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SDN-based Application-Aware Networking on the Example of YouTube Video Streaming

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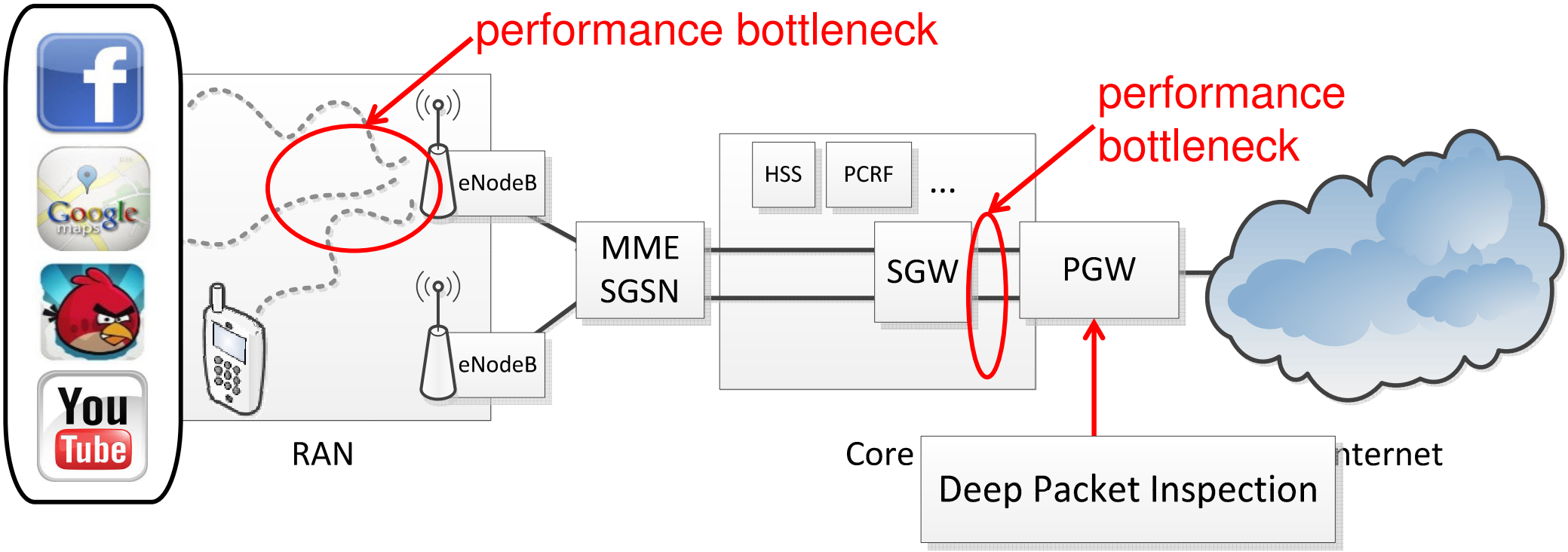
The Challenge in Traffic Detection



- **Deep Packet Inspection (DPI)** used to solve congestion problems
- Unsolved problems:
  - DPI identifies protocols only. (Everything is HTTP!)
  - DPI does not know the current network state (when is resource management necessary?)
  - DPI does not specify how to react

Beyond Pure DPI – Knowing the Application State

- Concurrent applications compete for scarce (wireless) resources
  - Heterogeneous traffic mix, different applications
  - Large number of devices

➔ sophisticated traffic detection to enhance resource allocation (scheduling) or resource management

- Simple classification based on protocols is not enough
  - Applications adapt to network resources, e.g., DASH, Skype,…

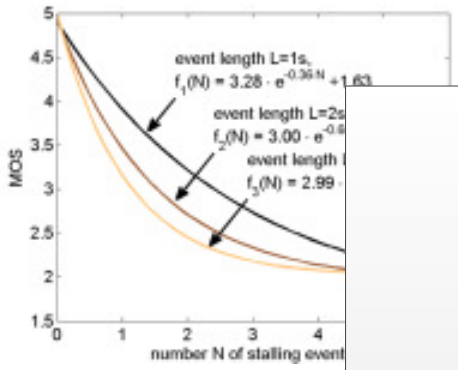
- Application-centric resource management required (QoE fair share)
  - relationship between QoS and application behavior
  - relationship between application and user-perceived QoE

➔ Estimation of the current **application state**

Measuring Unit for Determining the Application State

- Application Model
  - →defines key quality indicators
    - E.g. packet loss for live streaming
    - buffer-level for progressive streaming

Possibly a new network function? (→ NVF)



DPI

Application State Analysis

Client / application feedback

Information sources:
- DPI for detecting type of application
- Network situation
  - → current bandwidth
  - → maximum bandwidth
  - → SNR/PSNR,…

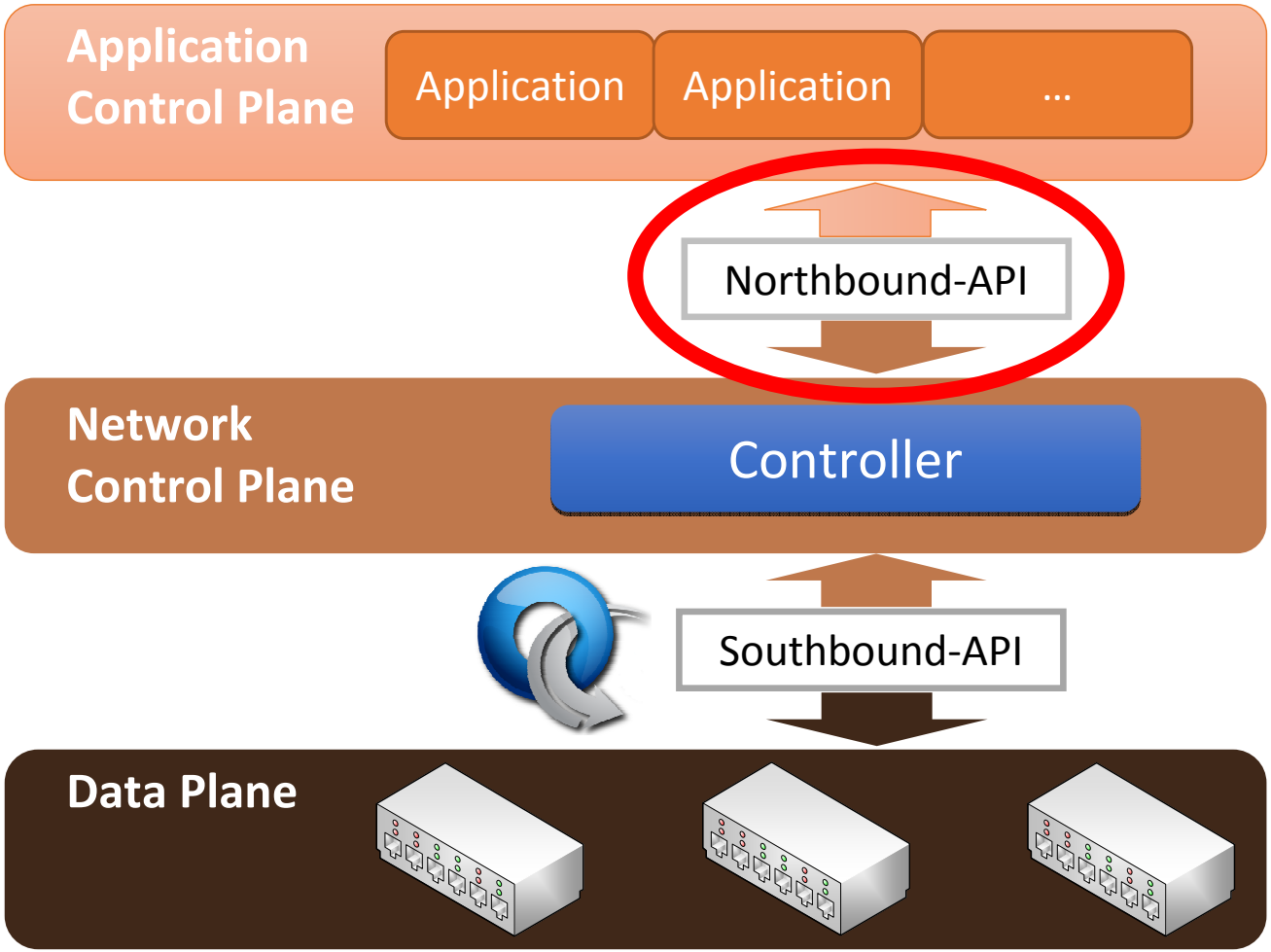
Static information:
- provider prefrences ?
- user preferences ?
- AAA data

application state metric

Implementation of application awareness functions within an SDN-enabled network

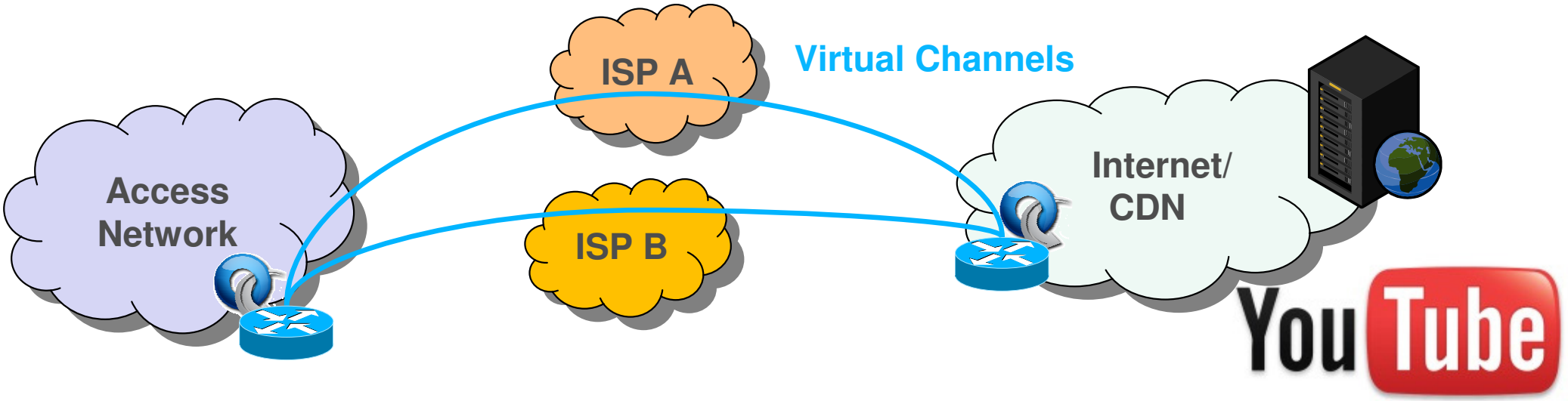
APPLICATION-AWARENESS AND SDN

SDN-enabled Application-Aware Networking



▶Use application state information to optimize the user experience and resource management

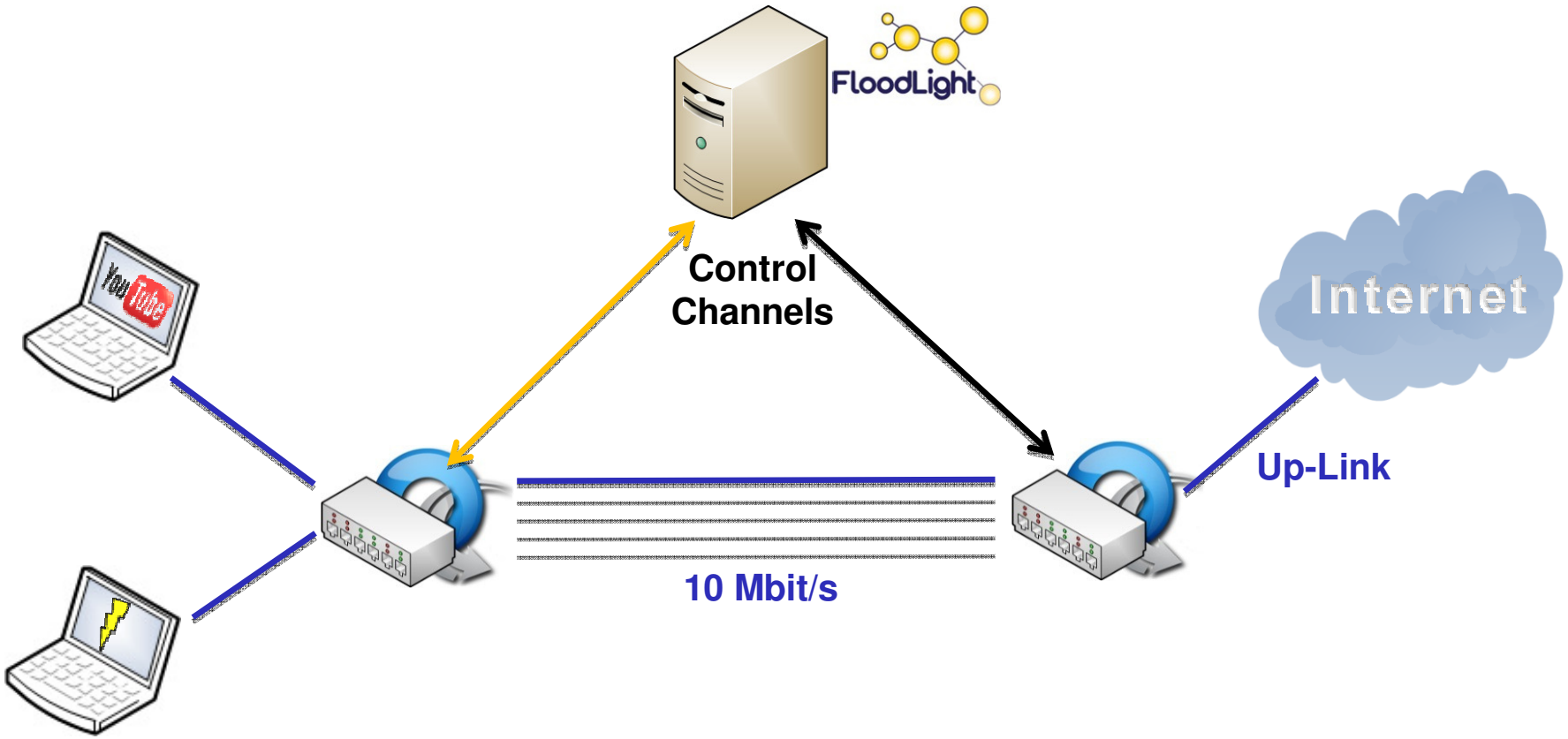
Scenario



- Simplified scenario to study benefits of SDN and application awareness
- Leveraging SDN for network resource management
- Dynamic shift of application flows between available channels to enhance quality of critical applications
- Specific Example: Concurrent download and YouTube flows
  ➔ Maintaining a good YouTube quality

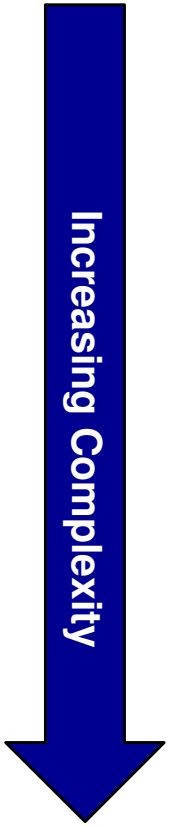
Reference Testbed

- Controller running “switch” application
  → only one link between the two OpenFlow switches usable
- Maximum throughput: 10 Mbit/s



Resource Management Approaches

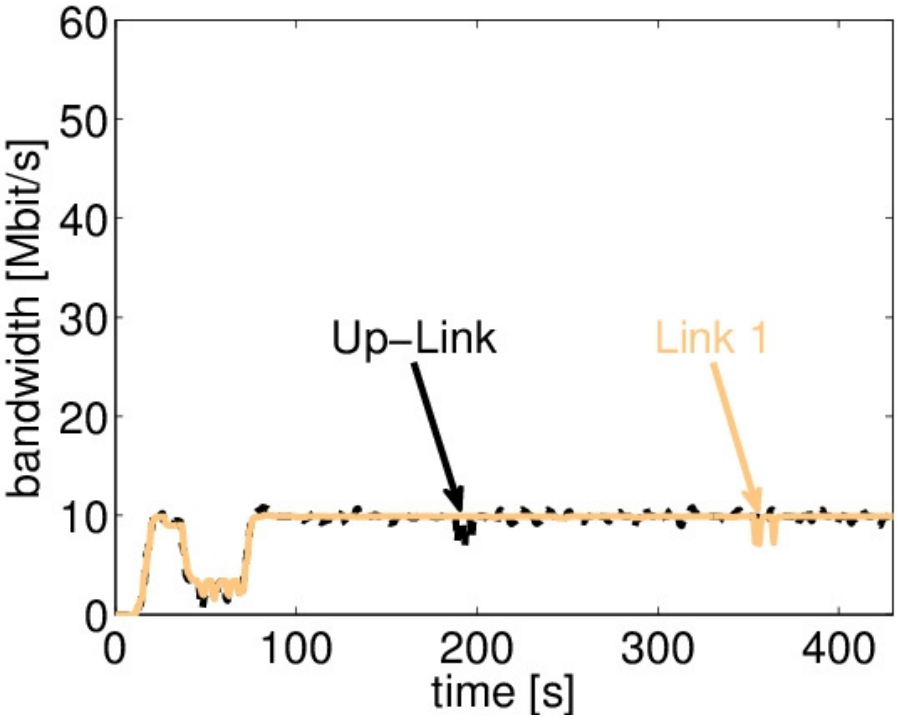
Method	Required Information	Source of Information
Network information-based	Used bandwidth of flows	OpenFlow statistics
DPI	Type of traffic/application	DPI software
Application awareness	DPI and flow information	Application Analysis Entity

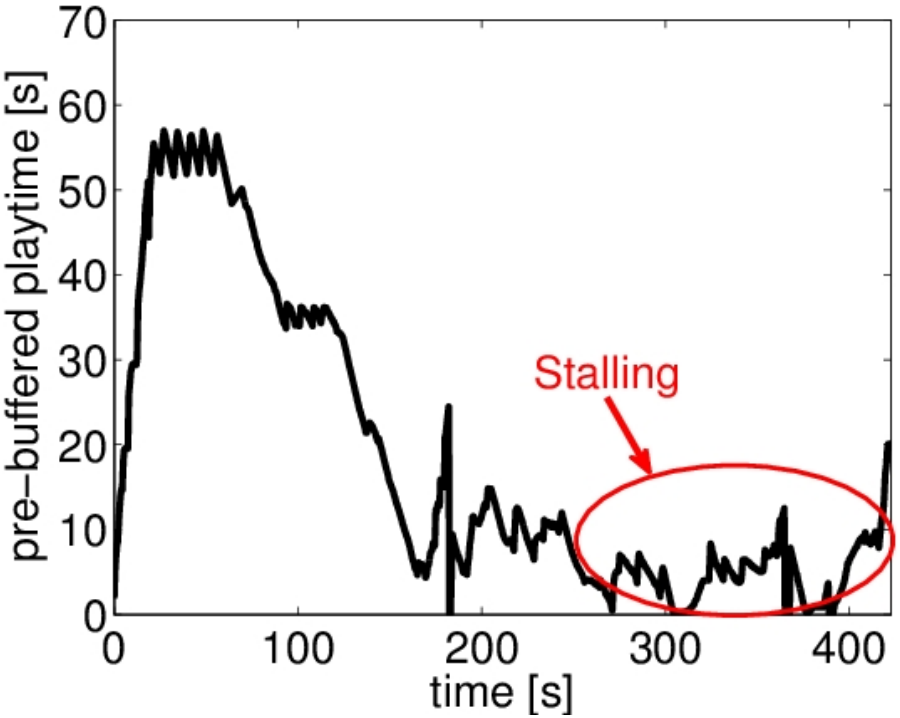


Experiment Procedure

- 0s: Begin of experiment; YouTube video is started
- 60s: Start of interfering traffic
- Iperf-generated TCP flows are used as interfering traffic
- 60s+x: Interfering traffic flows start with a 1s interval
- 420s: End of experiment

Reference Case with 5 TCP Flows

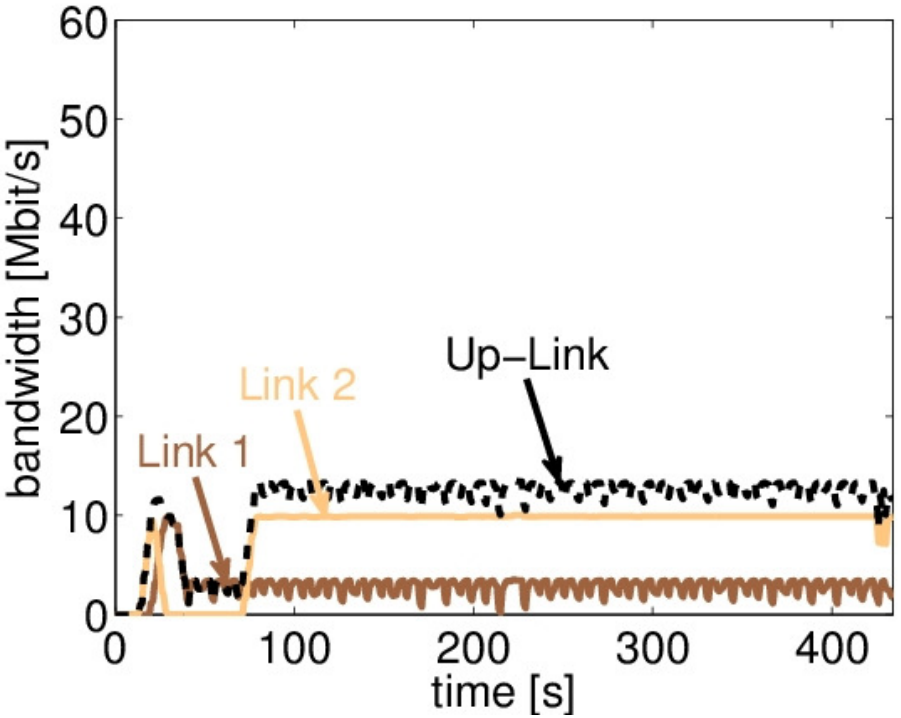


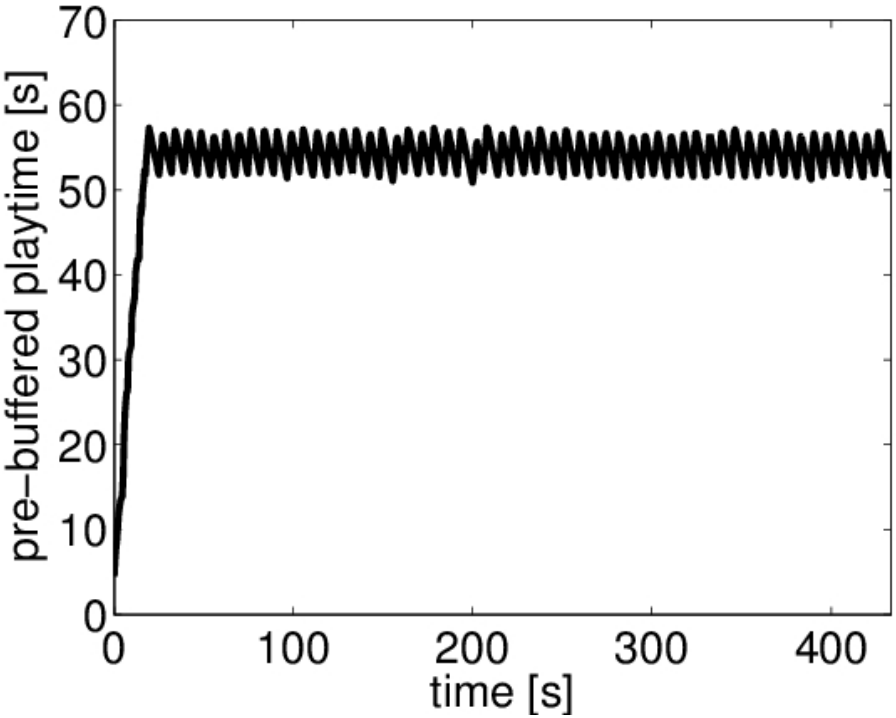


- Maximum throughput of 10 Mbit/s
- The YouTube flows do not have sufficient bandwidth available

➔ Stalling can not be prevented

Deep Packet Inspection - 50 TCP-Flows

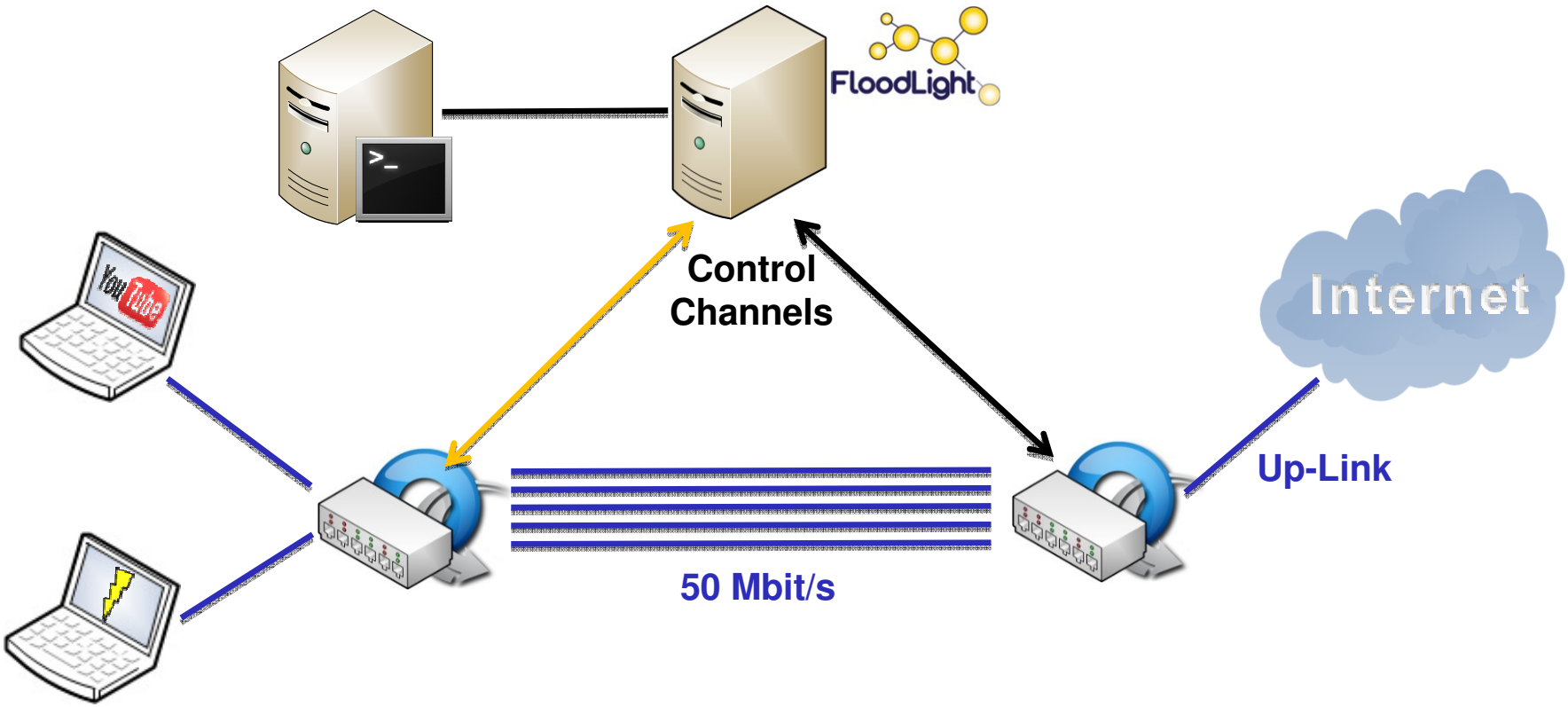




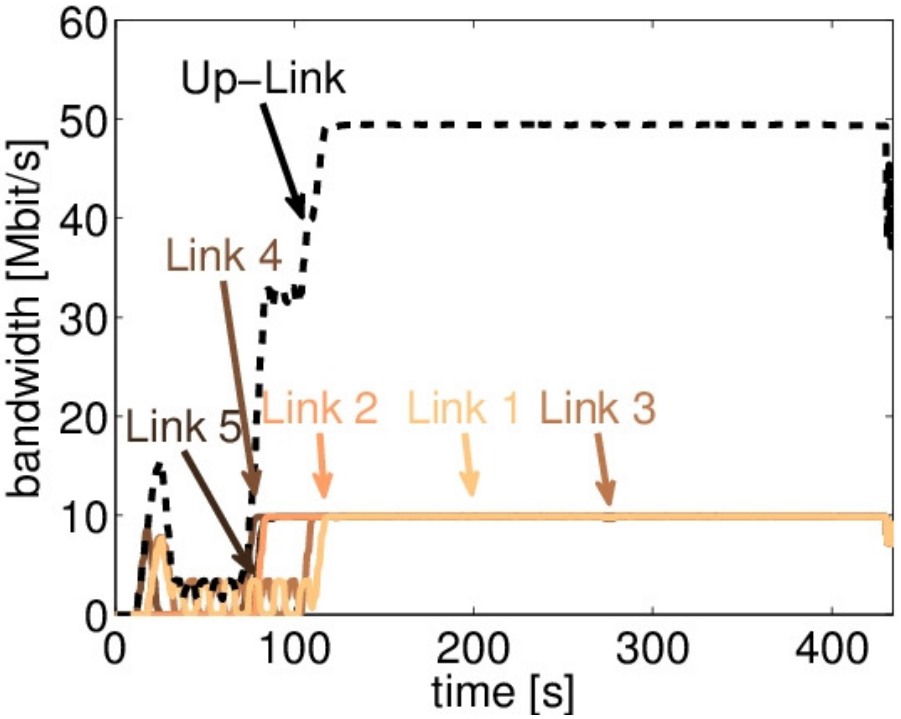
- Classification of flows in five priority levels
- Reservation of a dedicated link according to the priority levels
- No Stalling if one YouTube video is in the network
- Problem: multi-application case
  - Waste of bandwidth (other traffic is heavily throttled)
  - What to do if more than one YouTube video is in the network?

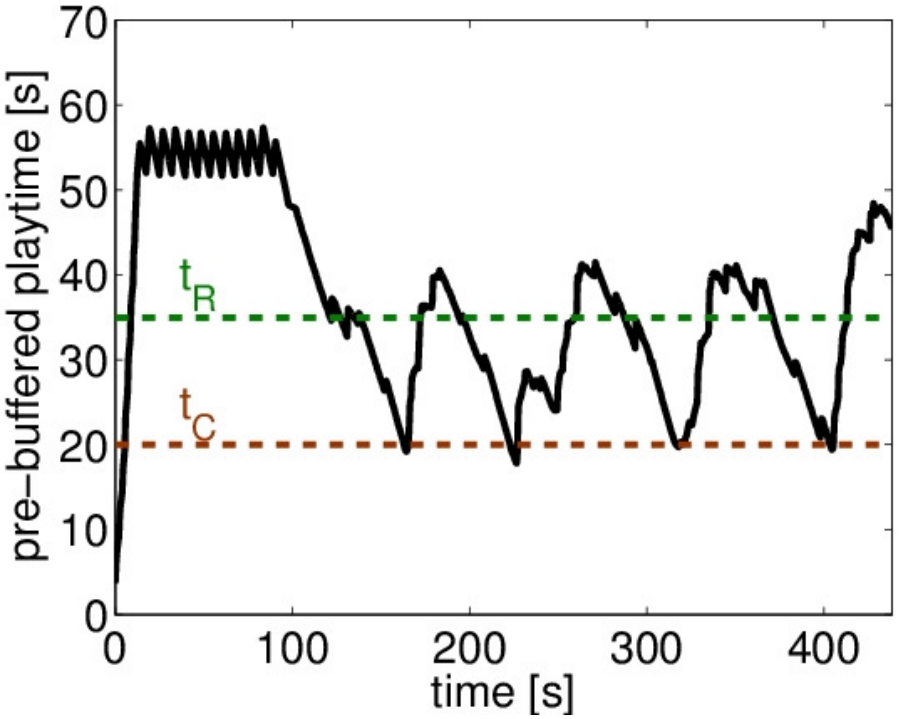
Using Application State

- Application analysis entity notifies the controller about application traffic
- Algorithm:
  - Classification of the flows into different priority classes
  - The highest flow priority on a link determines the allowed number of flows



Application-Aware Allocation with 50 TCP-Flows

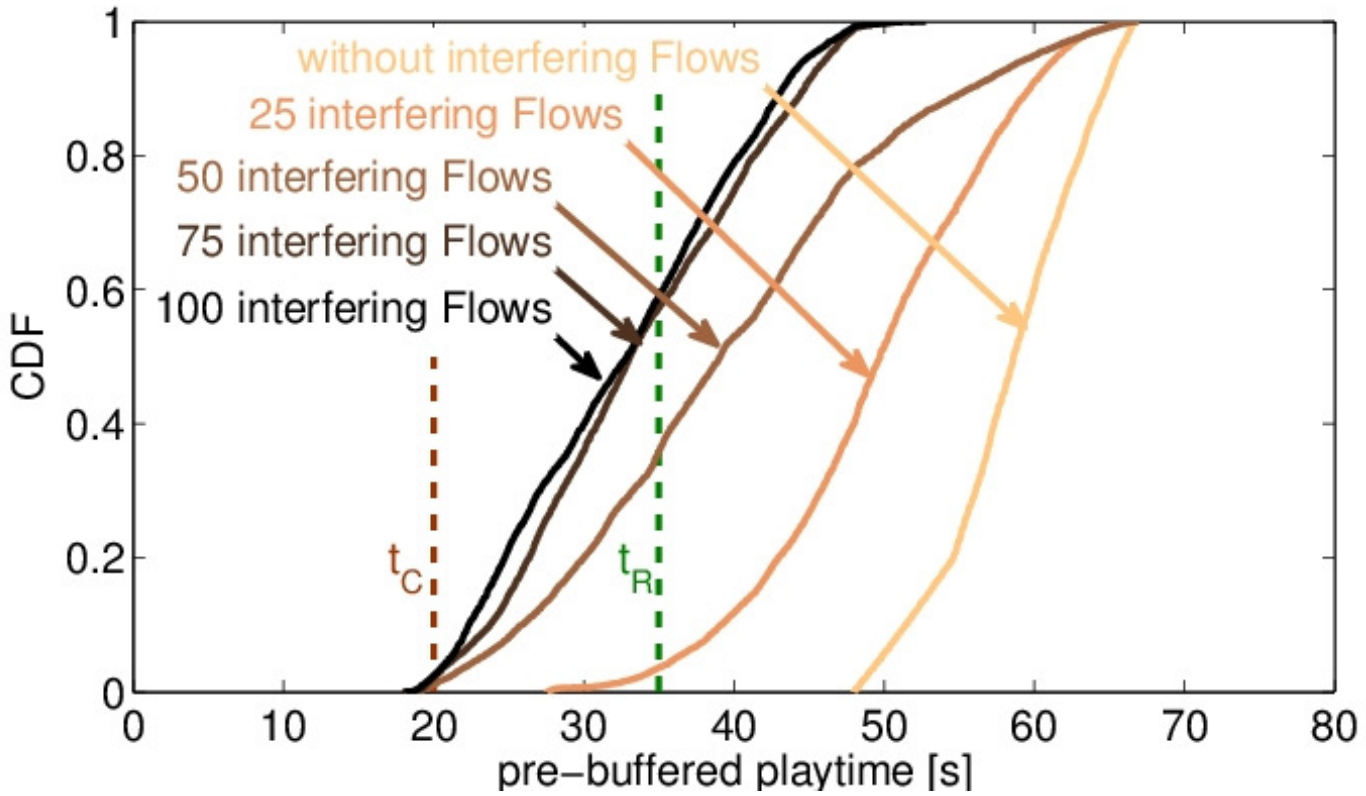




- The maximum possible throughput is reached
- Critical threshold t_C at 20 s pre-buffered playtime
- Regular threshold t_R at 35 s pre-buffered playtime
- Shift of interfering flows, if the buffer falls below the threshold

➔ No stalling of the YouTube video

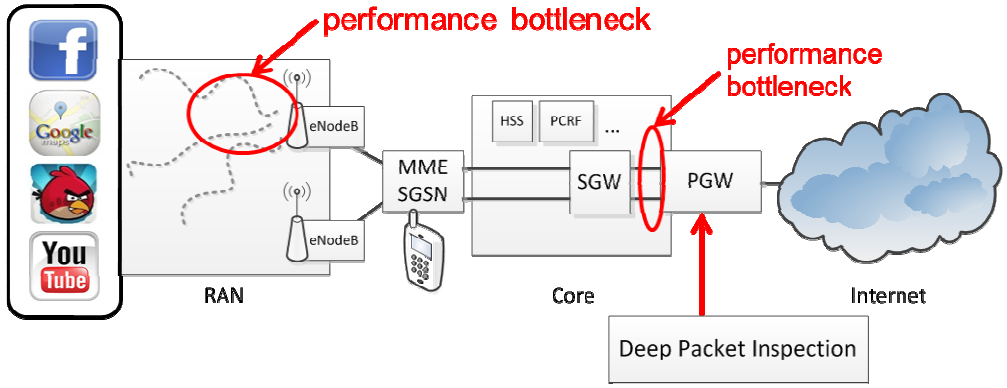
Efficiency of the Application-Awareness Approach



- Without interfering traffic the typical YouTube behavior is observed
- With 25 TCP flows an influence is visible
- With 50 TCP flows an intervention of the scheduler is necessary
- For 75 and 100 interfering TCP flows a similar behavior is visible

➔ Pre-buffered playtime can be maintained

Possible Application Scenarios for SDN



- SDN in Access?
  - Flow based network control required?
  - Open interfaces required to adjust control plane?

} rather not necessary…

- SDN in Mobile Core?
  - Flexible modifications of control plane required? (with NFV)?
  - Prospectives for a resource management on flow aggregates?

- Additional application cases for SDN in cellular networks?

Open Research Questions

- Ongoing work.
- We linked a useful but complex DPI (application awareness) with a SDN-enabled network

- What else can I achieve with SDN?
- Are there some limits for SDN? (mobile network, complexity, operator issues, security, trade-off between benefit and effort)

- Where can I efficiently use application awareness? (performance bottlenecks in the mobile network! Scheduling? Core Network?)

- And how can I bring together both worlds?
- When does it make sense to use SDN and application awareness within a mobile network?

Conclusion

- Improved traffic detection to estimate application state
  - dynamic applications, adaptive applications)
  - separation of DPI and application analysis
- Implementation for a SDN-enabled network
- Application-aware approach outperforms conventional mechanisms in terms of QoE
- Future Work:
  - Trade-offs between multiple critical applications
  - Other QoS management mechanisms, e.g. OF 1.3 flow meters
  - More types and sources of application (state) information
  - Identification of a suitable standard Northbound-API realization

Questions and Comments ?