Services and Applications

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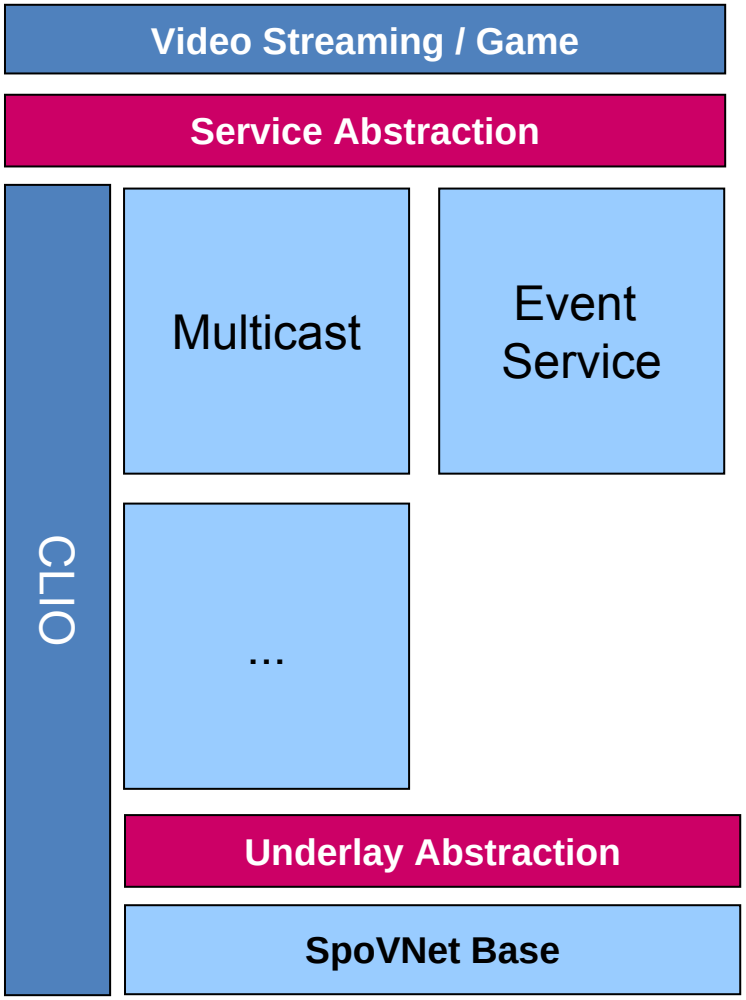
Background

- Characteristics of applications for the NGI
  - large number of cooperating users
  - interact with many heterogeneous devices
  - operate on heterogeneity of devices and networks
  - provide resources in time and on demand
  - robustness
- Services facilitate the deployment of application
  - provide inherent properties
    - scalability by decentralized organization
  - requirements negotiated via QoS
- Objective of SpoVNet: Services should help the development of NGI applications

Outline

How does SpoVNet address requirements of NGI applications?

- Introduce applications + services
- Demonstrate how services provided by SpoVNet match the application requirements
- Show how the SpoVNet architecture supports such services
- Conclusion



Overview: Applications in SpoVNet

- **Objective:** Selected two challenging applications with respect to NGI requirements
  - Game
    - real-time interactions
    - multi-user interactions
  - Video Streaming
    - Bandwidth, latency and jitter requirements
- General requirements
  - many to many communication
  - scalable organization
  - adaptive to dynamic set of users
  - adaptive to network conditions

Overview: Services in SpoVNet

- Two exemplary services
  - Multicast
    - group management
    - dissemination to all group members
  - Event service
    - selective event dissemination
    - correlation of events
- Characteristics addressed in SpoVNet
  - Application can specify requirements in terms of QoS
    - e.g. latency, bandwidth, …
    - data related quality
    - Security
  - Efficient adaptation
    - based on overlay organization and cross layer optimization
    - follows application requirements and network and device properties

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How does SpoVNet address requirements of NGI applications?

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- Show the value of SpoVNet's architecture in supporting such services
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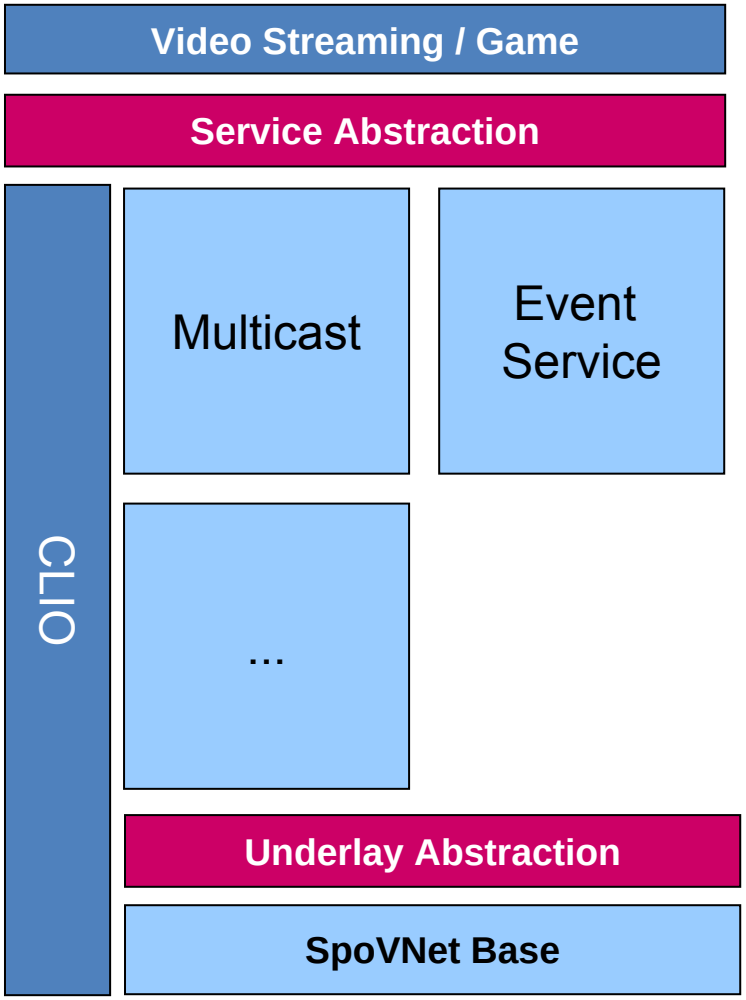
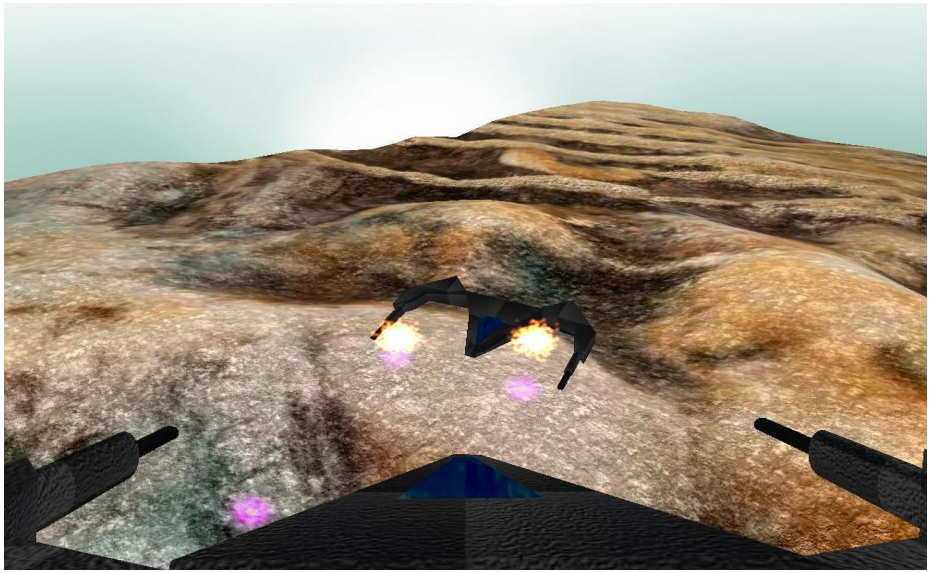


Multiplayer Online Game

Planet Π4:

- *Massively Multiplayer Online Game* (MMOG)
- highly demanding with respect to real-time capabilities
- Aproach: Peer-to-peer architecture

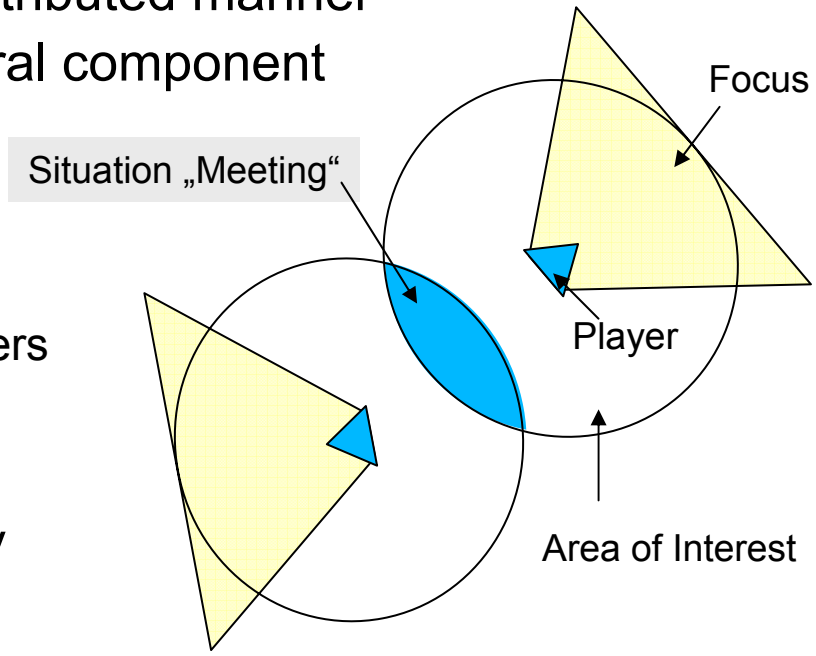


Supports

- Large number of players
- fast movement,
- collision detection of objects

MMOG Communication

- Peer-to-Peer architecture
  - Game state is managed in a distributed manner
  - Situation detection without central component
  - Low-latency communication
- Main Challenges
  - Responsiveness
    - Equal relative latency for all players
  - Consistency
    - Equal view for all players
  - Reliability, Security, Persistency
- Solution's required properties
  - Scalable for Massively Multiplayer Online Game
  - Capable of the Responsiveness-Consistency trade-off despite dynamicity

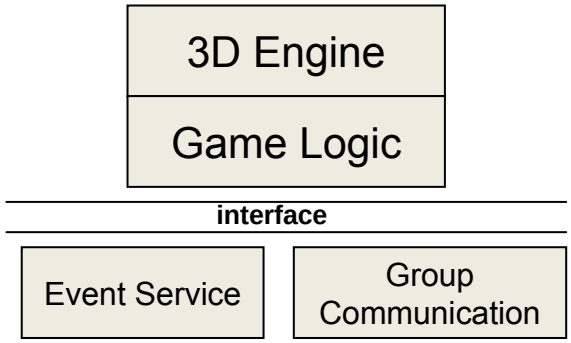


Multiplayer Online Game

Solution:

- Reduce communication to small groups, e.g. by Area of Interest (AoI)
- signal QoS requirements, e.g. responsiveness
- Use SpoVNet Services for group selection and group communication

Game architecture:



Group selection via the Event Service

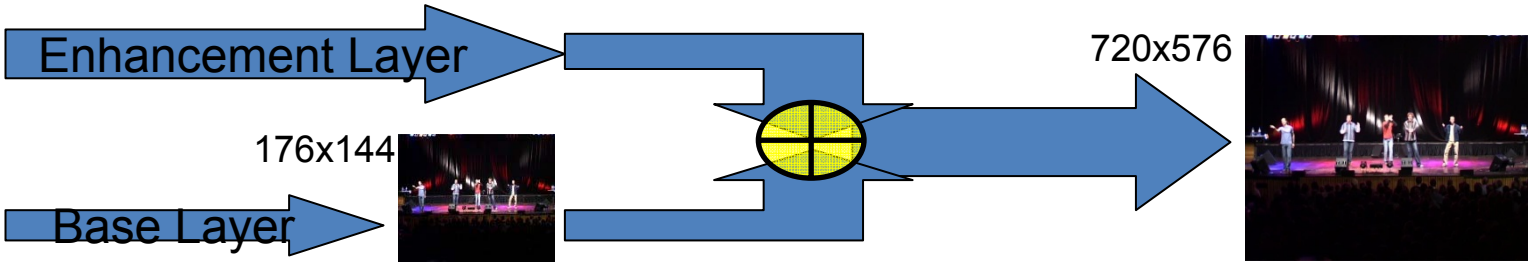
1. Define complex events
   - movements of avatars
   - meetings and departures
     - e.g. dist(x,y) <50 $\Rightarrow$ meeting
2. Subscribe to events of interest
   - e.g. players in my area of interest
3. Publish continuously game coordinates

Group Communication: MCPO

1. state exchange within an area of interest
2. Manage multicast group for an area of interest
   - responsiveness determines QoS requirements

Video Streaming

- Goal: Adaptive to the characteristics of end devices and to their network path.
- Approach:
  - Adapt the video in size (spatial), in framerate (temporal) and in quality (SignalNoiseRatio)
  - Based on the new H.264 Scalable Video Coding (SVC)
  - Adjustment of enhancement layers based on network and device properties.



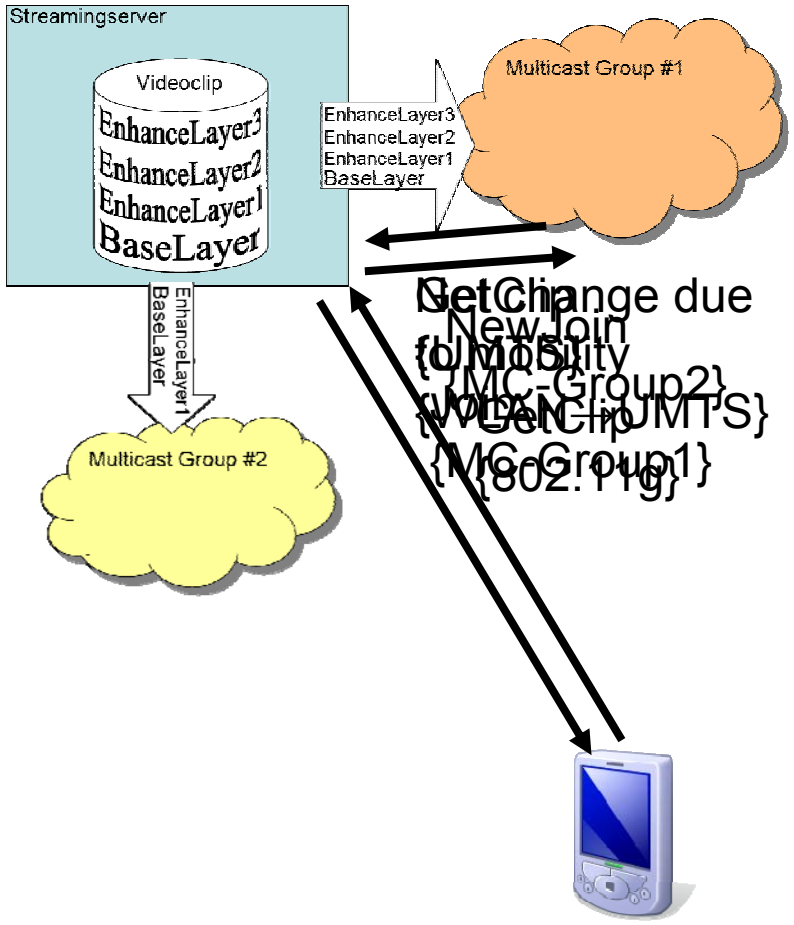
Adaptation of Video Streams

Two points to adapt the video stream:

- Server centric: Collect feedback
  - from the end device and
  - from its network path
- Along the path adaptation
  - performed by intelligent network device bridging fast and a slower network
  - adapt the stream if the packets use a hierarchical payload

Interactions withSpoVNET services

- Cross Layer Information (CLIO) determines
  - end device, its network connection, and its network path.
- Event Service
  - aggregation and delivery of information along the network path.
- Multicast Overlay (MCP-O)
  - delivers the resulting video stream to multiple end devices.



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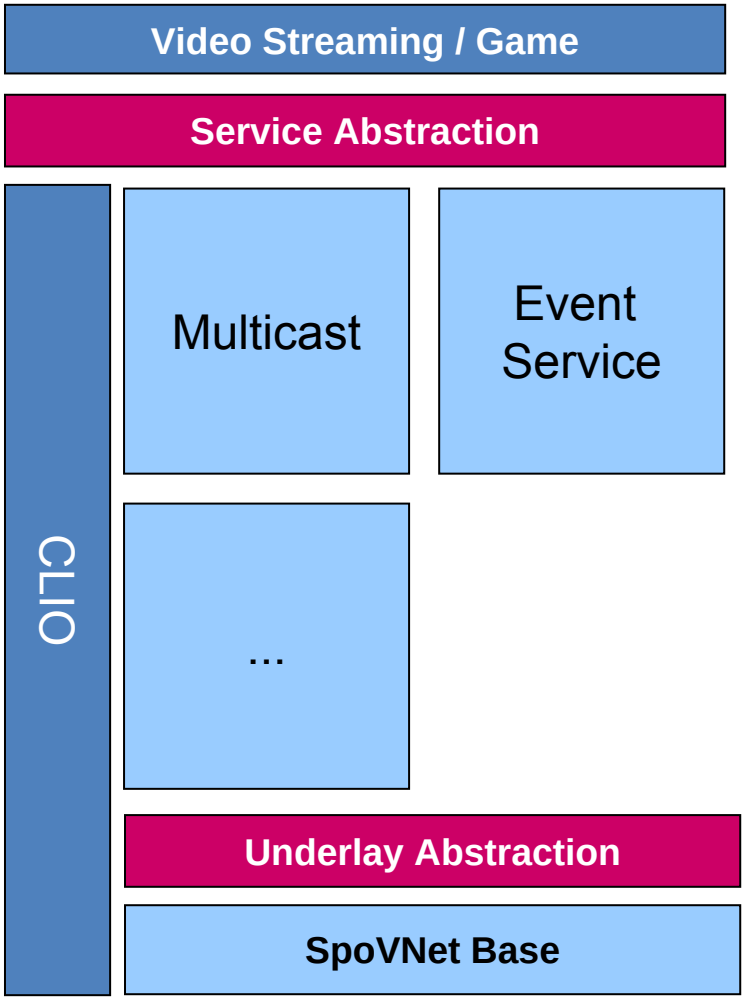
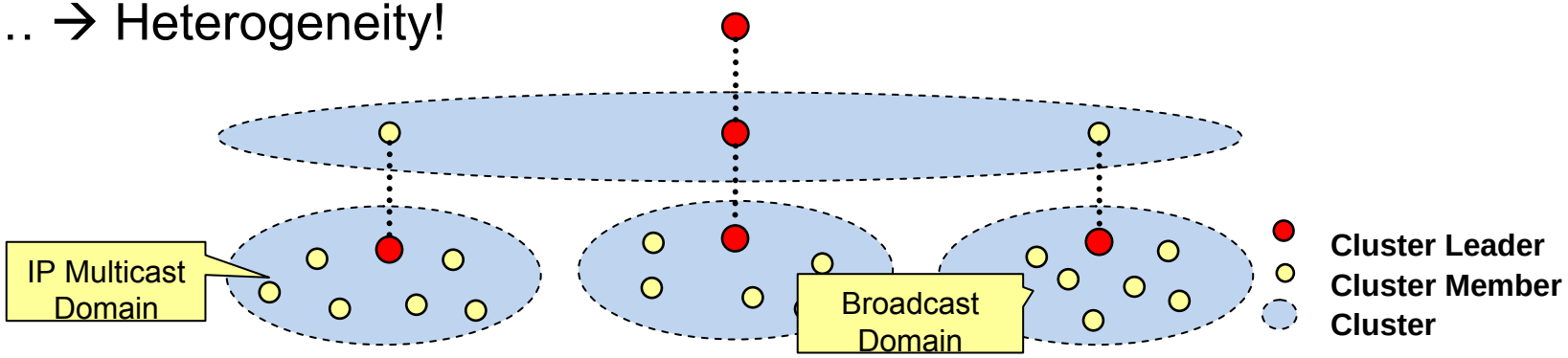


MCP-O: QoS-Enabled Multicast

- Achieve scalability through hierarchical clustering
  → (Limit protocol overhead)
- Logical structure determines data dissemination
- Use Service Metric to affect building of structure:

$$d : K \times K \rightarrow \mathbb{R}_{\geq 0}$$
$$d : (x, y) \mapsto \sum_i a_i f_i(x, y)$$

- Weights a_i determined through application requirements
- $f_i(x,y)$ e.g. latency, same WiFi domain, same IP Multicast domain, … → Heterogeneity!



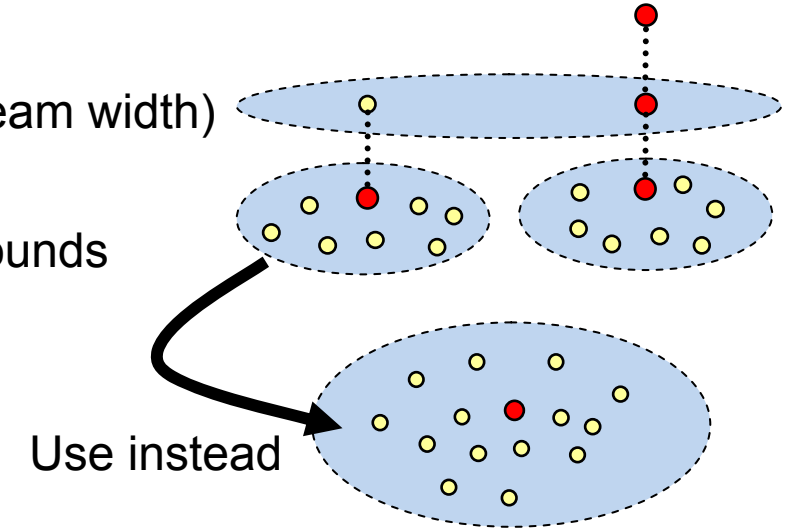
Adaptivity of MCP-O Hierarchy

- Hierarchical approach not always the best choice
  - Good scalability, but cutting back e.g. latencies 😐
- Example: Latency-sensitive app with few members
  1. Application describes ist demands and data stream width (Priority on Latency)
  2. CLIO provides upstream bandwidth per member
  3. Adapt cluster size K

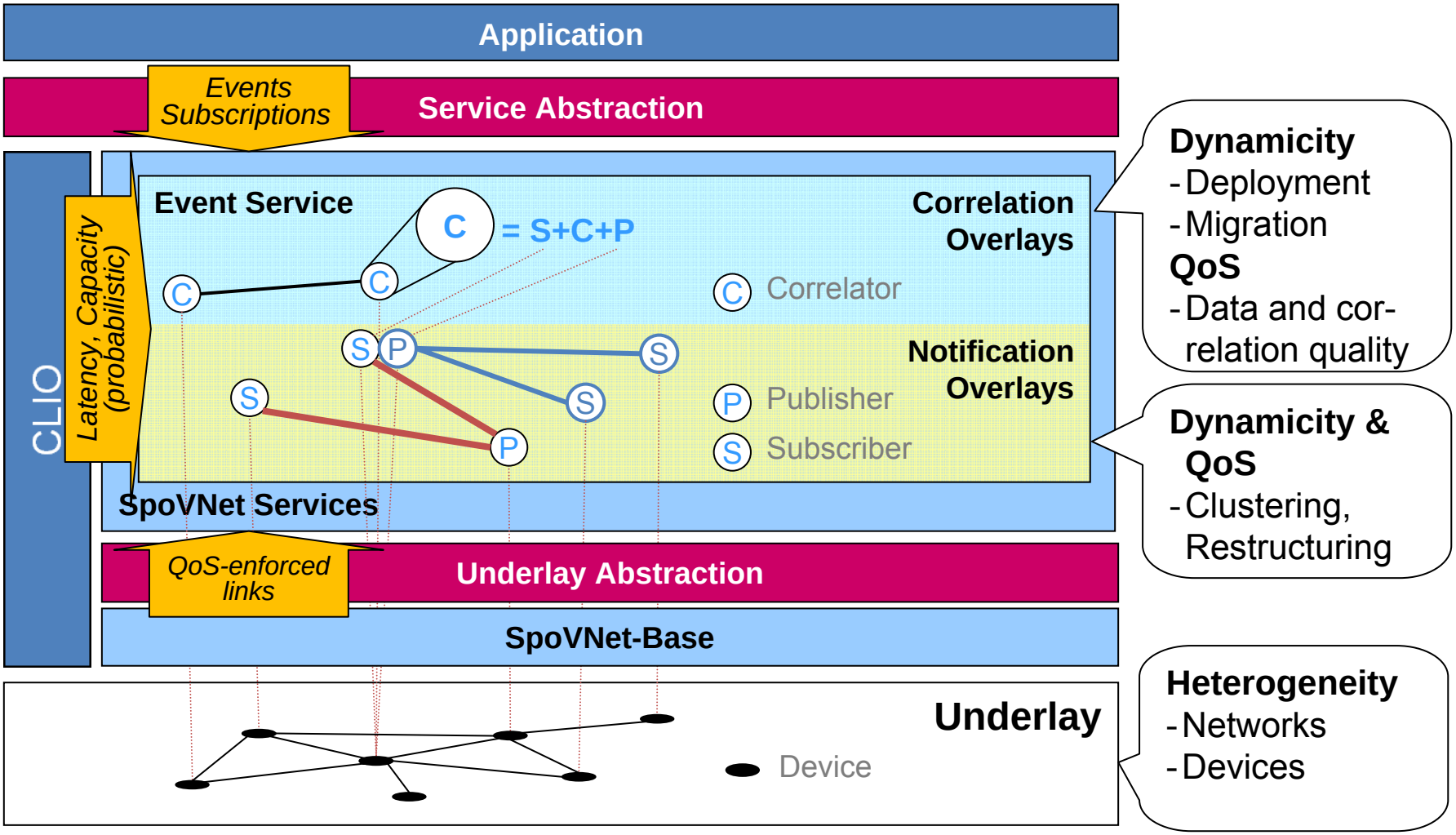
→ K = (lowest current upstream) / (data stream width)

Unicast brings best achievable latency,

protocol decides reasonable overhead in bounds

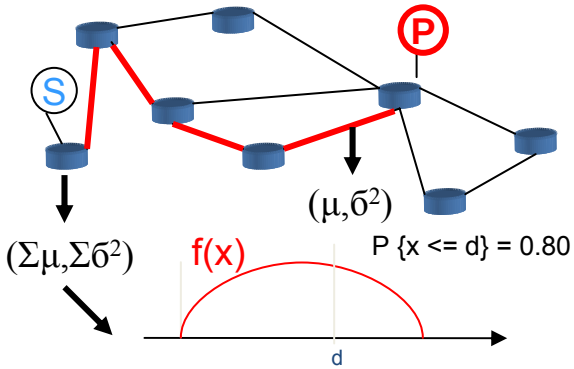


Event Service

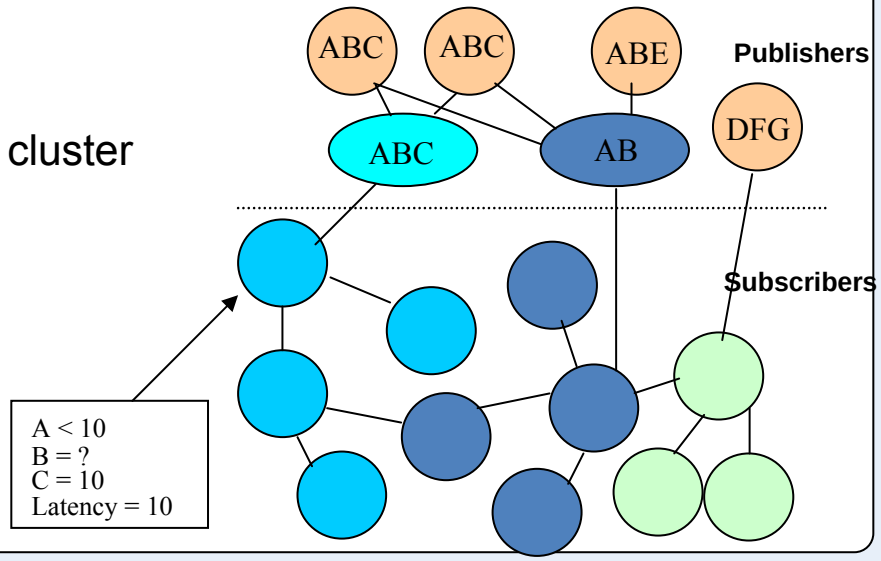


Event Notification

- Publish/Subscribe paradigm
  - Publication is a named set of attributes e.g. {A,B,C}
  - Subscription is a filter e.g. {A = 10 ^ B = 5}
- QoS metrics
  - Latency : probabilistic promises
  - Capacity: max amount of data/time that a node can forward
- Hybrid approach
  - Interest based subscriber clustering
  - Content-based forwarding within each cluster
- Overlay adaptation
  - Publisher centric
    - Partitioning of event space
  - Subscription centric
    - Fulfilment of QoS requirements.



Probability distribution of end-to-end path delay



Conclusions

- SpoVNet provides an extensible set of services
  - facilitate the deployment and development of applications
- Services match many requirements of NGI applications
  - scalability
  - support for QoS
  - effective adaptation
- SpoVNet architecture of value for the integration of services
  - Some services may become part of the NGI
    - Seamless transition of services
  - When possible services use reservation protocols
  - Otherwise QoS typically reflects what is currently possible

Questions