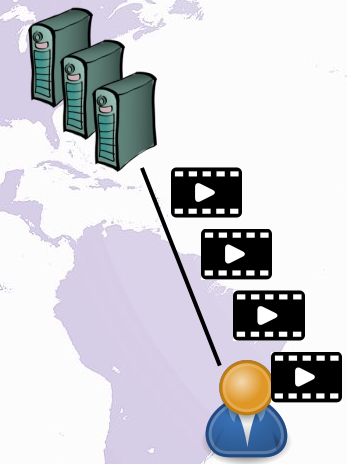
AERO: Adaptive Emergency Request Optimization in CDN-P2P Live Streaming

João F. A. Oliveira, **Ítalo Cunha**, Eliseu Miguel, Sérgio V. A. Campos

UFMG

CDN streaming

CDN streaming



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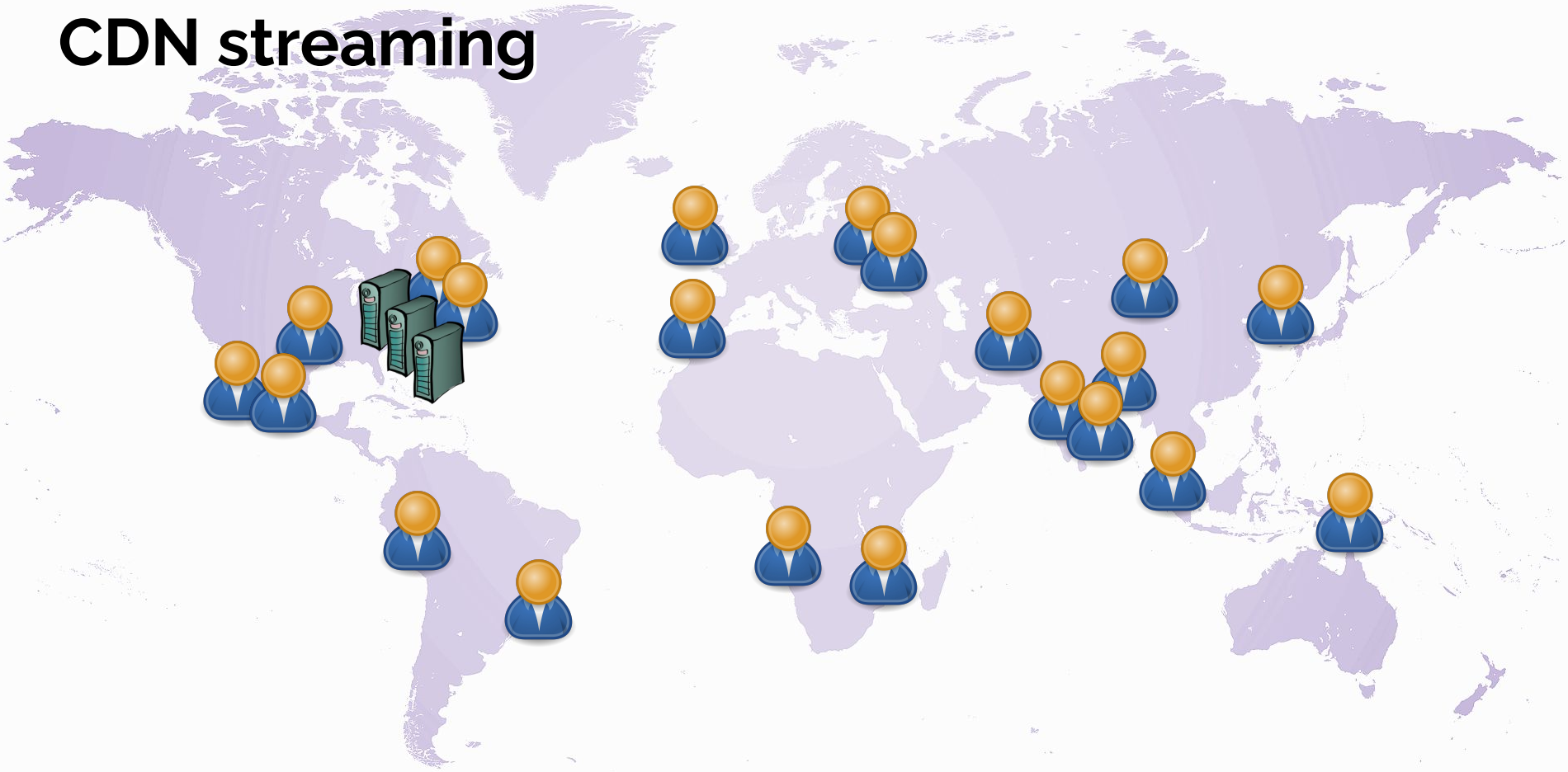

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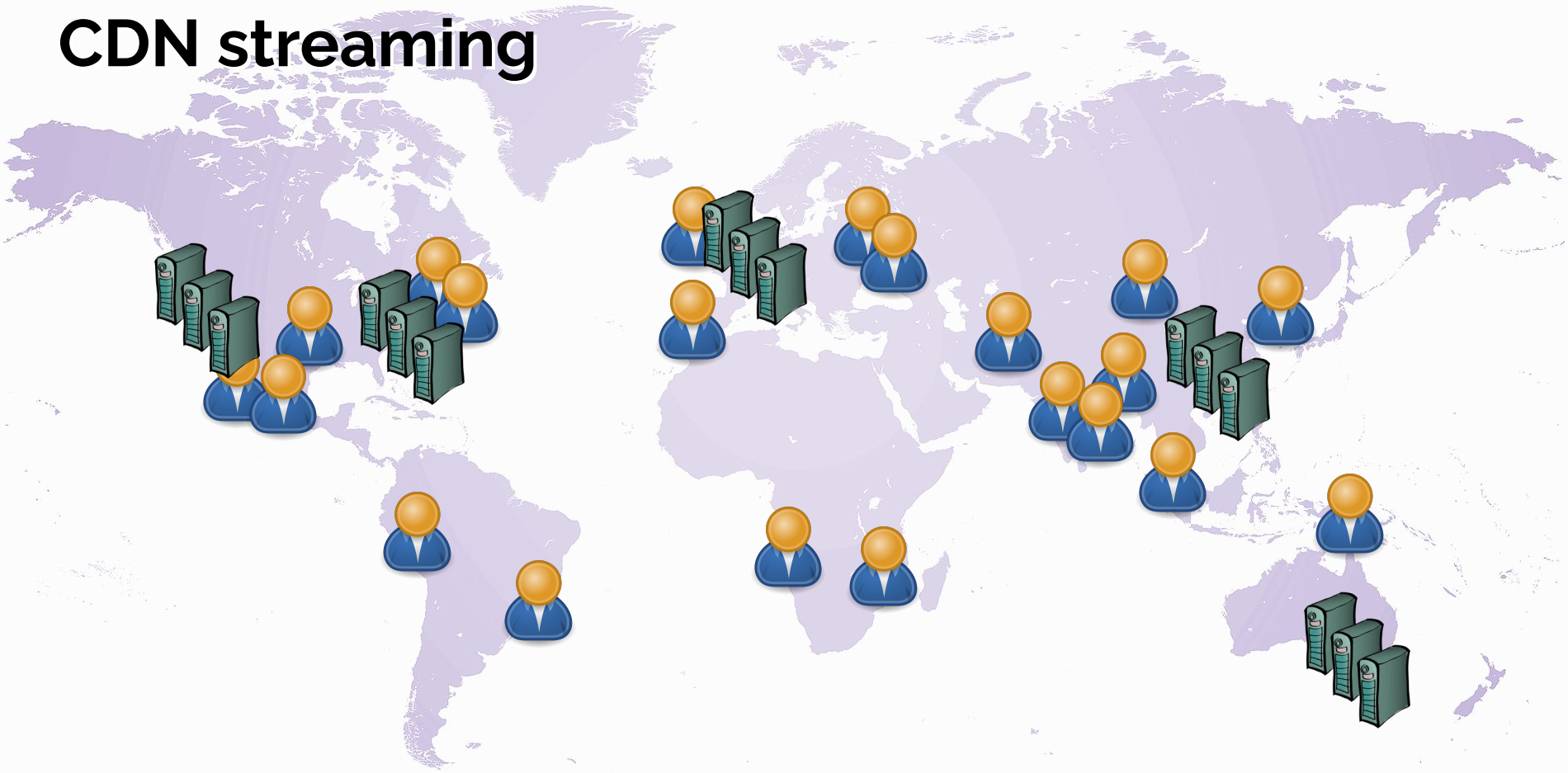
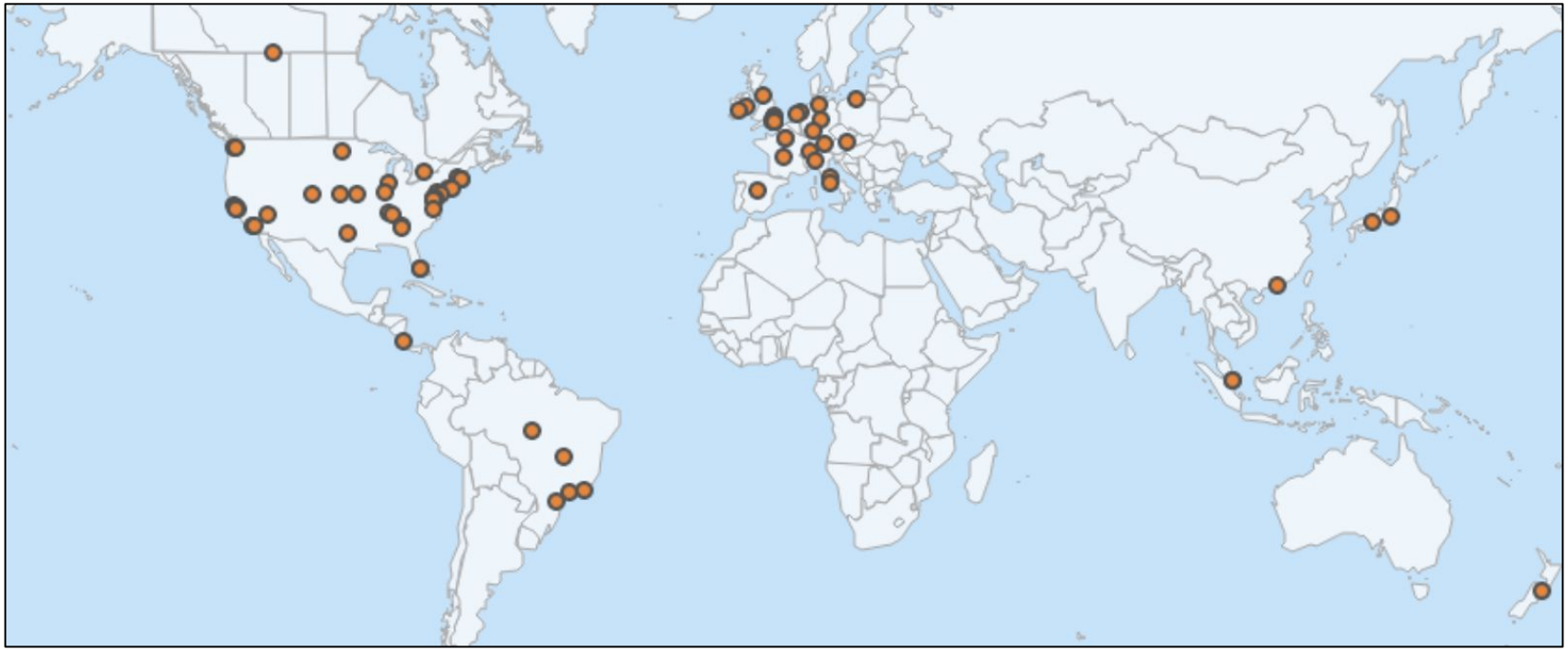


Facebook estimated connectivity in 2014



Source: Renesys

CDNs are going nowhere but up

CDN Market Pricing Down, but Overall Growth Continues

At last week's Content Delivery Summit, Dan Rayburn presented his annual survey of pricing and trends in the industry. Per-GB prices are down, but CDNs are making up for the drop with increased efficiencies and value-added services

By *Dom Robinson*
Posted on May 22, 2017

CDNs are going nowhere but up

Akamai

Revenue	▲ US$ 2.3 billion (2016)[2] ▲ US$ 1.37 billion (2012)[2]
Operating income	▲ US$ 414 million (2013)[2] ▲ US$ 314.5 million (2012)[2]
Net income	▲ US$ 293.5 million (2013)[2] ▲ US$ 204 million (2012)[2]
Total assets	▲ US$ 2.96 billion (2013)[3] ▲ US$ 2.6 billion (2012)[2]
Total equity	▲ US$ 2.63 billion (2013)[3] ▲ US$ 2.35 billion (2012)[2]

Source: Renesys

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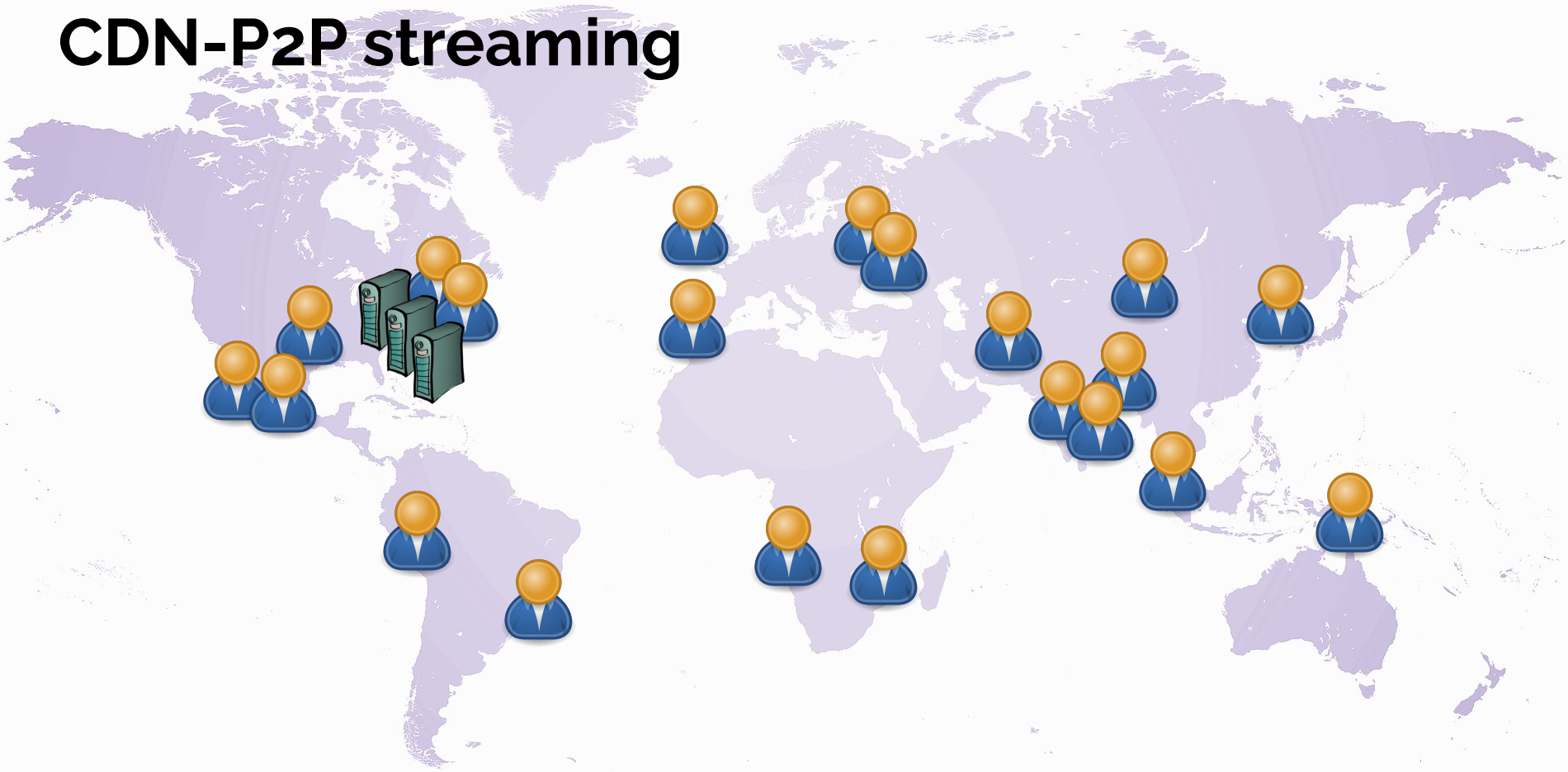
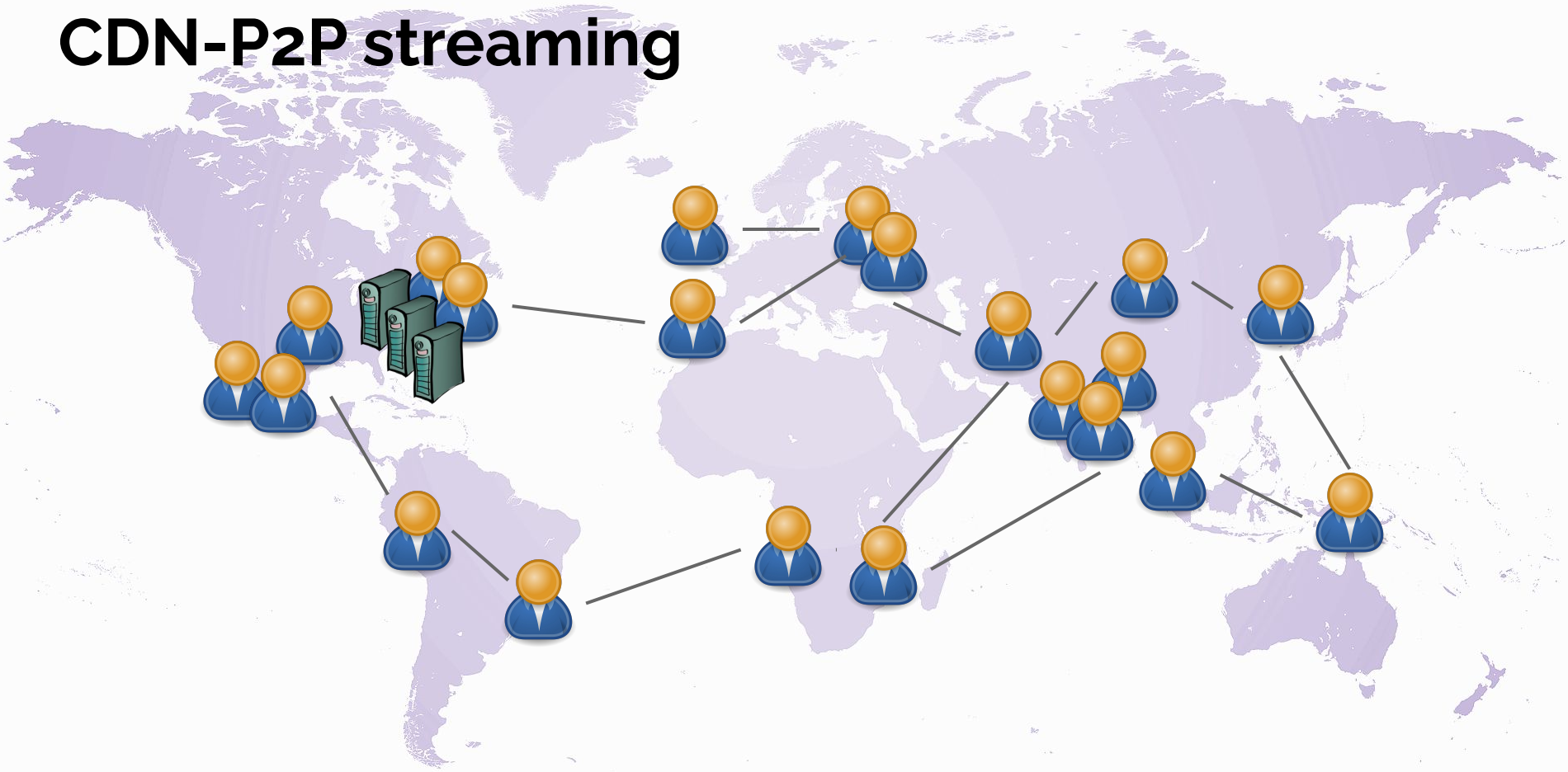
CDN-P2P streaming



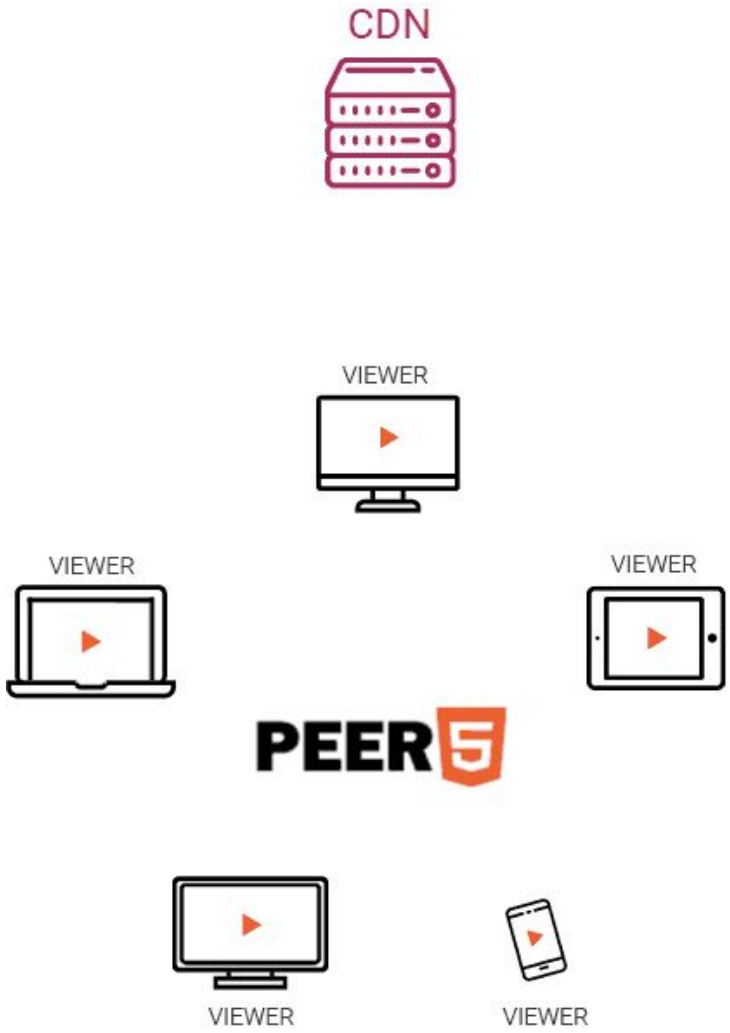
CDN-P2P streaming



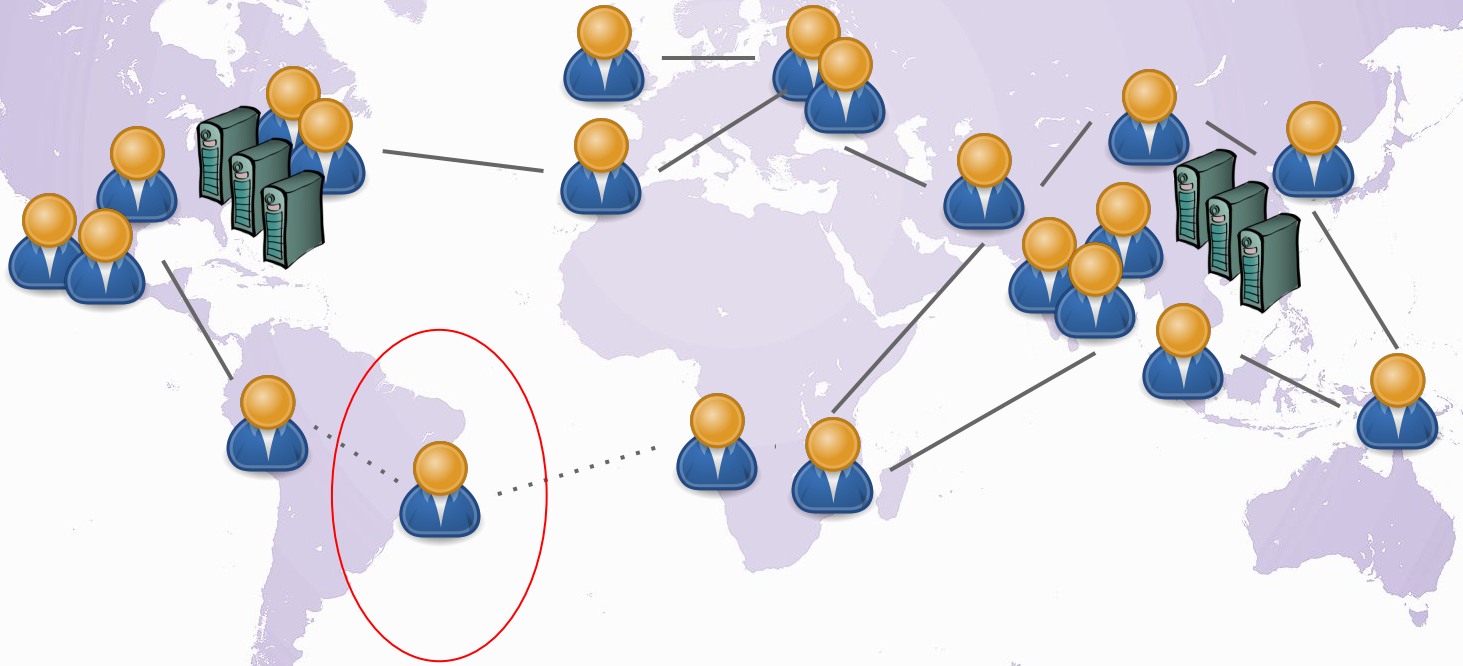
Peer5

The Serverless CDN

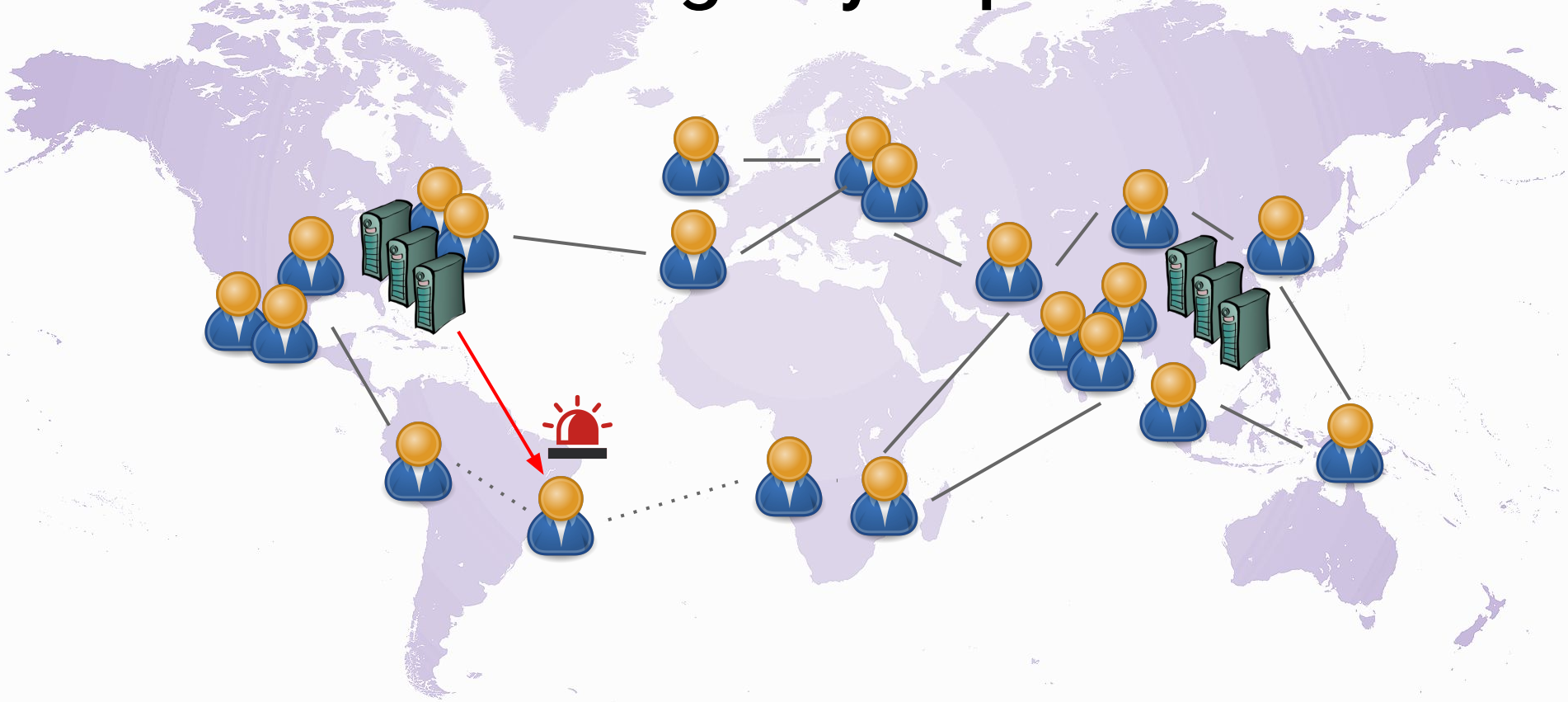
Increase your video delivery capacity by 50x
More users = Better performance



CDN-P2P streaming challenge: Peer resource availability variability



CDN-P2P with emergency requests



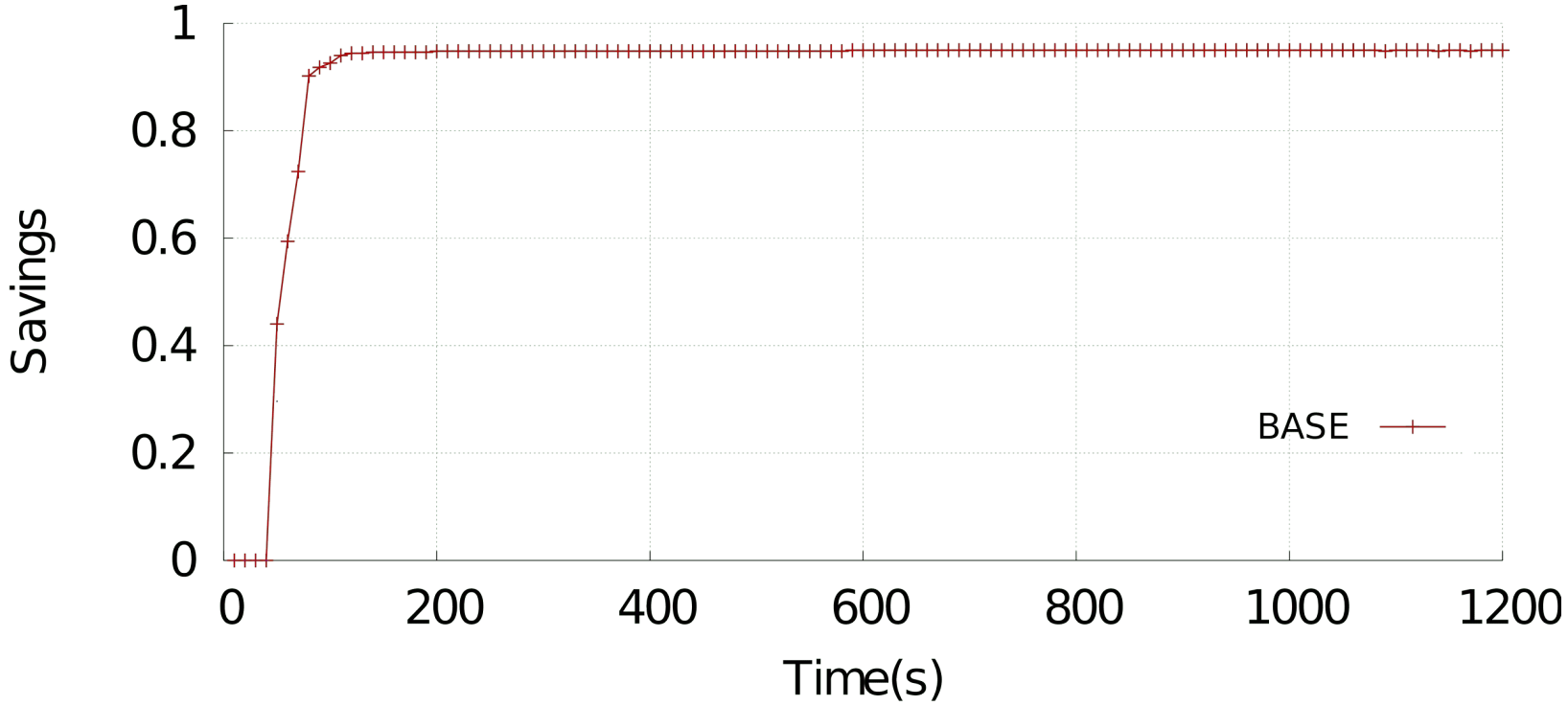
Outline

- Simulation setup
- Impact of emergency request on P2P distribution
- AERO: Adaptive Emergency Request Optimization
- Evaluation

Simulation configuration

- Run real system on top of a simulated network
- Underlay network
  - No congestion
  - End-to-end latency uniformly distributed between 10–50ms
- Streaming channels of varying client populations
  - 100–2000 clients
- Realistic peer upload distributions

CDN-P2P bandwidth savings



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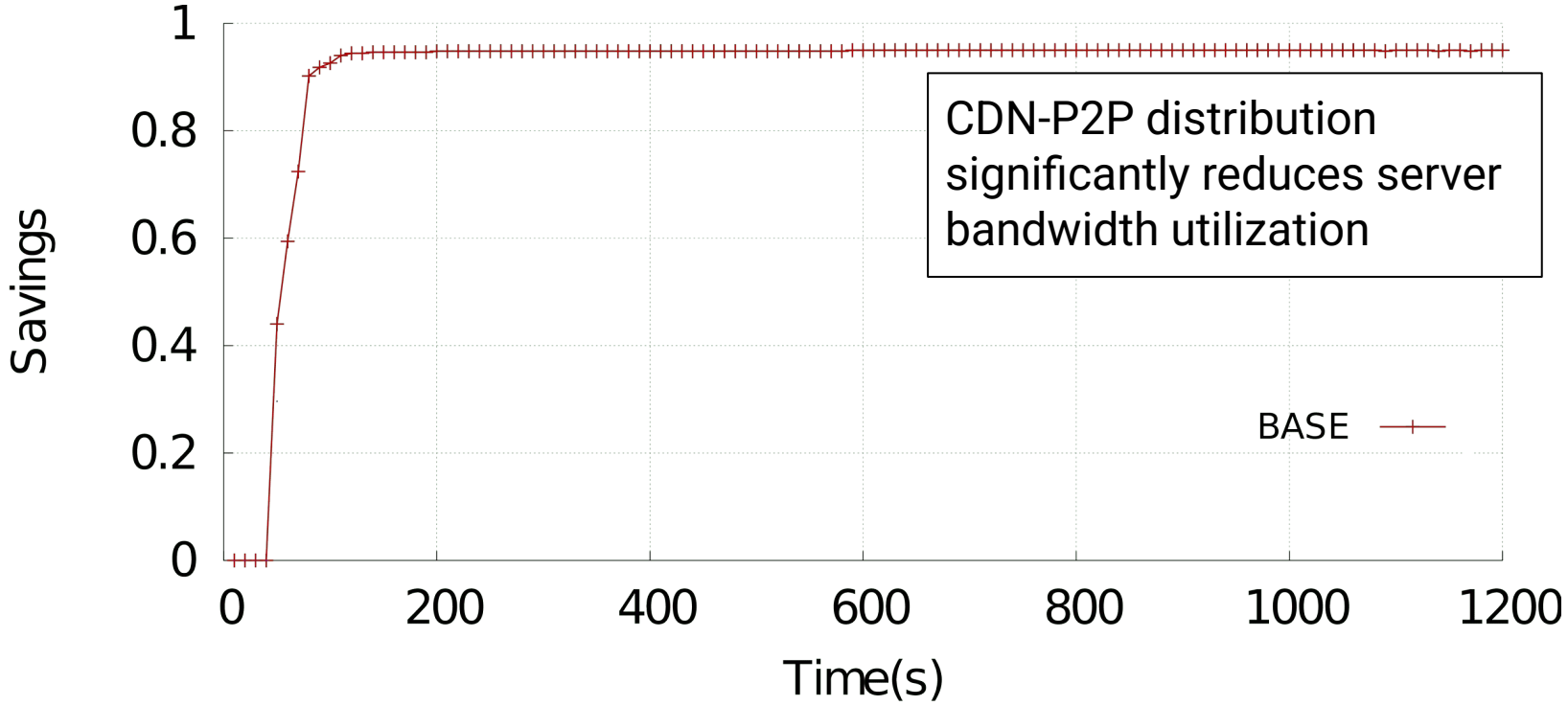
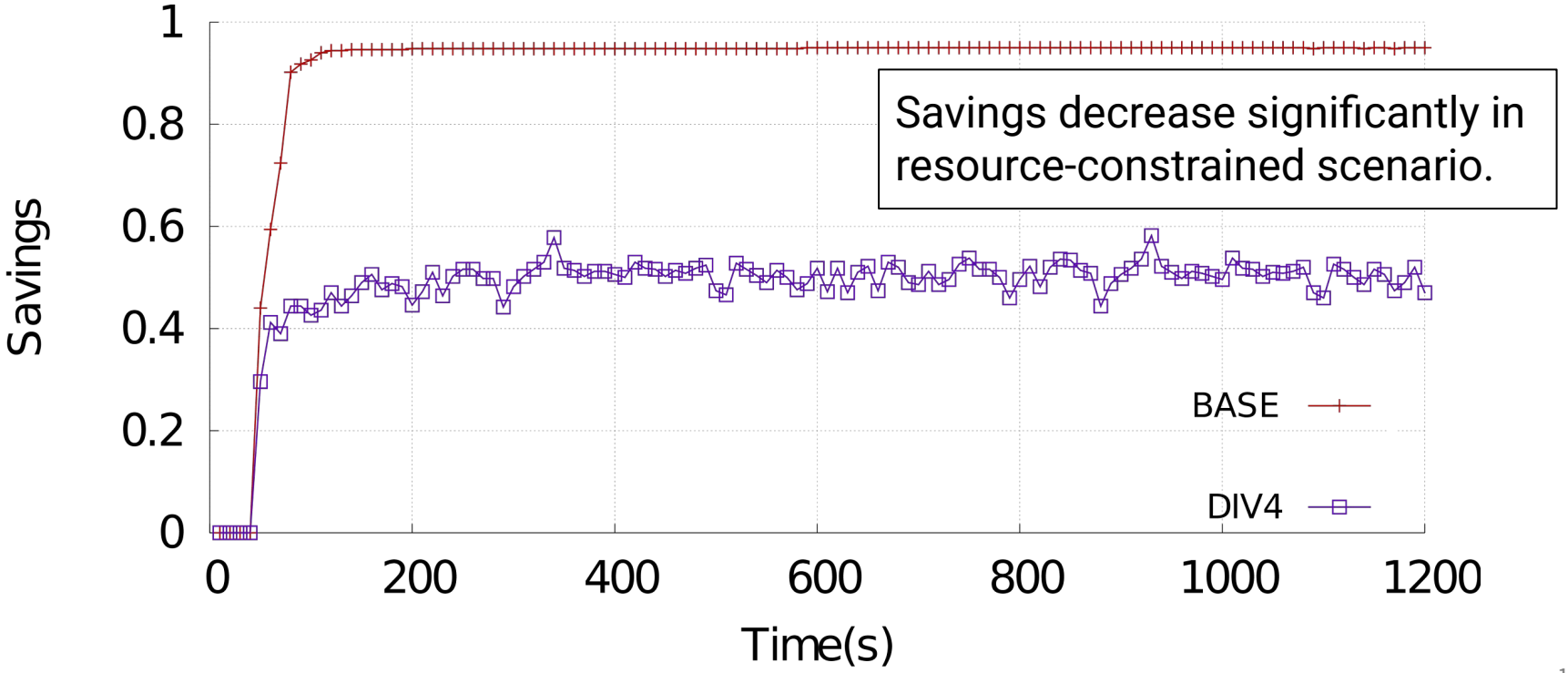


CDN-P2P bandwidth savings



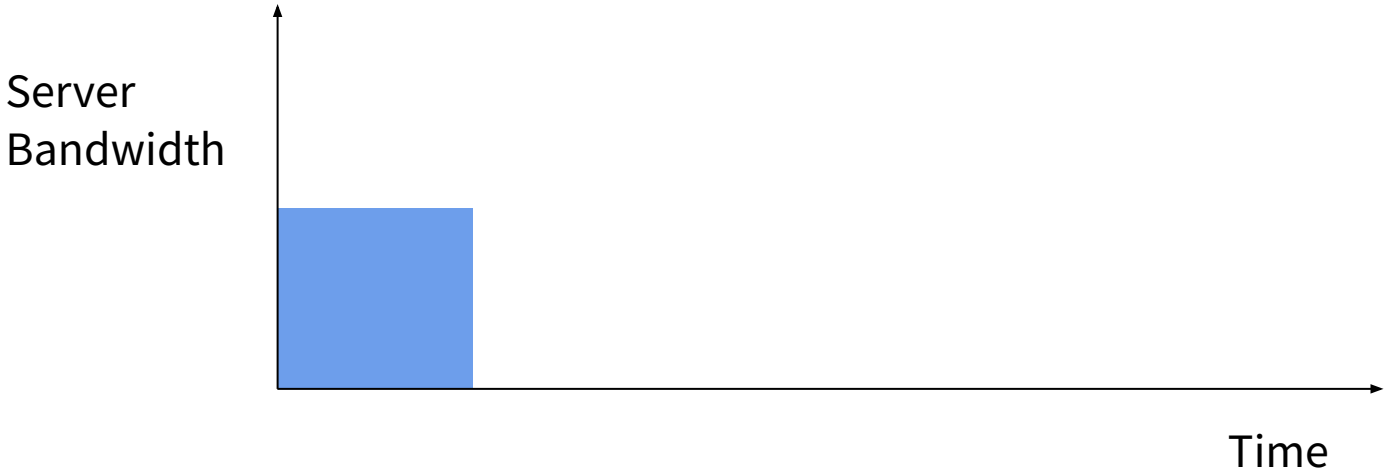
Emergency requests hurt P2P efficiency

Chunk Origin	Scenario	
	Baseline	Constrained
Seeded by server	1.4%	0.7%
Emergency request	3.0%	49.5%
P2P overlay	95.6%	49.8%

Emergency requests hurt P2P efficiency

	Scenario		Average Retransmissions	
Chunk Origin	Baseline	Constrained	Baseline	Constrained
Seeded by server	1.4%	0.7%	2.65	0.84
Emergency request	3.0%	49.5%	0.01	0.43
P2P overlay	95.6%	49.8%		

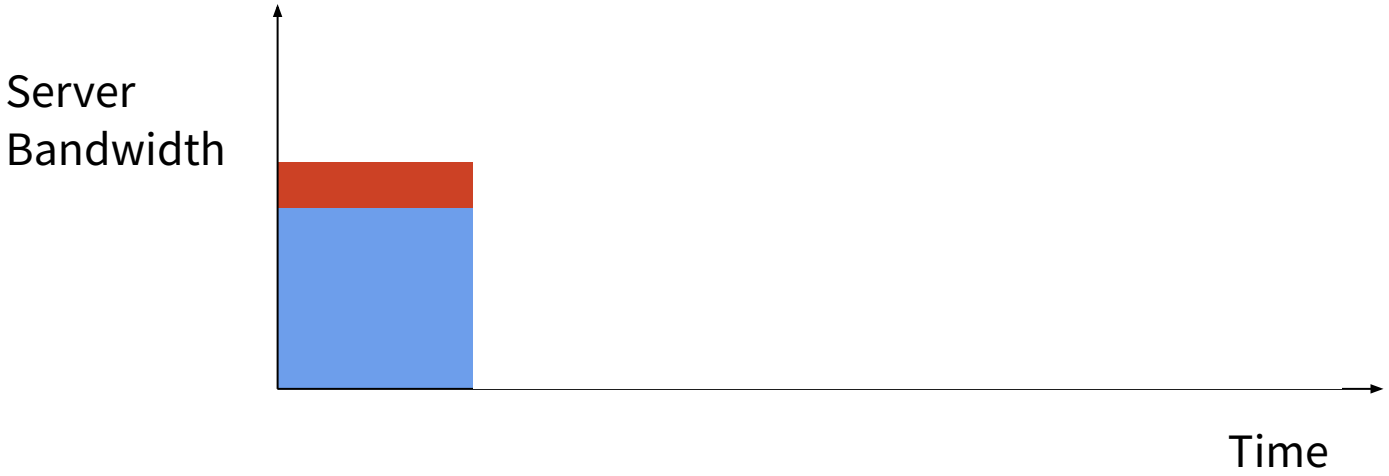
AERO: Adaptive Emergency Request Optimization



Seeded

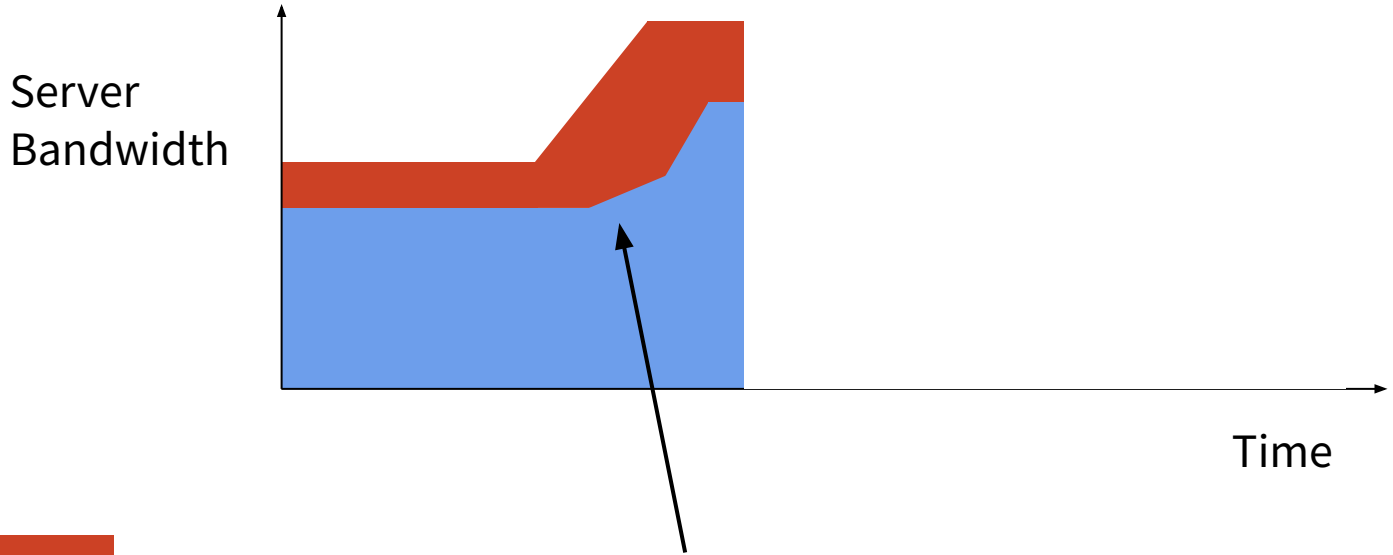
Controlled

AERO: Adaptive Emergency Request Optimization



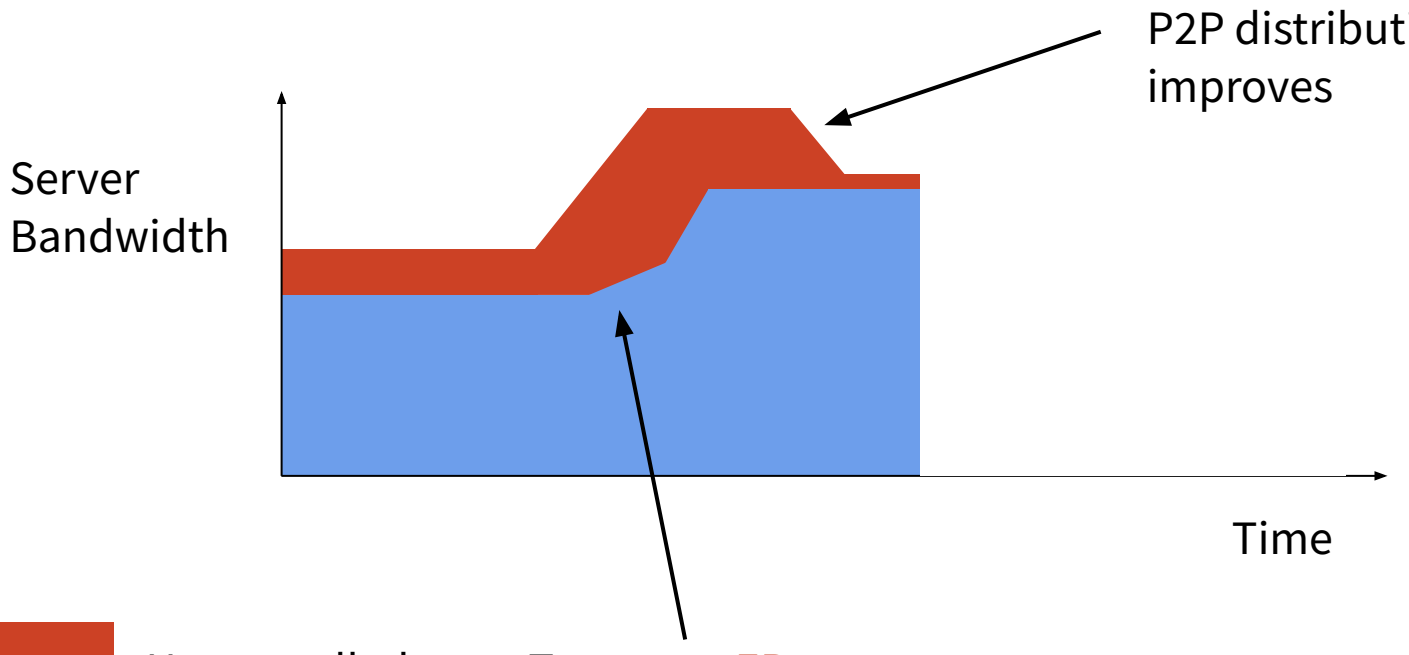
Emergency	Uncontrolled
Seeded	Controlled

AERO: Adaptive Emergency Request Optimization



Emergency	Uncontrolled
Seeded	Controlled

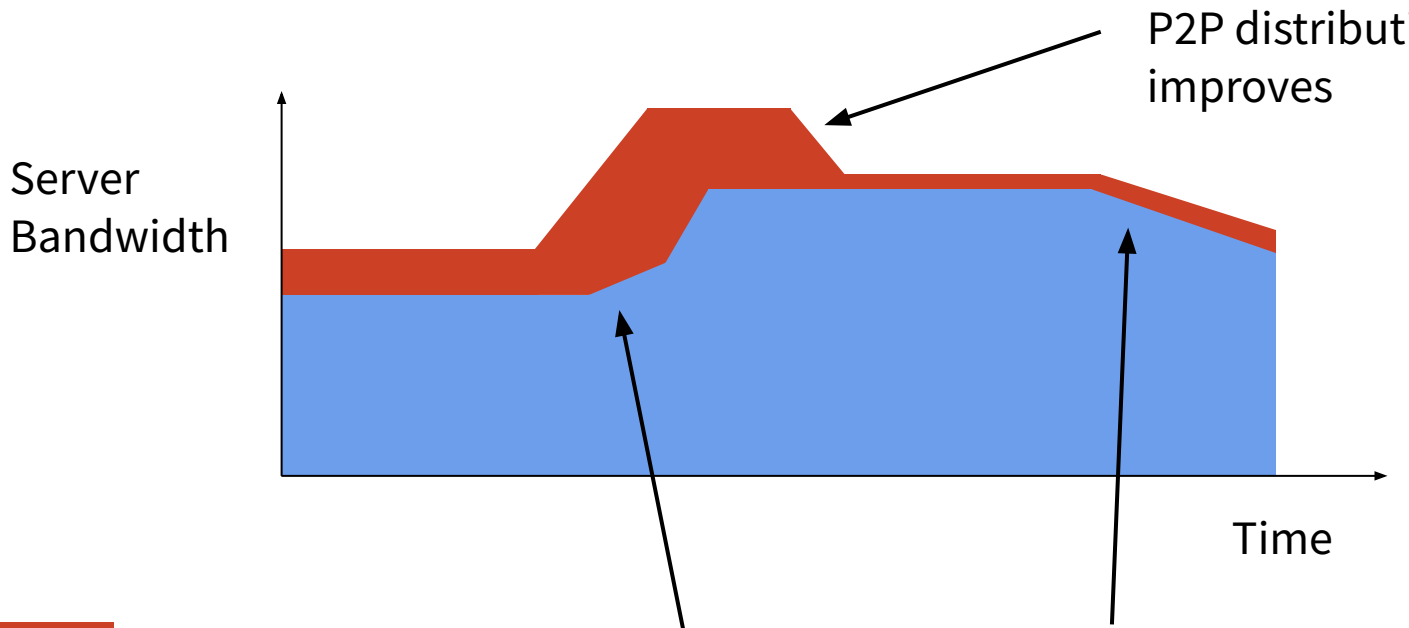
AERO: Adaptive Emergency Request Optimization



Emergency — Uncontrolled

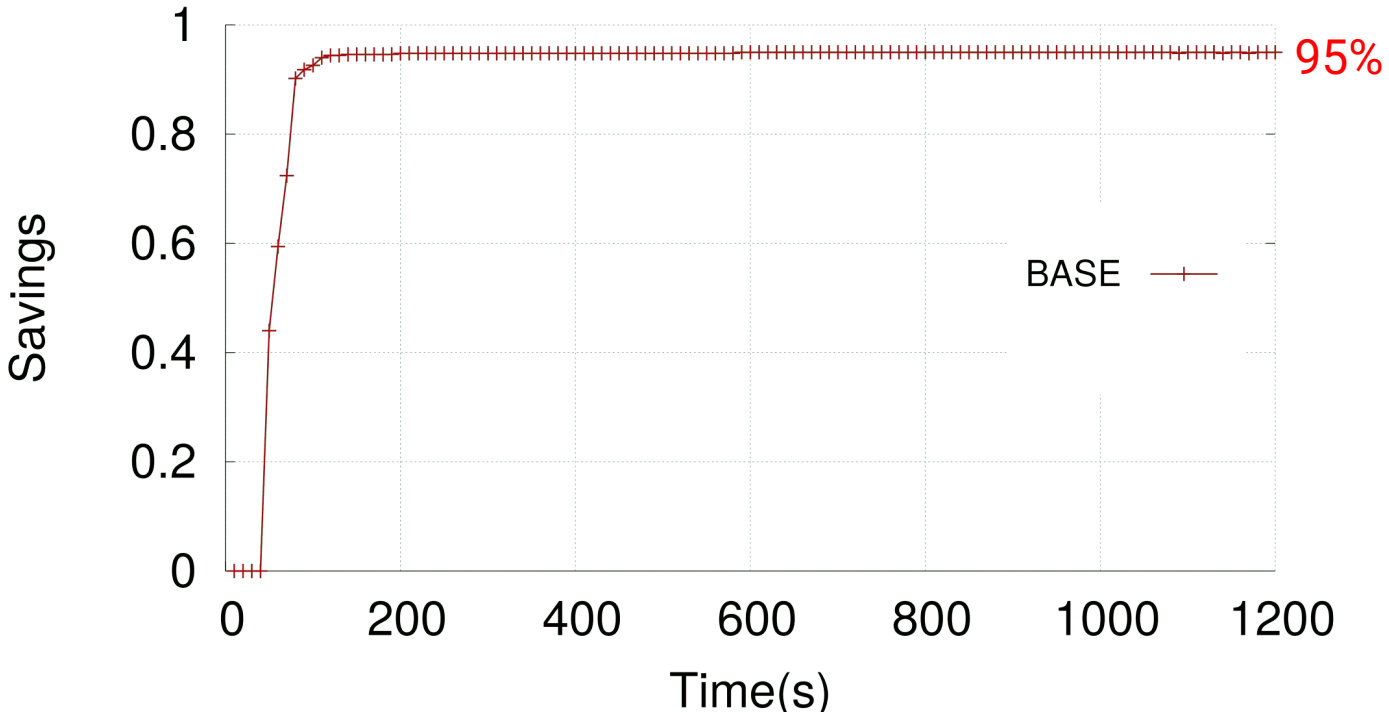
Seeded — Controlled

AERO: Adaptive Emergency Request Optimization

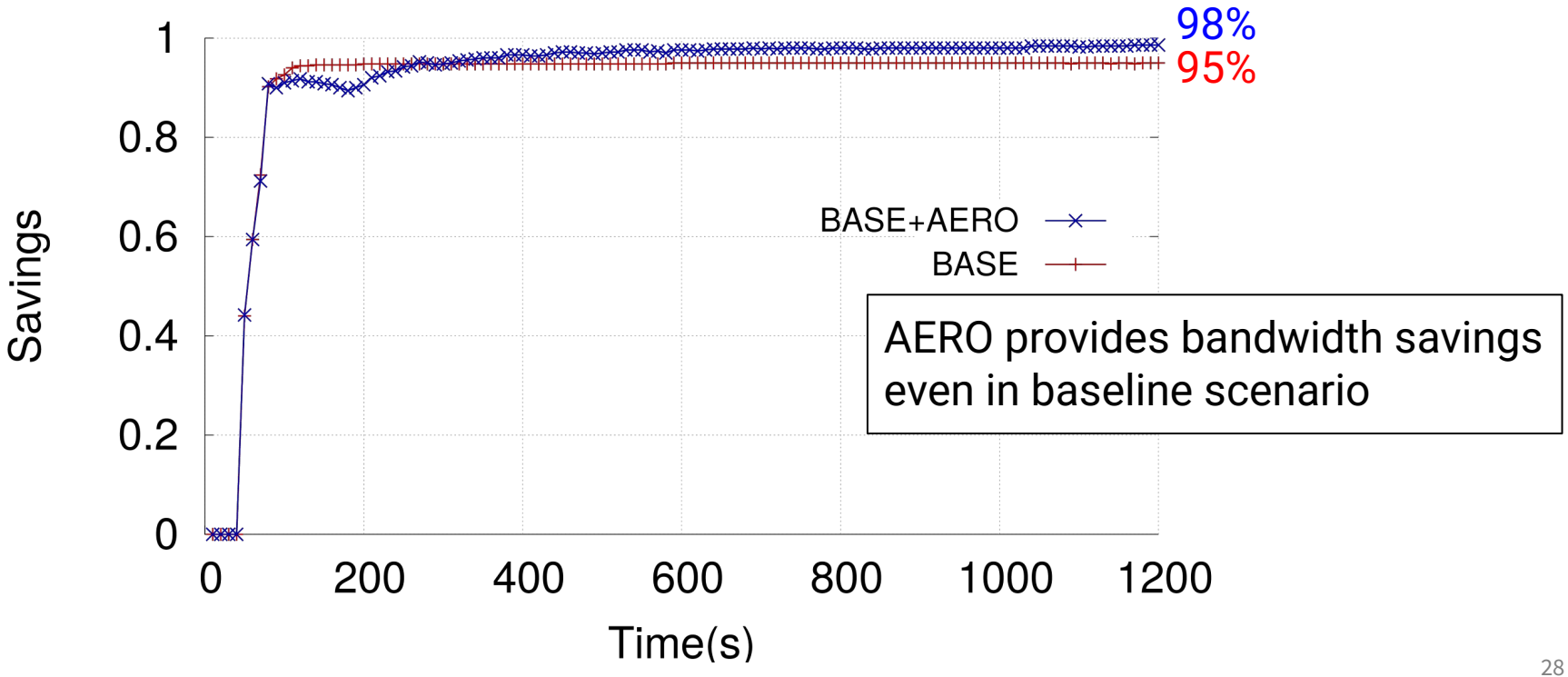


Emergency	Uncontrolled
Seeded	Controlled

CDN-P2P bandwidth savings with AERO



CDN-P2P bandwidth savings with AERO



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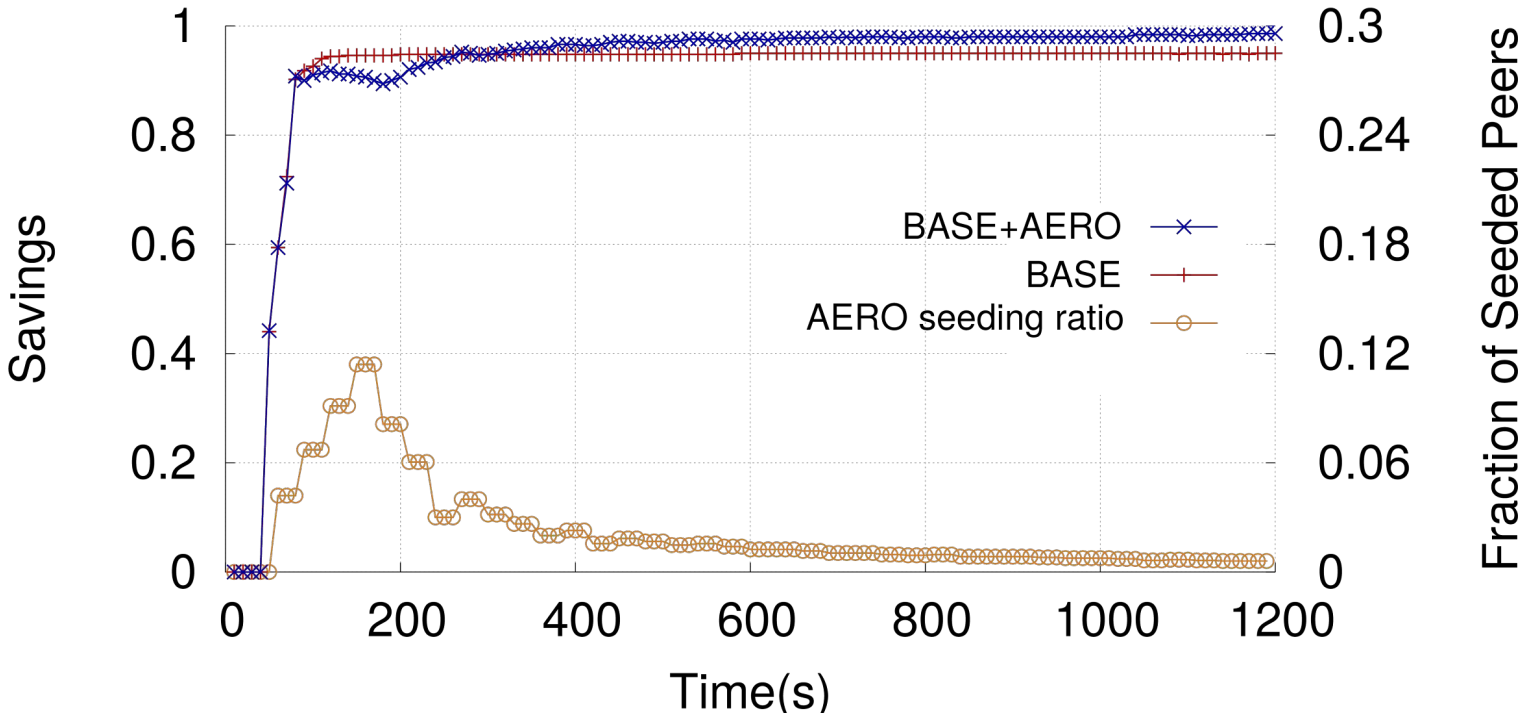

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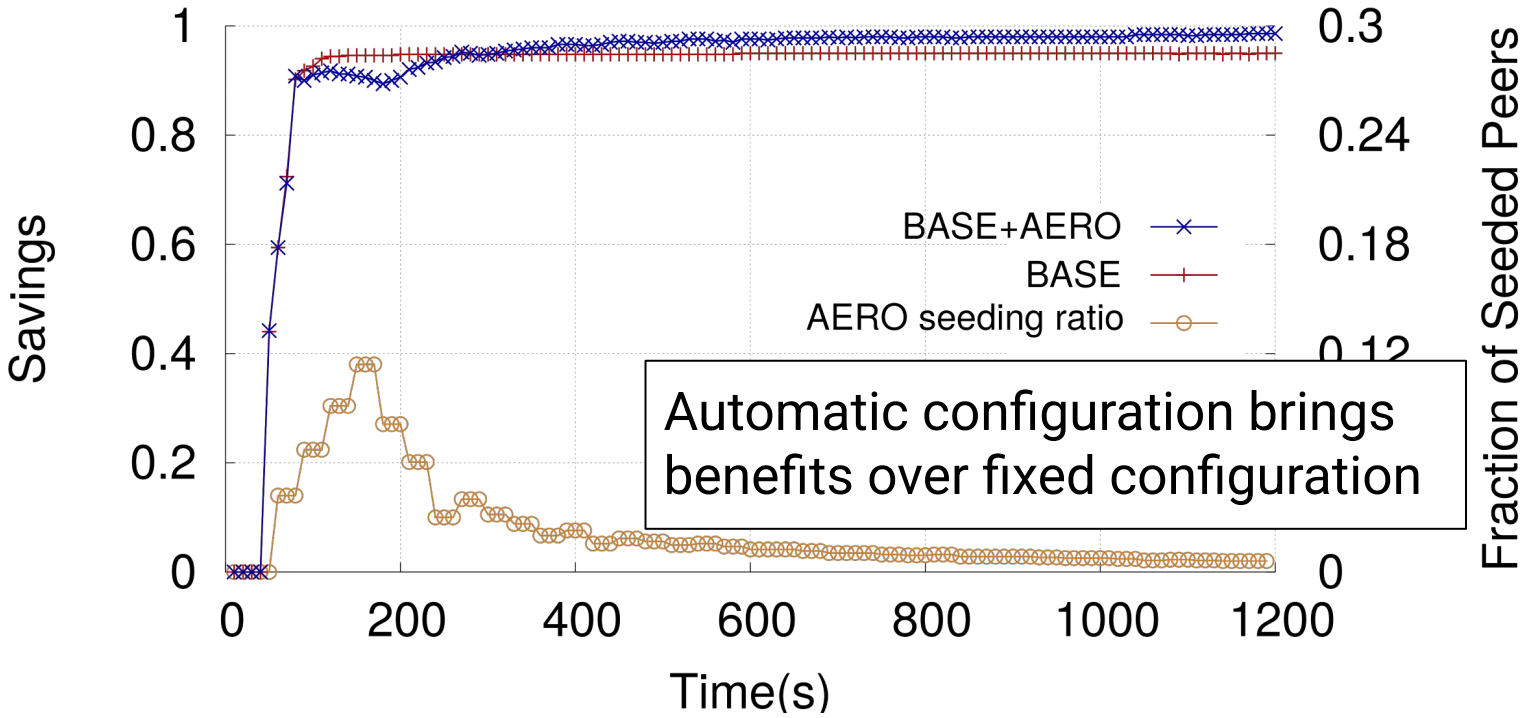

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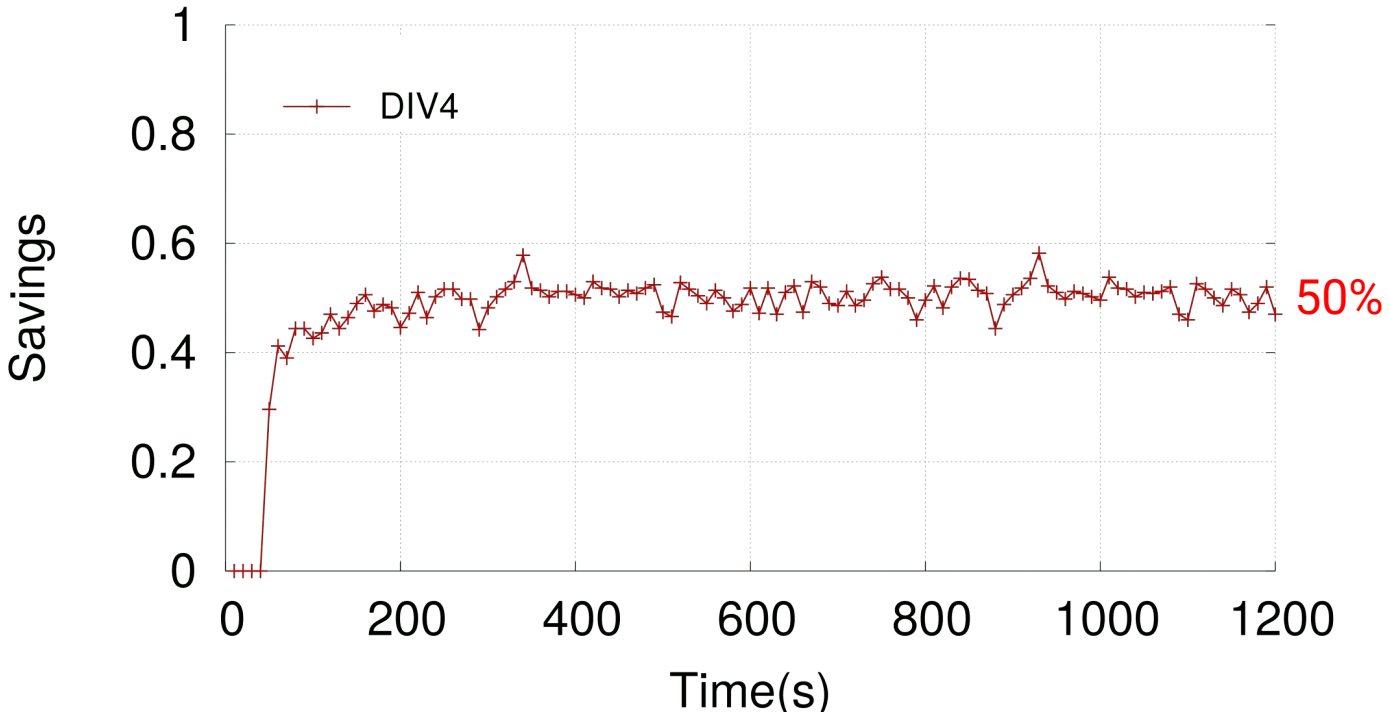

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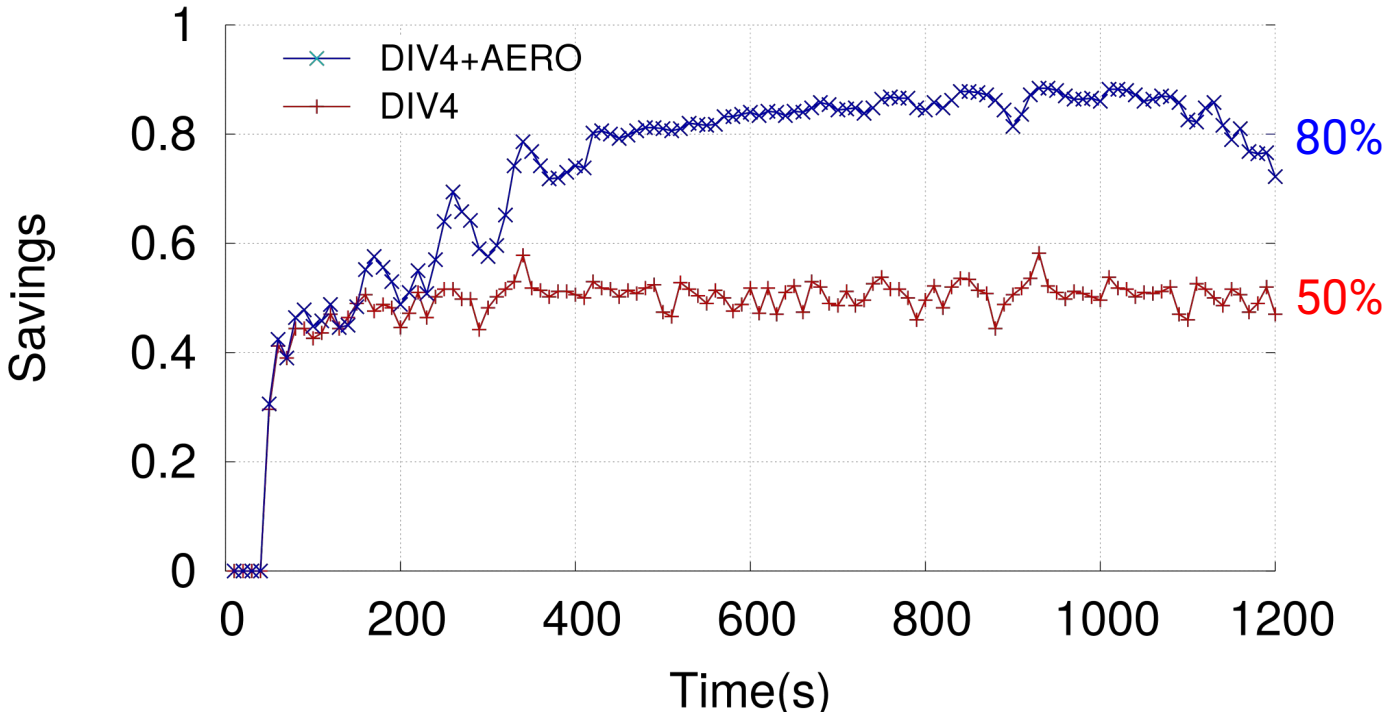

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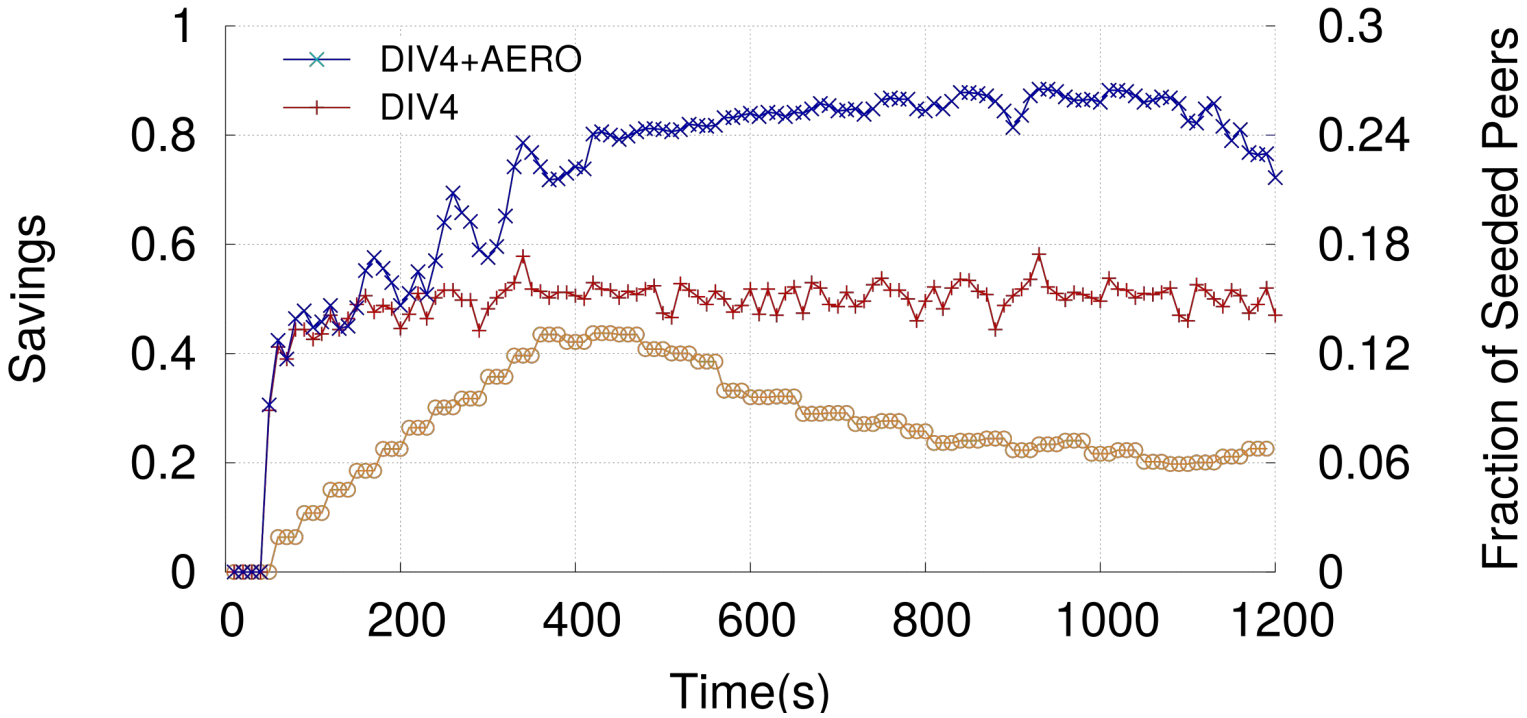

AERO restores P2P distribution efficiency

	Without AERO		With AERO	
Chunk Origin	Baseline	Constrained	Baseline	Constrained
Seeded by server	1.4%	0.7%	1.6%	6.6%
Emergency request	3.0%	49.5%	0.9%	13.4%
P2P overlay	95.6%	49.8%	97.5%	80.8%

Complementary results in the paper

- How AERO performs in face of peer churn
- How AERO performs in face of free riders
- How AERO performs during flash crowds

Conclusions

- Emergency requests hurt P2P distribution efficiency
  - Leaves no time for chunks to be forwarded
- AERO adapts seeding ratio as function of the rate of emergency requests
  - Reduces seeding without compromising P2P distribution
- Significant bandwidth savings improvements

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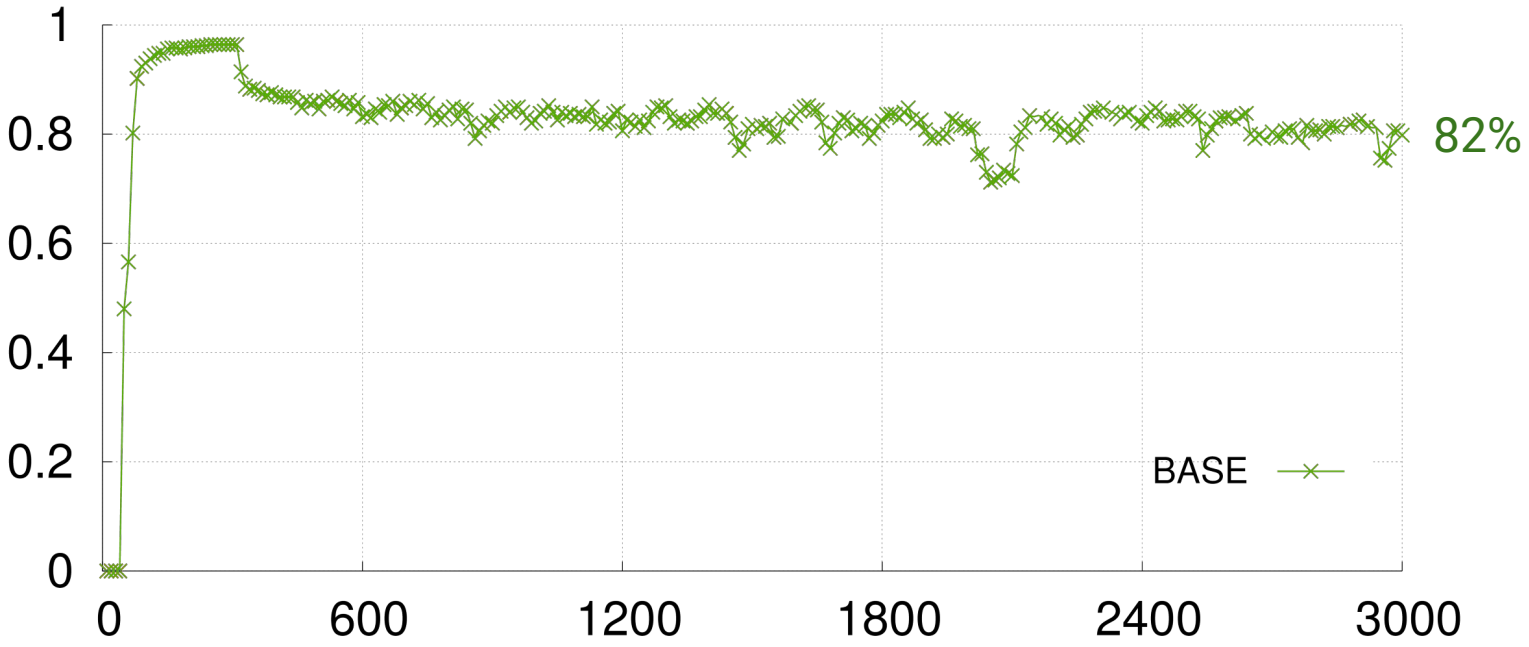
Ítalo Cunha
cunha@dcc.ufmg.br

UFMG

CDN-P2P bandwidth savings with AERO



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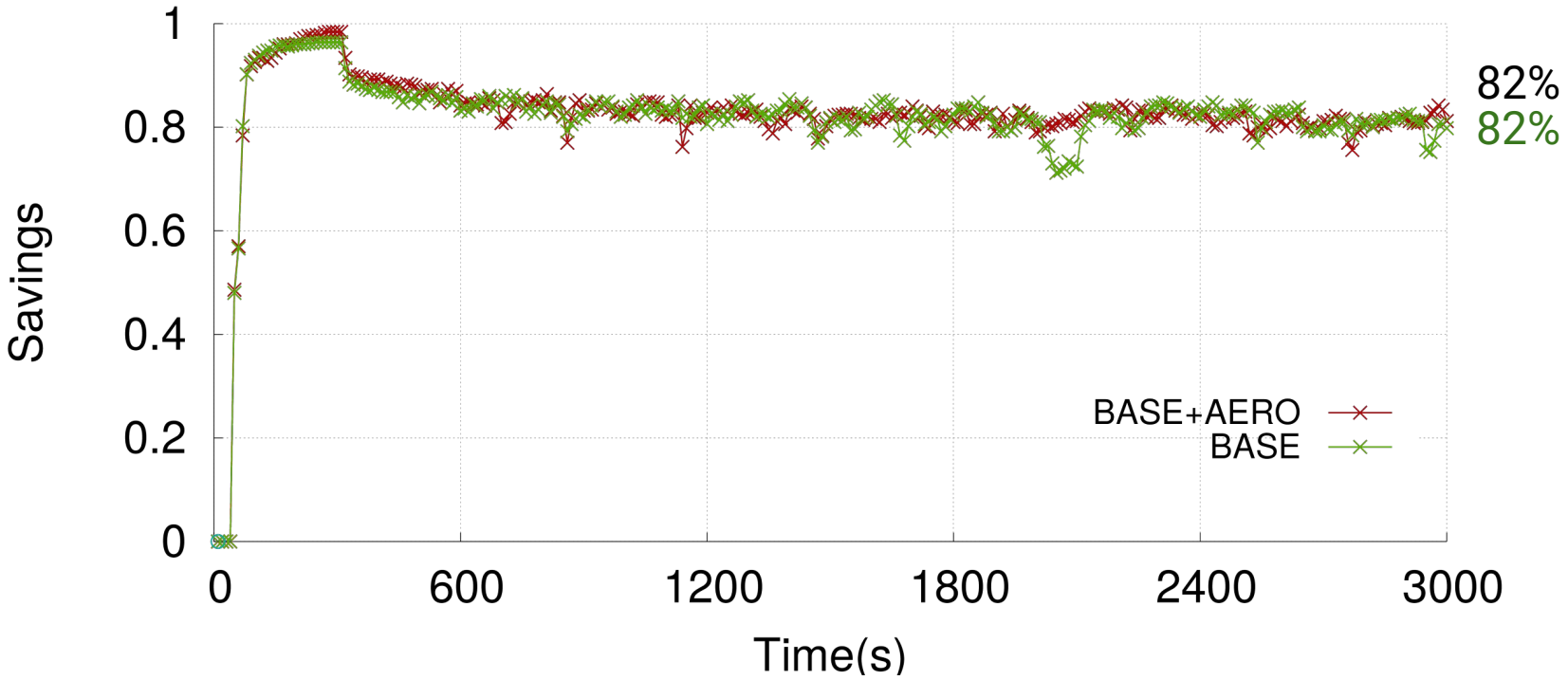

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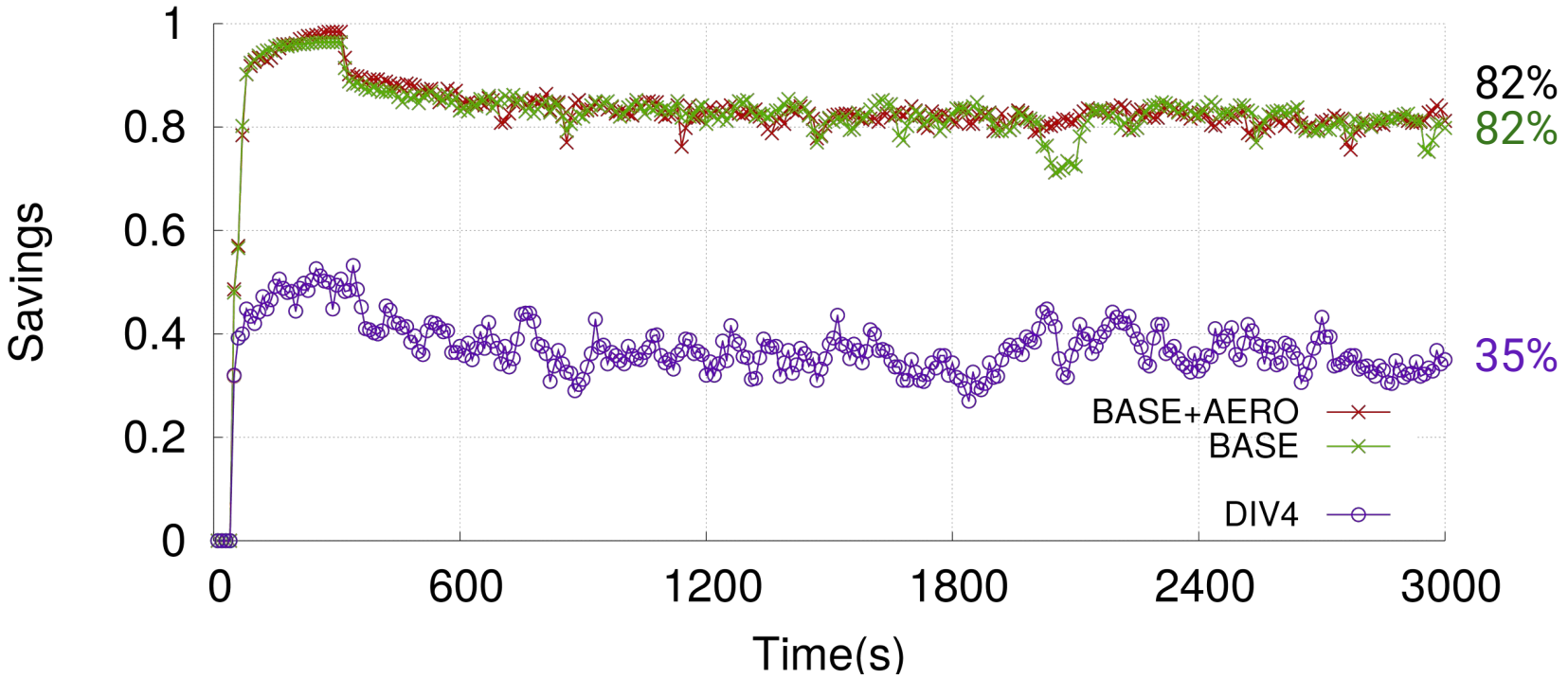

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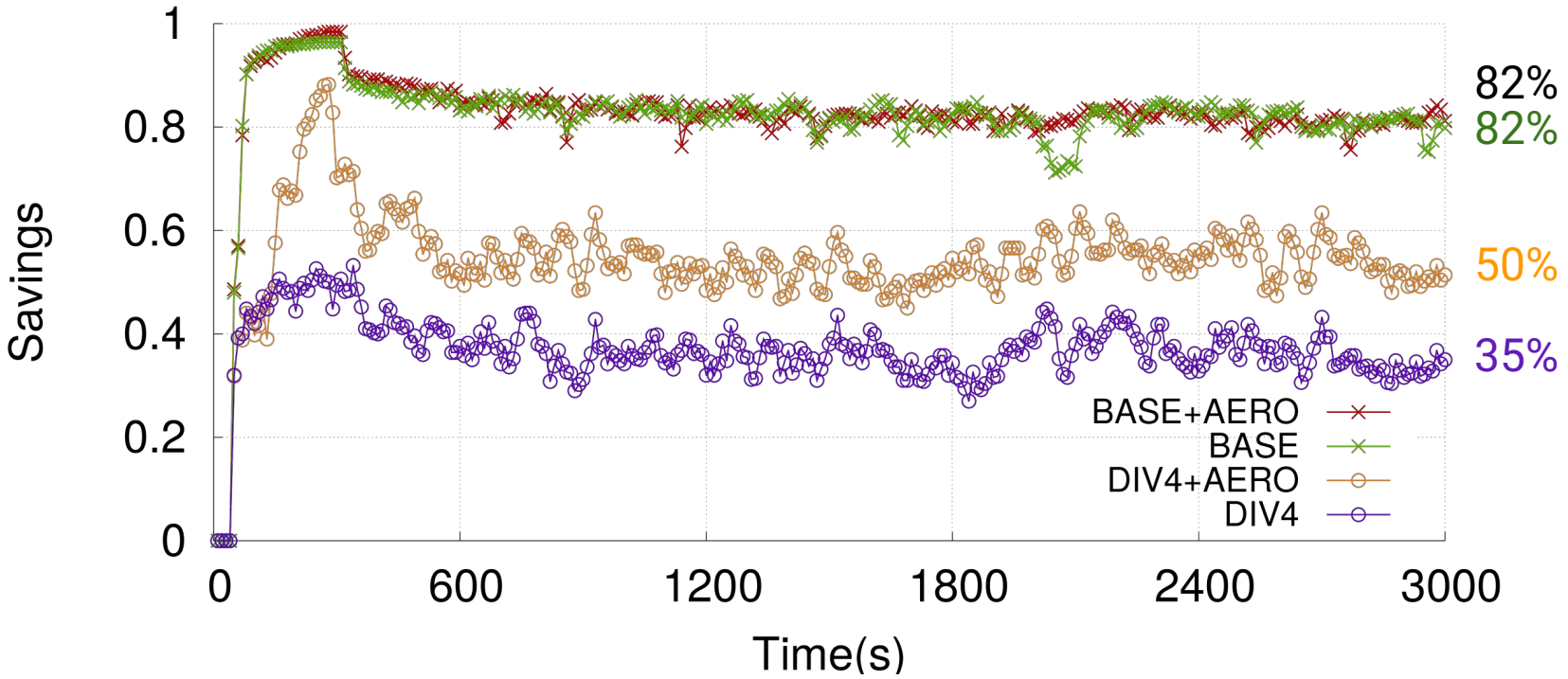
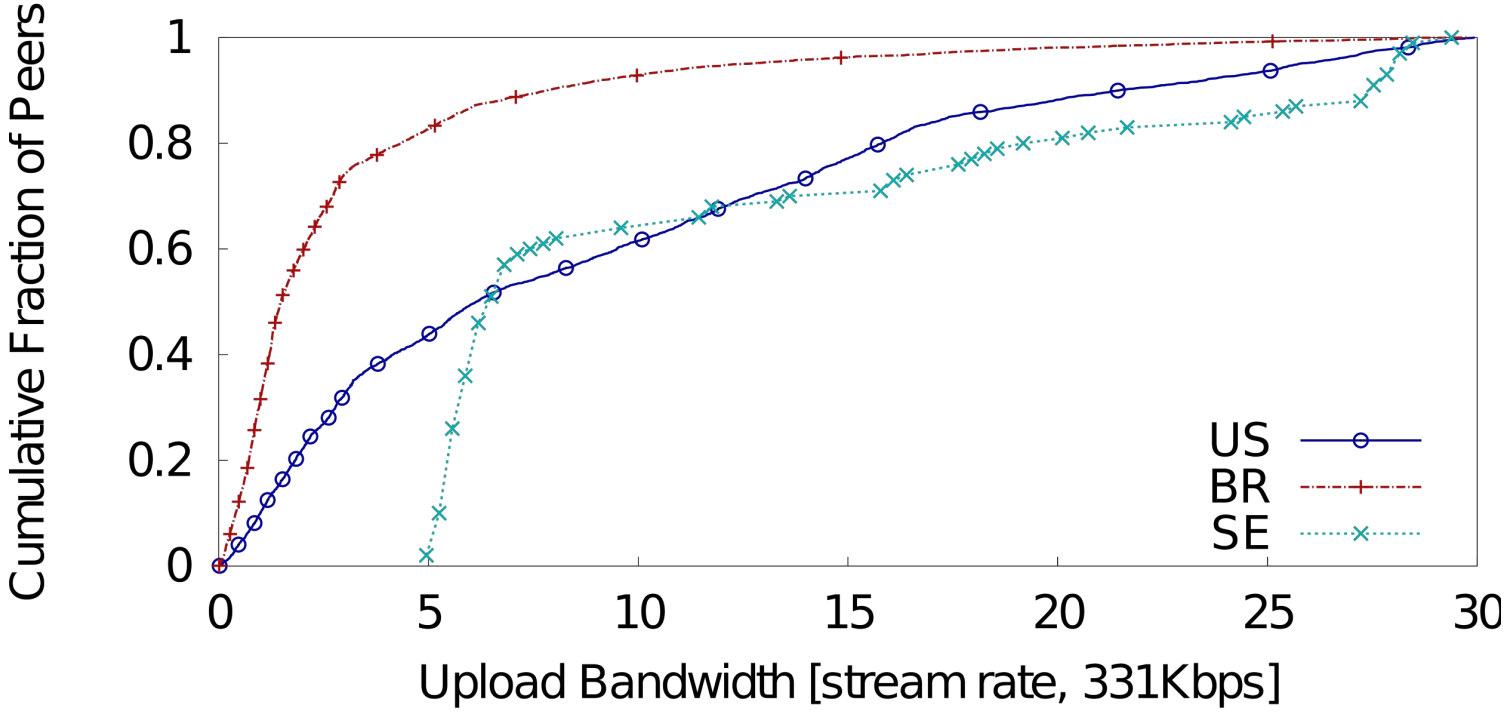


Peer upload bandwidth

- Real peer upload bandwidth distributions from three sources



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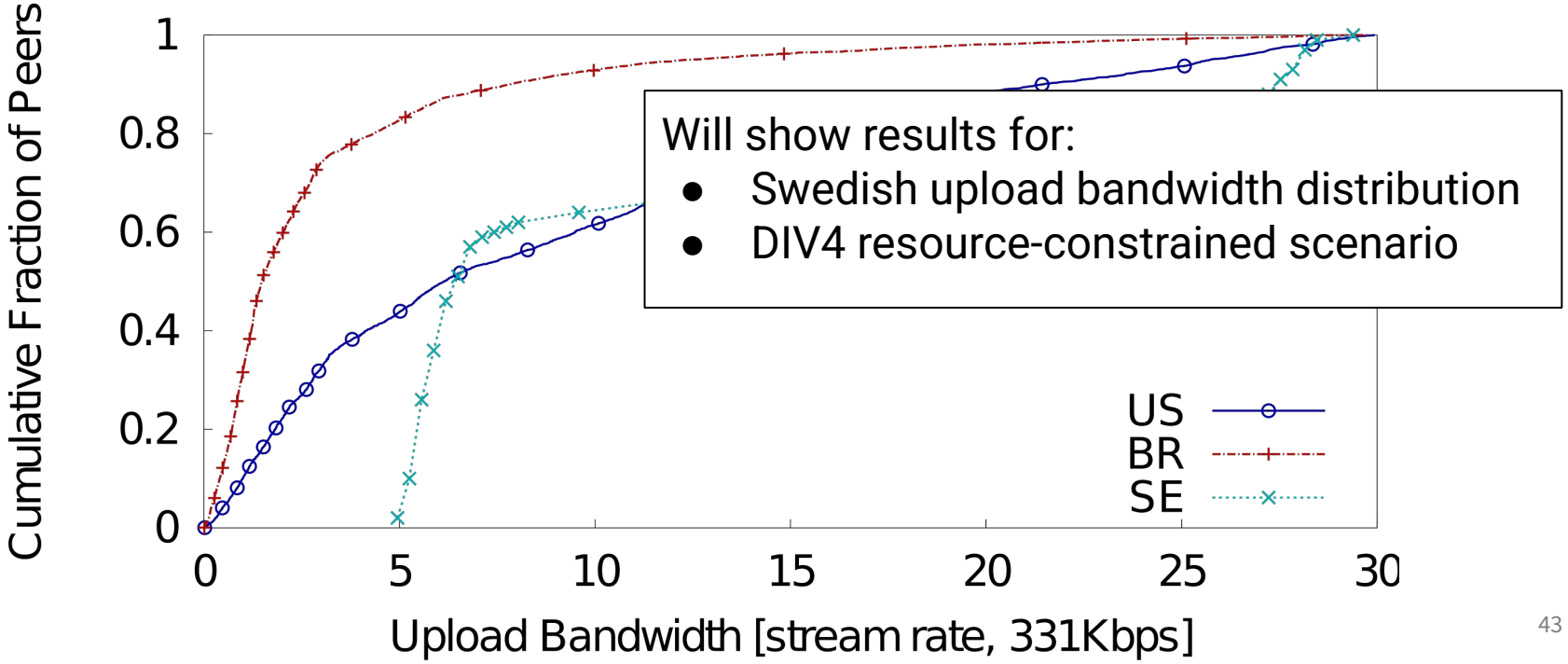

Algorithm 1: AERO's algorithm to update the seeding ratio S at each round

input: history of bandwidth consumption, seeding ratio
input: seeding ratio scaling factor δ (upper bound Δ)
input: seeding ratio error E at rounds t and $t-1$

if *bandwidth consumption is stable* **then** $S \leftarrow 0.95S$;
else
    if *bandwidth consumption jump* **then** $\delta \leftarrow \Delta$;
    else
        if $\text{sign}(E_t) = \text{sign}(E_{t-1})$ **then**
            $\delta \leftarrow \min(\delta/0.75, \Delta)$;
        else $\delta \leftarrow 0.75\delta$;
    end
    $S \leftarrow S + \text{sign}(E_t)\delta$
end

Chunk origin

CHUNK ORIGIN	BASE	50F	75F	DIV4
Seeded by servers	1.4%	0.8%	0.3%	0.7%
Emergency request	3.0%	4.9%	25.9%	49.5%
P2P overlay	95.6%	94.3%	73.8%	49.8%

Number of chunk retransmission

CHUNK ORIGIN	BASE	50F	75F	DIV4
Seeded	2.65	3.07	3.59	0.84
Emergency	0.01	0.30	0.47	0.43

Eme

CHUNK ORIGIN	BASE	50F	75F	DIV4
Seeded	2.65	3.07	3.59	0.84
Emergency	0.01	0.30	0.47	0.43

CHUNK OI

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P2P overlay	97.5%	96.8%	90.9%	80.0%

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Emergency request	3.0%	4.9%	25.9%	49.5%
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Simulation configuration

- Run real system on top of a simulated network
- Underlay network
  - No congestion
  - End-to-end latency uniformly distributed between 10–50ms
- P2P overlays
  - 100–2000 peers
  - 2–10 neighbors per peer

Peer upload bandwidth

- Real peer upload bandwidth distributions from three sources
  - TestMy.net bandwidth measurements
    - Brazilian users
    - American users
  - Measurements from a Swedish corporate network

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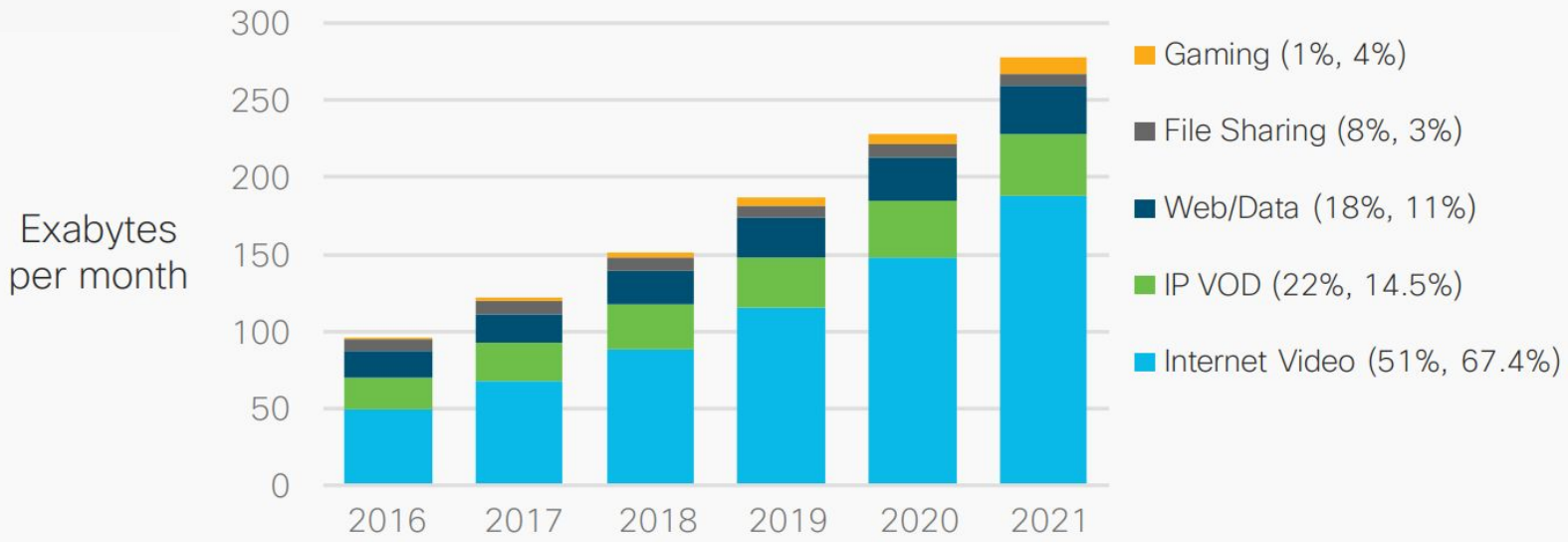
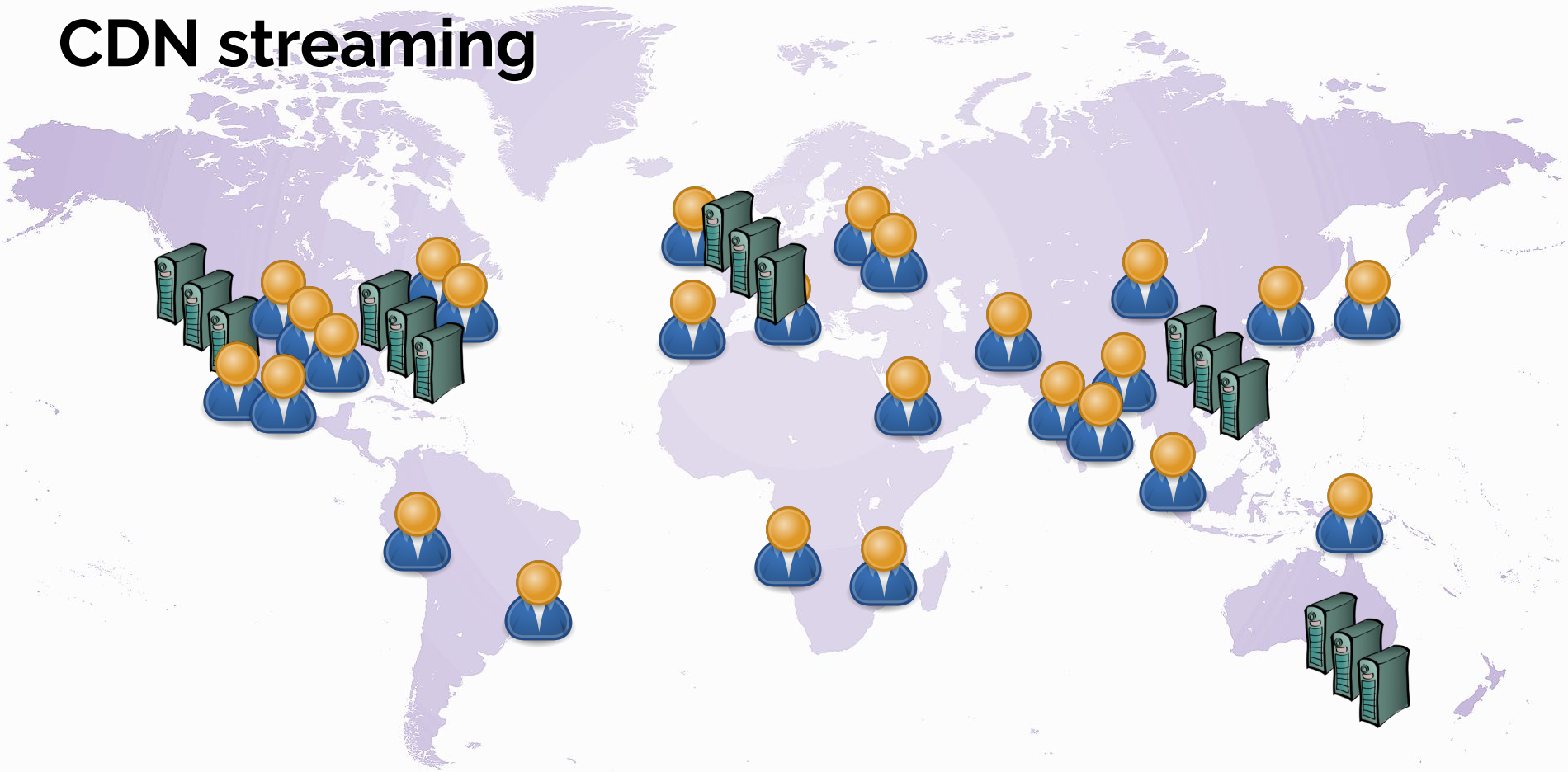
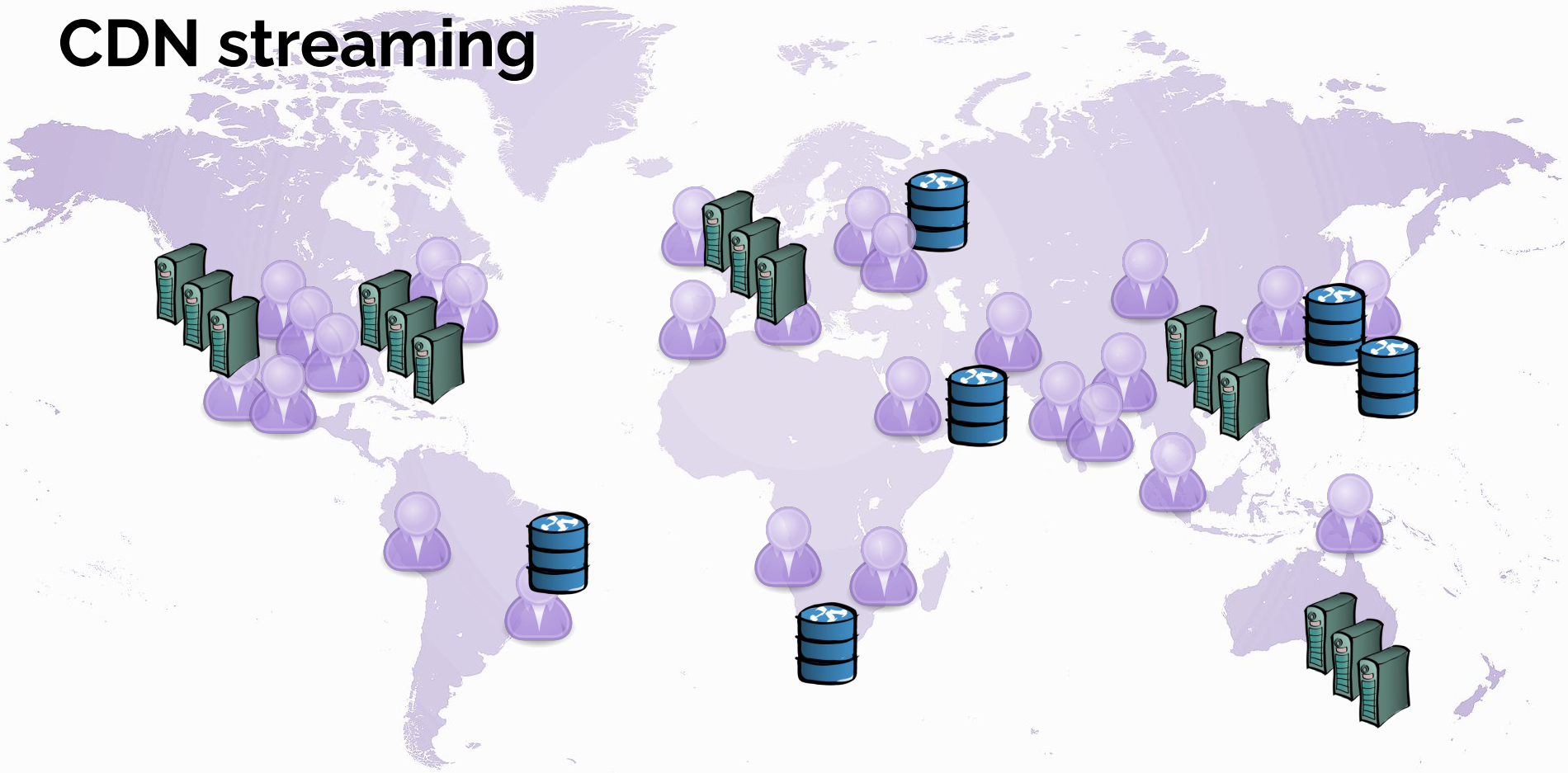
Cisco traffic volume estimates



Figures (n) refer to 2016, 2021 traffic shares.

Source: Cisco VNI Global IP Traffic Forecast, 2016–2021.

CDN streaming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