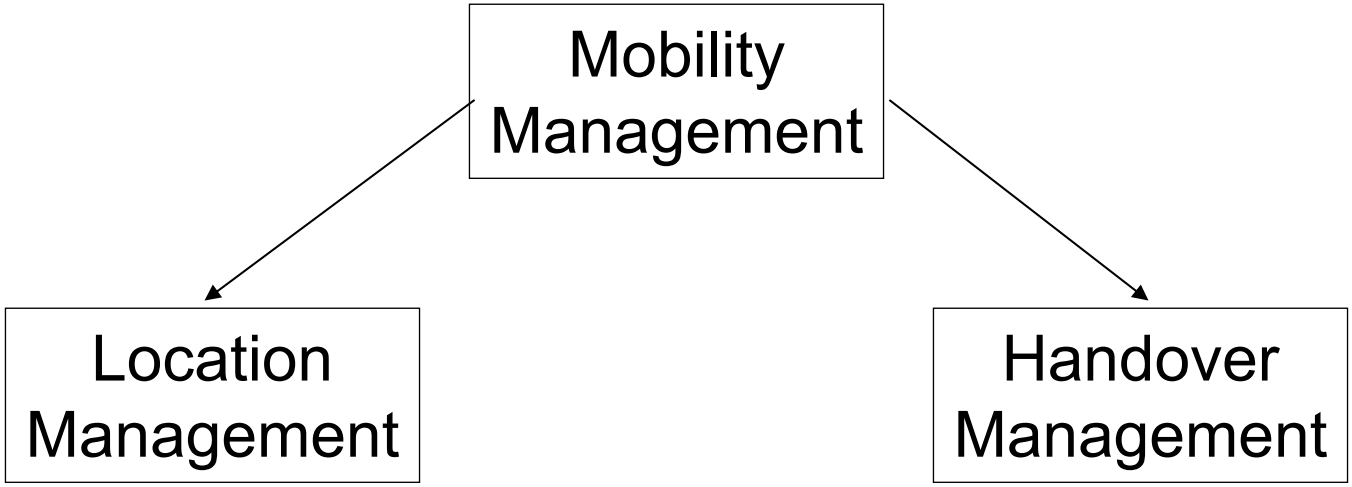
Mobility Management

- Consists of:
  - Protocols providing information to establish and maintain connections between (mobile) users in a (mobile) network



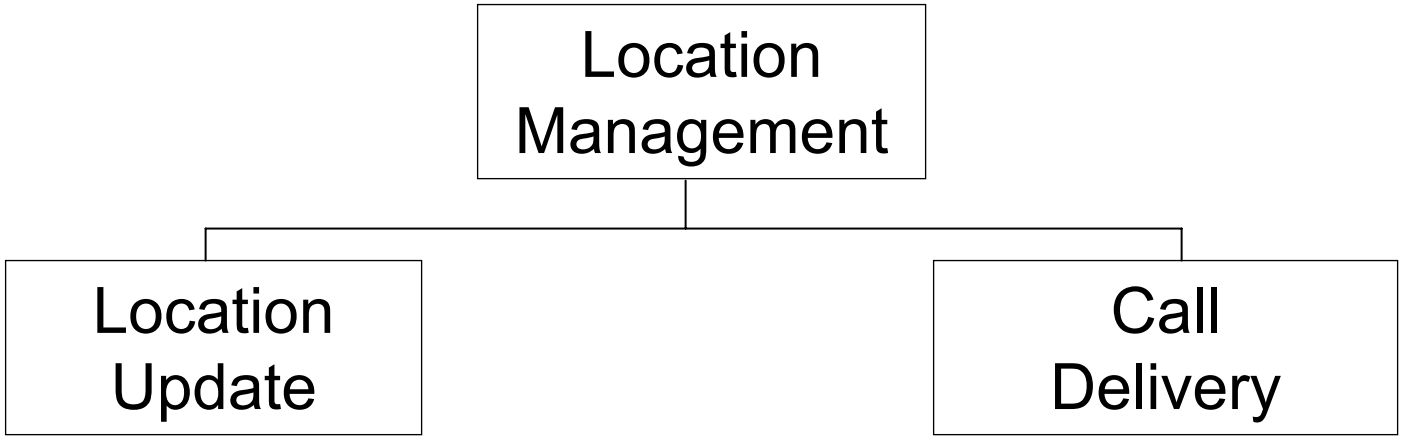
Mobility Management

- Location Management
  - Process allowing network to locate a user
  - Location corresponds to access point or geographical position
- Handover Management
  - Process allowing the network to maintain an established connection, if
    - terminal/network node moves so that radio connection cannot be maintained
    - connection path within network must be rerouted

Contents

- **Location Management Overview**
- Location Management in LEO-ATM Systems
- Handover Management Overview
- Handover Management in LEO-ATM Systems

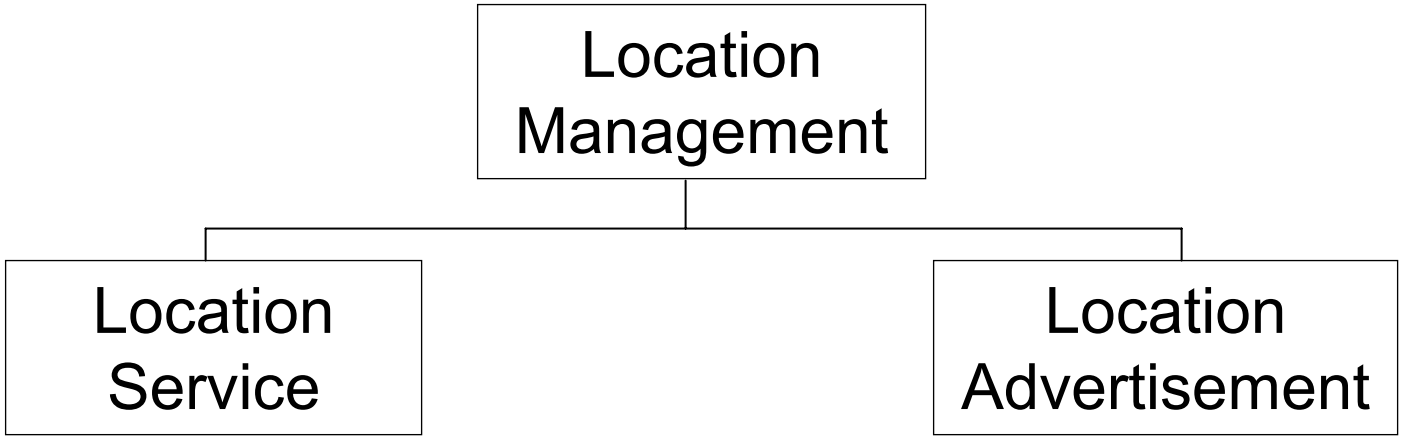
Operations



- Stores/propagates location information
- Update criteria
  - Always
  - Distance/time/etc
  - Profile

- Query database/ evaluate reachability info
- Terminal paging for exact location

Techniques



- Relies on databases
  - Two Tier Database
  - LR Hierarchy
  - Centralized DBMS
- Examples:
  - GSM, IS-41, Iridium

- Reachability exchange
  - Mobile PNNI
  - Virtual Connection Tree
  - Integrated Resolution

Improvements

- Objectives
  - Reduce required overhead
  - Reduce delay
- Improvement methods
  - Caching
    - Result of a location query is stored
    - Cache invalidation algorithm
  - Replication
    - Location of user might be replicated at specific sites
    - Determination of optimal set of replication sites

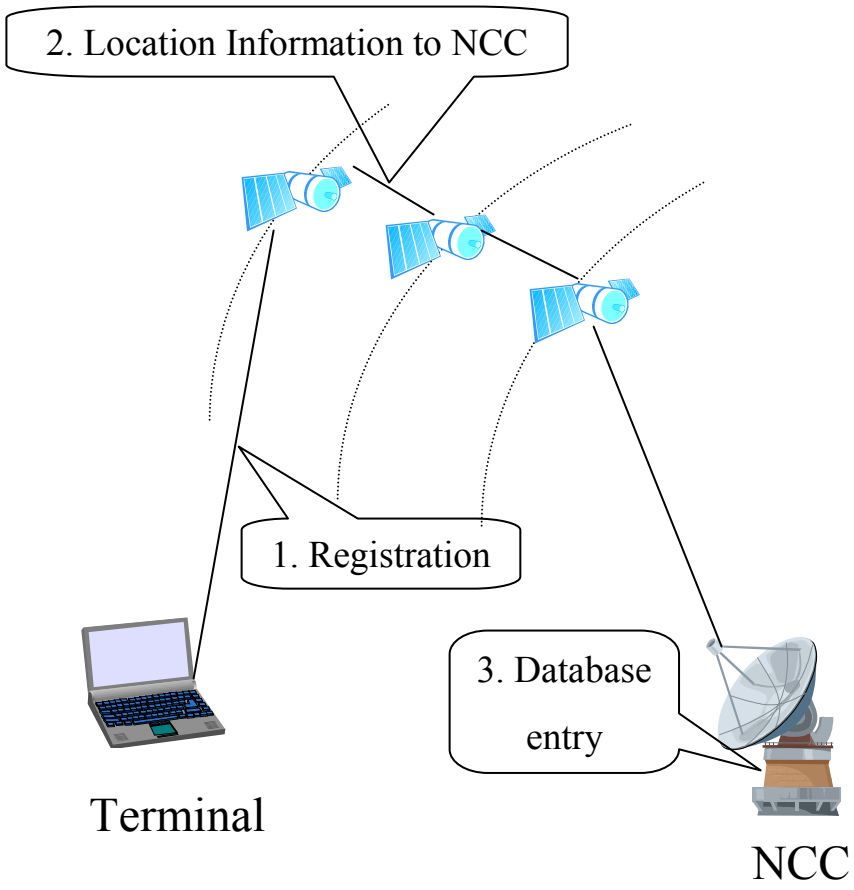
Progress

- Location Management Overview
- **Location Management in LEO-ATM Systems**
- Handover Management Overview
- Handover Management in LEO-ATM Systems

General statements

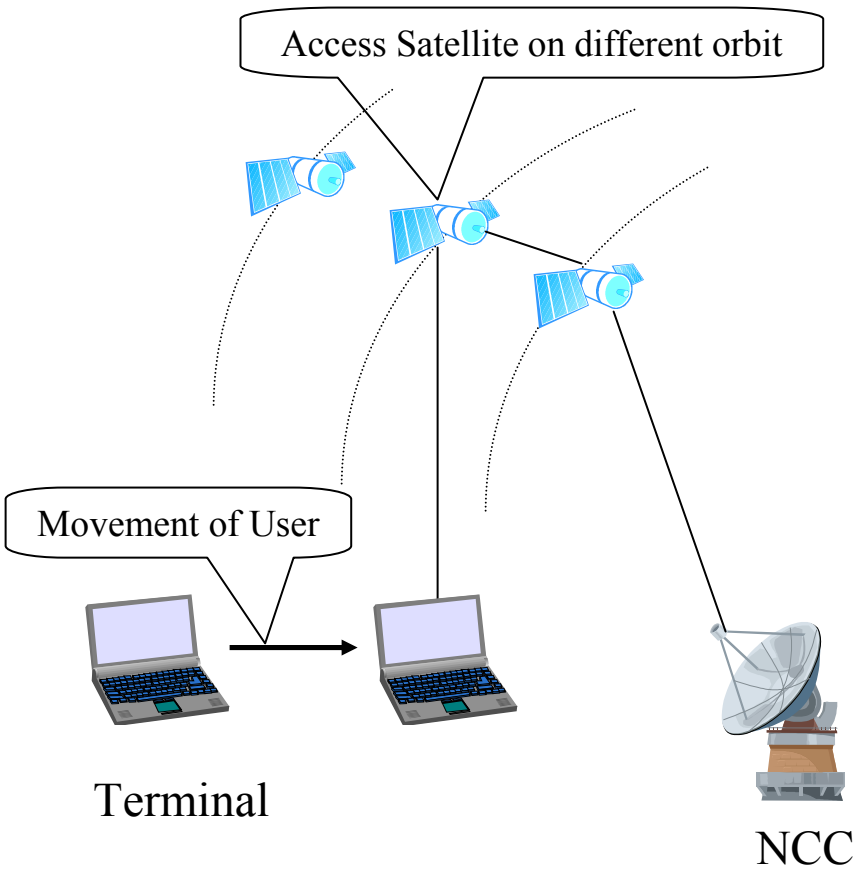
- Technique used:
  - Centralized database (NCC)
  - Location update not based on access node (satellite) to reduce location update
  - Terminal paging for call delivery if necessary
- Improvements used:
  - Caching in satellites:
    - “calling” satellite
    - intermediate satellites

Location Registration



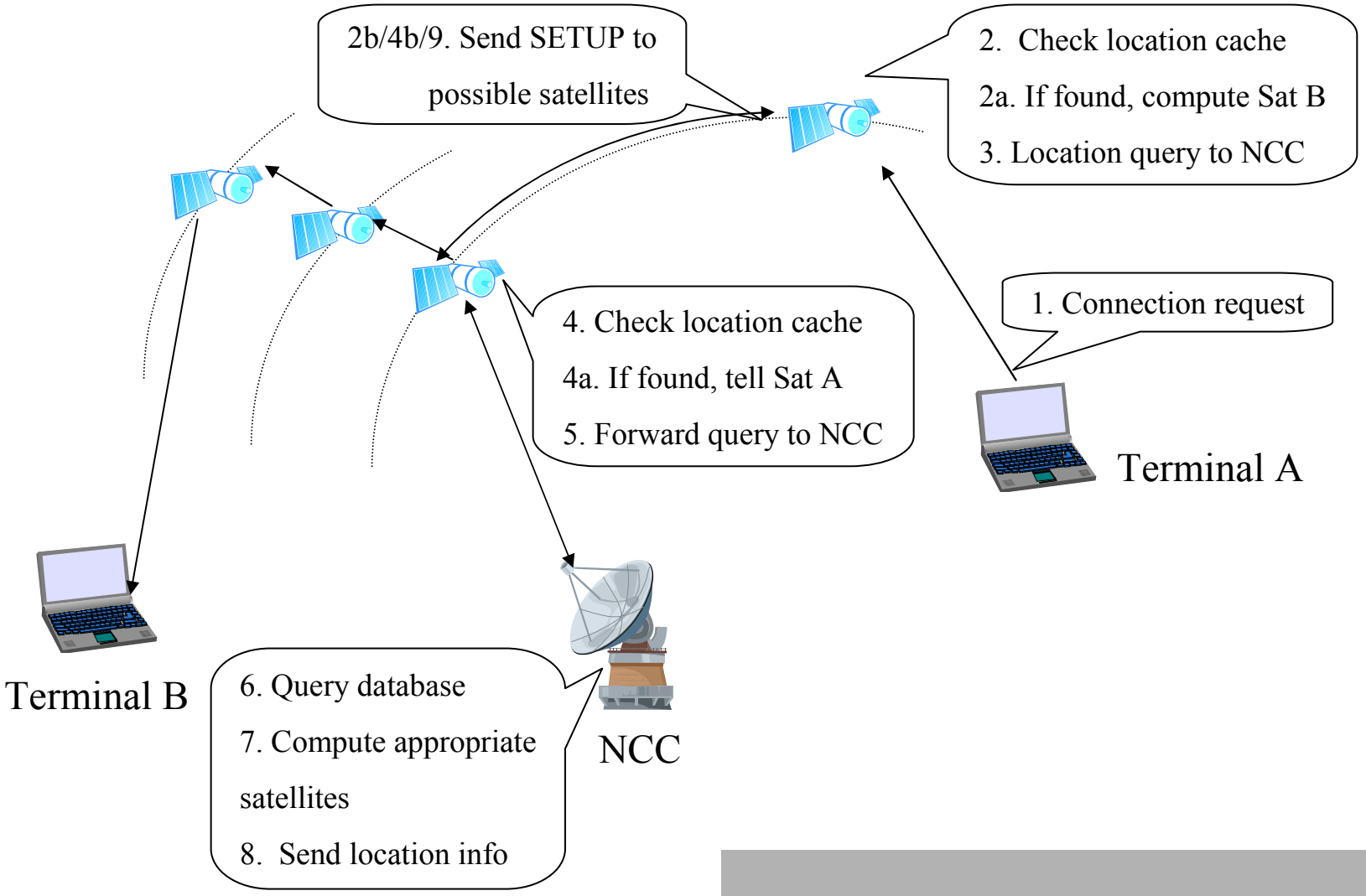
- Satellites connected to NCC
- Terminal registers (1)
- Satellite sends geogr. position and identification to NCC (2)
- NCC stores geographical position and satellite orbit (3)
- Satellites cache location information

Location Update



- Location update only for:
  - Vast terminal movement
  - New access satellite in different orbit
  - Connection interruption
- No update for:
  - Small satellite movement
  - New access satellite in same orbit
- Caching/Replication
  - Update of cache along the path
  - Replication possible

Call Delivery



Call delivery (cont.)

- Always ask NCC
- compute destination based on geographical position and satellite orbit $\Rightarrow$ possible paging
- try connection establishment if location information is cached in source satellite or along path of location query

Pros/Cons

- Location Registration/Update
  - Pro: Reduced number of location updates
  - Pro: Longer “live” for caching info
  - Cons: Exact position not known
  - Cons: Additional resources for caching
- Call delivery
  - Pro: Reduced connection setup delay
  - Cons: Added signalling for paging

Future Work

- Location Registration/Update
  - Simulation of algorithm with regard to:
    - Movement distance before update
    - Accuracy of satellite computation algorithm
- Call delivery
  - Evaluation of different schemes, e.g. hierarchical database location
  - Cost-Benefit analysis of described algorithm

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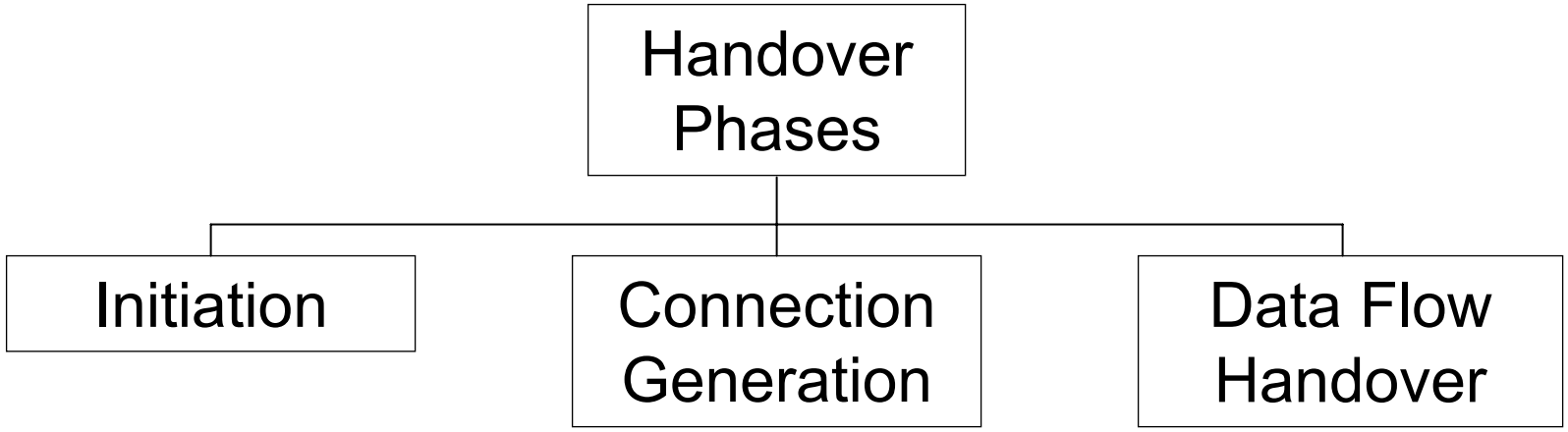
- **Handover Management Overview**
- Handover Management in LEO-ATM Systems

Process Description

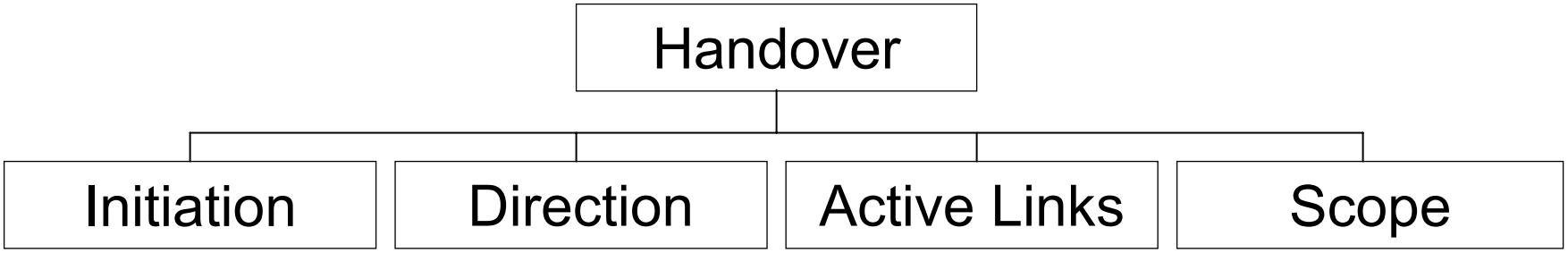


- Detection of handover condition
- Decision for handover execution

- Determine best path
- Establish path and allocate resources

- Switch to new path
- Ensure data integrity

Characterization



- Terminal
- Terminal with support from network
- Network

- Forward
- Backward

- Hard
- Soft

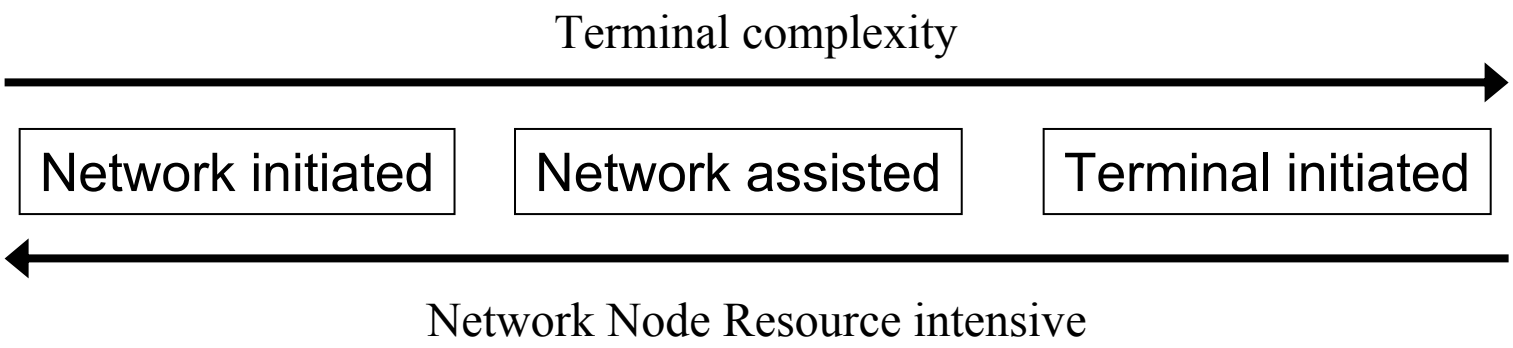
- Spotbeam
- Inter-Satellite
- Link (rerouting)

Requirements

- Ensure handover of all user connections
- Design algorithm to be scalable
- Resource consumption within acceptable limits
  - signalling load
  - satellite/terminal computation resources
- Guarantee QoS parameters during handover process
- Guarantee QoS parameters on new paths

Influence of Attributes (1)

- Initiation
  - Amount of network resources needed to begin handover
  - Complexity of handover node determination algorithm in terminal



Influence of Attributes (2)

- Active links
  - Both: Cell integrity must be maintained (cell loss, cell duplication, cell misordering)
  - Hard:
    - Simpler design of terminal
    - Delay and Delay variation parameters might be exceeded

      $\Rightarrow$ Intelligent Algorithms needed
  - Soft:
    - Complex terminals
    - Simpler to guarantee QoS during handover

Influence of Attributes (3)

- Direction
  - Effect depends on realization of active link attribute
  - With hard handover:
    - Forward handover introduces delay because link is interrupted till handover is completed
    - Backward handover shortens delay to actual connection switching
  - With soft handover
    - Without delay restriction, other factors like handover duration and complexity can be considered

Influence of Attributes (4)

- Scope
  - Spotbeam (Intra-Satellite) Handover:
    - Quite frequent (1 min) ⇒ simple algorithm is needed
    - Requests might be blocked because of missing radio resources
  - Inter-Satellite Handover
    - New path determination/creation involves higher layers ⇒ long delay possible
    - Connection switching ⇒ cell loss, duplication, misordering
  - Link Handover
    - Influence depends on network topology - satellite orbits, counter-rotating links, etc.

Handover Metrics

- Handover parameters to evaluate algorithm
  - Handover rate
  - Handover delay
  - Call and handover blocking probability
  - Handover probability
  - Duration of interruption
  - Handover failure probability
  - Probability of unnecessary handover

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- **Handover Management in LEO-ATM Systems**

General Statements

- Initialization of handover is terminal driven with network assistance
- Soft handover should be supported as well as forward and backward handover
- Spotbeam handover independent from network topology
- Network topology determines algorithm for Inter-Satellite and Link handover

Spotbeam handover

- Handover is executed at radio layer $\Rightarrow$ simpler, smaller delay
- Handover call blocking less desirable than new call blocking, can be reduced by:
  - Dynamic channel allocation
  - Handover queuing
  - Guard channels
  - Call admission control in radio (or higher) layer

Inter-Satellite Handover

- Long delay requires intelligent algorithms to keep track of QoS parameters
- Lossless handover algorithms (no cell loss, no cell duplication, no cell misordering):
  - Use of mechanism to mark end of data flow on old path, start of data flow on new path and to forward undelivered data
  - Use of mechanism to buffer and transmit data on the new path early to compensate for predictable delay

Routing Issues

- Topology depends on constellation and ISL configuration:
  - Permanent ISLs allow to have a network connectivity pattern that can be represented by a finite state machine
  - ISL between counter-rotating orbits introduce shorter paths and fast changing connectivity
- Static topology allows pre-computed routes
- Dynamic topology requires routing algorithms on satellites

Routing Algorithms

- Full connection re-routing
  - Computes optimal route at expense of signalling load and delay
- Route augmentation
  - Adds link to existing route: fast, but not optimized
- Partial connection re-routing
  - Cranks back existing route till node with best link to destination: Speed/Short path compromise
- Multicast connection re-routing
  - Maintains multiple routes to reduce delay

Future Work

- Simulation of spotbeam handover
  - Evaluate usefulness of additional algorithms to prevent blocking
  - Determine best parameters for this algorithms
- Evaluate mechanism to ensure fast, lossless handover in static networks
  - Comparision between different schemes
  - Correctness of pre-computed routes