ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
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mmlab
Mobile Multimedia Laboratory

"QoS-Driven Multipath Routing for On-demand Video Streaming in a Publish-Subscribe Internet"

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- Path Formation Algorithms
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- Evaluation
  - QoS quantification
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Introduction

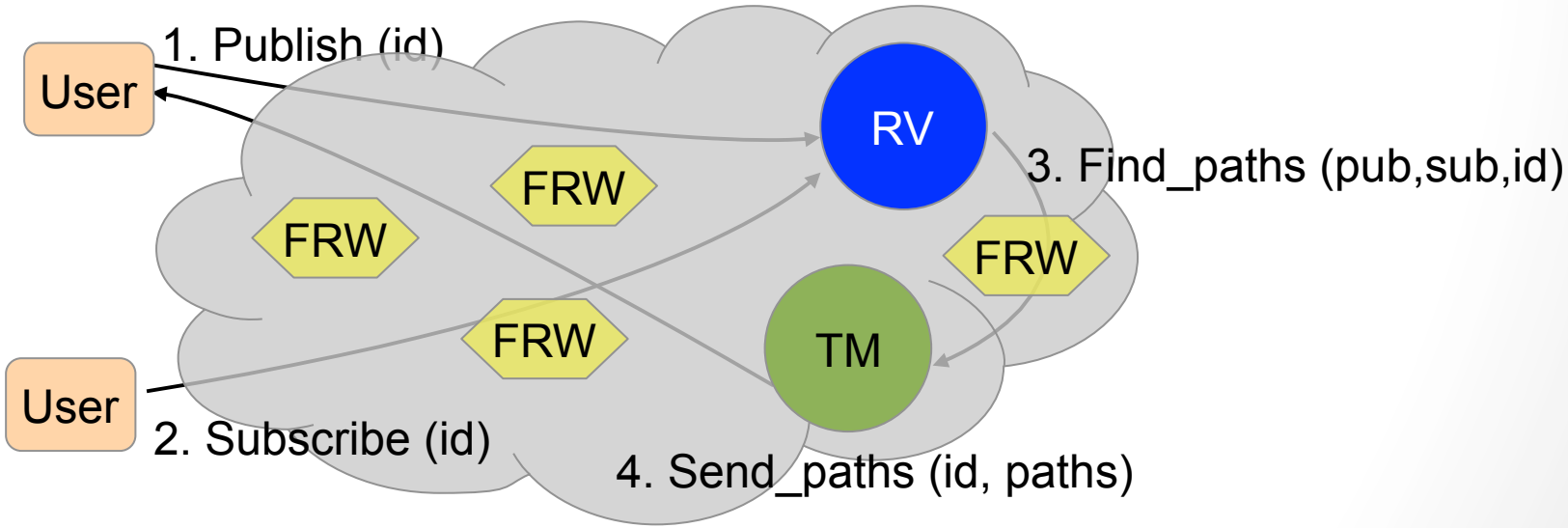
- Video traffic is dominating (80% of user traffic)
  - HD content anywhere, anytime and on any device
- Looking for efficient delivery techniques on both network and application-level
- Multipath communications is a well investigated solution
  - Increase throughput
  - Enhance resilience to failures
  - Provide better load balancing
- Multipath is not well supported in IP networks

Publish-Subscribe Internet (PSI)

- Clean-slate Information-Centric Network architecture
- All network operation relies upon content it-self and the pub/sub paradigm
- Separated network functionalities
  - Rendezvous
  - Topology Management
  - Forwarding
- Supports native
  - Caching, multicast, multisource/path among others

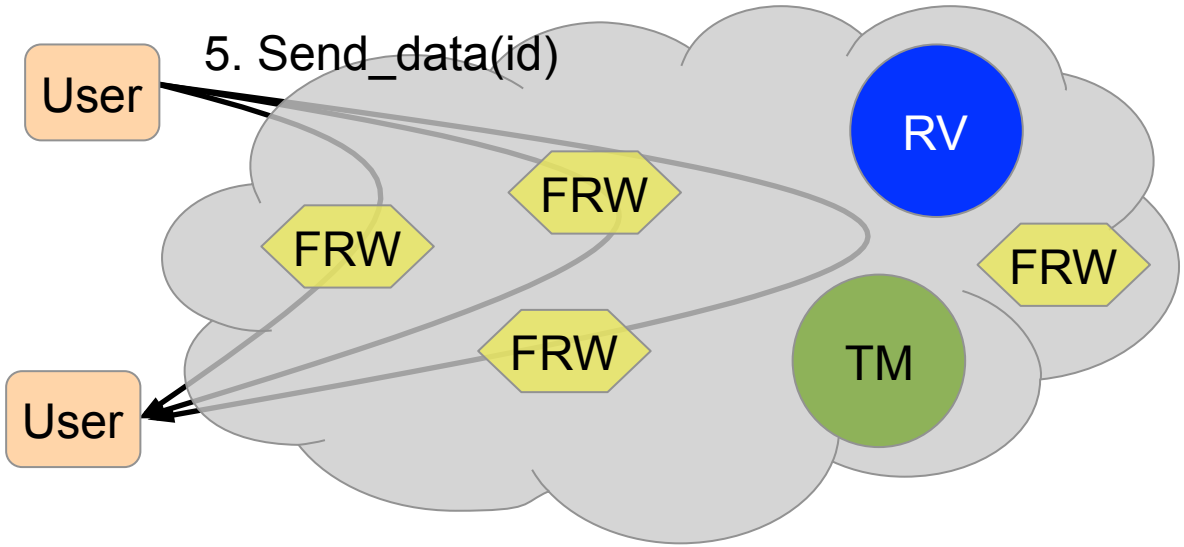
PSI: Network Operation

- Network undertakes content discovery via RV and path formation via TM and delivery via FRW
- TM is aware of network topology and state
  - Finds the “best” dissemination paths
  - Applies traffic engineering techniques



PSI: Network Operation

- Network undertakes content discovery via RV and path formation via TM and delivery via FRW
- FRWs implement bloom filter forwarding
  - Source routing across the entire network
  - Apply the transfer pattern (multisource/path etc) directed by TM



Path Formation Algorithms

- Single-Constrained Path problem (SCP)
  - Dijkstra's shortest path, Yen's *k*-shortest paths
- Multi-Constrained Path algorithms (MCP)
  - Self-Adaptive Multiple Constraint Routing Algorithm (SAMCRA)
  - link-DIsjoint Multiple Constraints Routing Algorithm (DIMCRA)
- Hybrid algorithms
  - Wang and Crowcroft shortest-widest path algorithm

	Finds feasible path (correctness)	
	YES	**NO**
Single-path	Wang, Dijkstra, Yen, SAMCRA	-
Multipath	-	DIMCRA

Bandwidth-, Error-rate- and number-of-Paths-constrained MultiPath (BEPMP)

- **Multipath** formation algorithm that operates under **three** constraints
  - Bandwidth: the "sum" of all paths' capacities - Additive metric
  - Error-rate: the maximum error-rate among all paths – Convex metric
  - Number of utilized paths: maximum number of paths that provide the required BW and error-rate
- Number of utilized paths
  - increases complexity during path computation
  - increases complexity during data distribution among the paths
  - After a certain point does not provide significant BW aggregation but is expected to increase the service error-rate

BEPMP operation

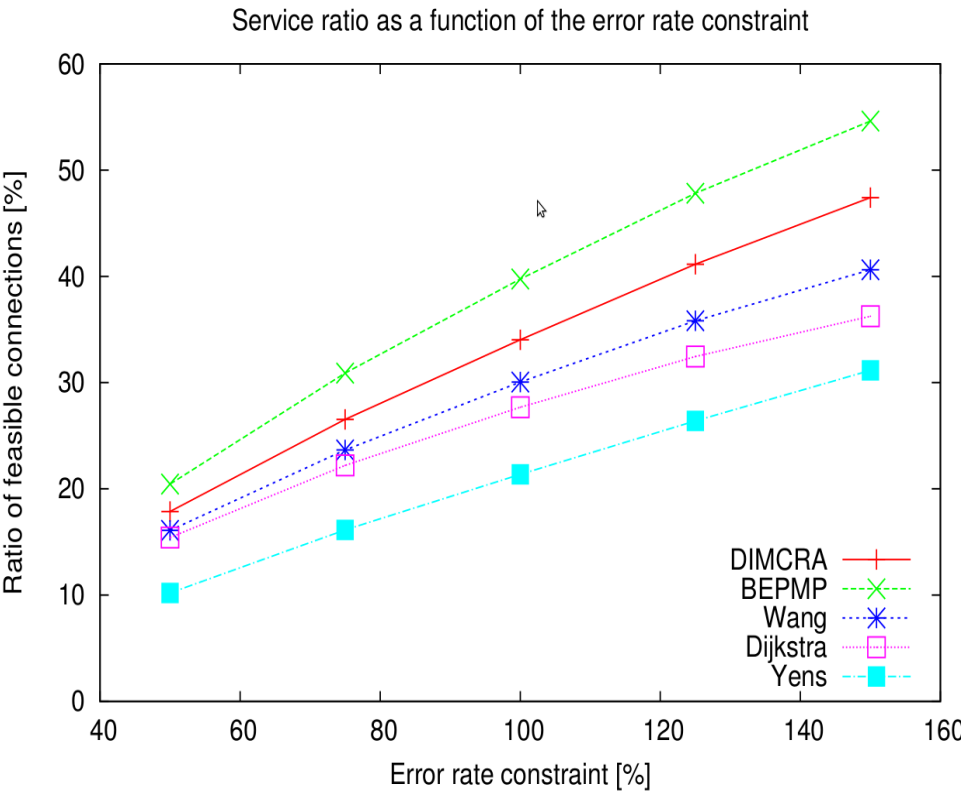
- Step 1
  - Run Yen's to find all paths that satisfy the error-rate constraint
- Step 2
  - Sort paths from the most wide to the least
- Step 3
  - Run Widest Augmenting Path (WAP) algorithm, until
    - the network flow calculated covers the bandwidth constraint, or
    - the number of paths added exceeds our requirement
- BEPMP is not optimal
- BEPMP is correct
  - given that Yen's algorithm is configured with *k* high enough

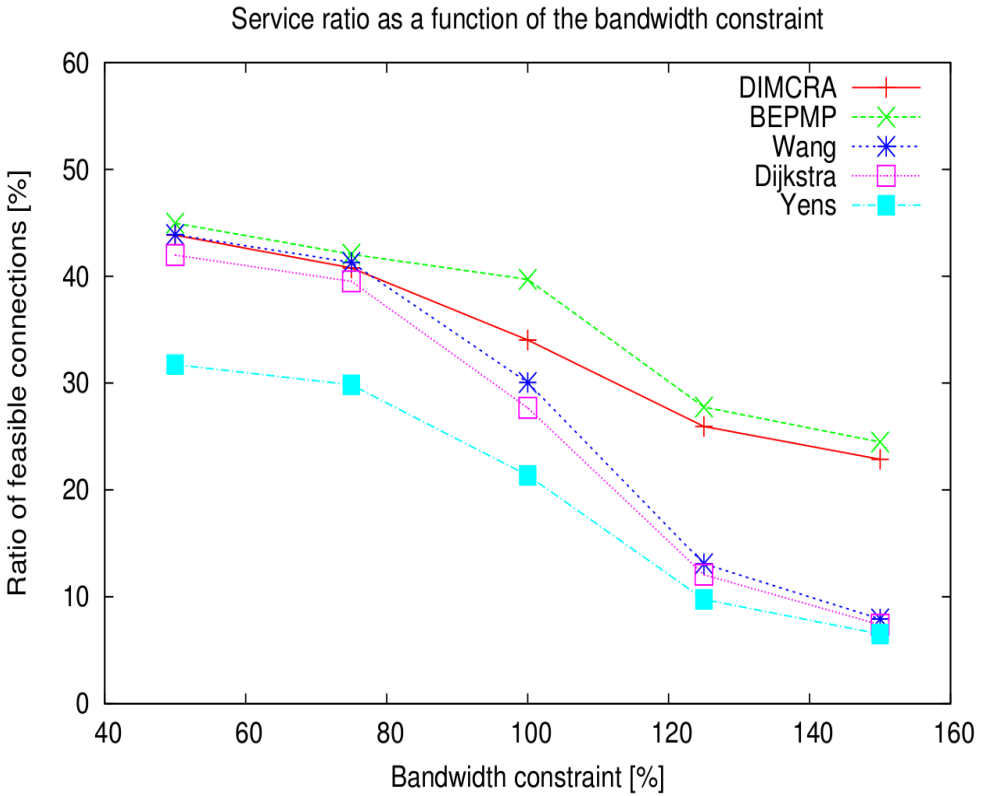
Evaluation

- We have built BEPMP, DIMCRA, Dijkstra, Wang's and Yen's algorithms into the PSI TM.
- Topologies
  - 20 randomly selected real AS topologies with actual link capacities
  - Zipf distribution of link error rates
  - Network congestion via random competitive traffic
- 100 runs of each topology with different error-rates and congestion
- At each run TM computed all the available dissemination paths among all pairs of edge-nodes using all algorithms

QoS Assesment

- $service\ ratio = \frac{\text{feasible path computations}}{\text{all path computations}}$
- Reflects the effectiveness of algorithm

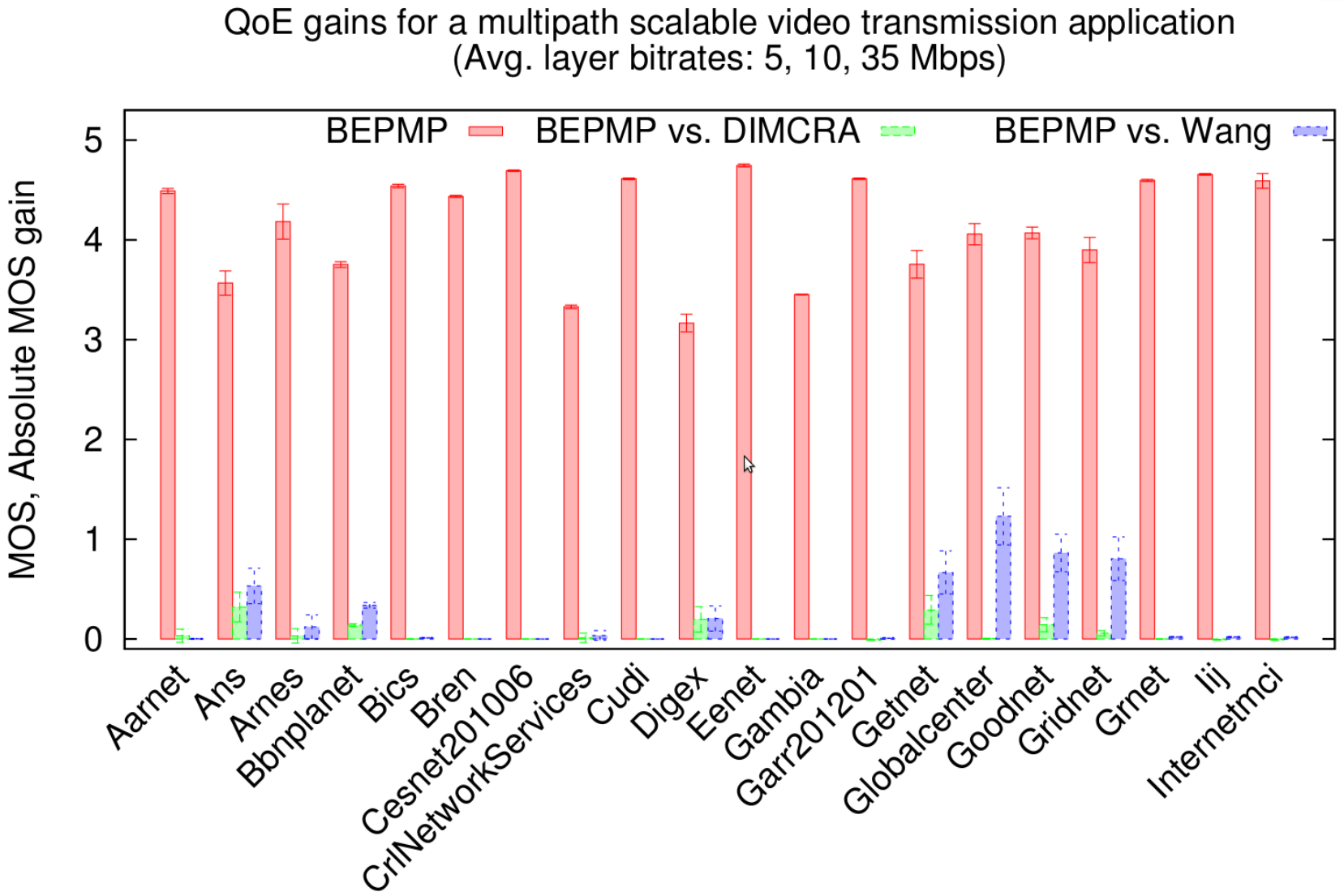




QoE Assessment

- Application
  - a video-on-demand streaming
  - H.264/SVC [4] encoding technology
  - 3 video layers send upon the discovered paths
- QoE quantification
  - Trained a Random Neural Network (RNN) on subjective tests under controlled conditions
    - Measuring conditions and user rating
  - The trained RNN classifier outputs the expected mean opinion score (MOS) given the input parameters
    - Service BW and error-rate

QoE gains


QoE gains for a multipath scalable video transmission application
(Avg. layer bitrates: 5, 10, 35 Mbps)
BEPMP
BEPMP vs. DIMCRA
BEPMP vs. Wang
MOS, Absolute MOS gain
0
1
2
3
4
5
Aarnet
Ans
Arnes
Bbnplanet
Bics
Bren
Cesnet201006
CrlNetworkServices
Cudi
Digex
Eenet
Gambia
Garr201201
Getnet
Globalcenter
Goodnet
Gridnet
Grnet
Iij
Internetmci

Thank you!