P2PRG Live Streaming Research Questions

March 24th, 2010

Omer Luzzatti
RayV

Overview

- The upstream problem - formulation
- Grid Topology constraints
- Push or Pull
- Static cost and Dynamic cost
- PET/IDA/Network Coding (the ‘depth’ question)?

RayV in a nutshell

Business:

- White label turn-key solution platform/CDN in a box for the Content owners/Telcos
- All content is legitimate
- Working with Telco/MSOs/ISPs
- Customers: NBA, DirecTV, Blizzard/Activision, Fox sports, American cap, Tennis Channel, Comcast CSN, AB Groupe, ex-pat channels, SMG

Usage:

- On average 500,000 connected peers
- 100,000 concurrent viewers at peak
- 8M minutes watched daily

P2P facts:

- 90%-95% cost saving (HW and bandwidth)
- Building the network cost per concurrent viewer $0.6
- Monthly per concurrent $0.5/month (10% of 1Mbps BW cost)
- Improves quality (due to stream localization)

Customers requirements - Quality

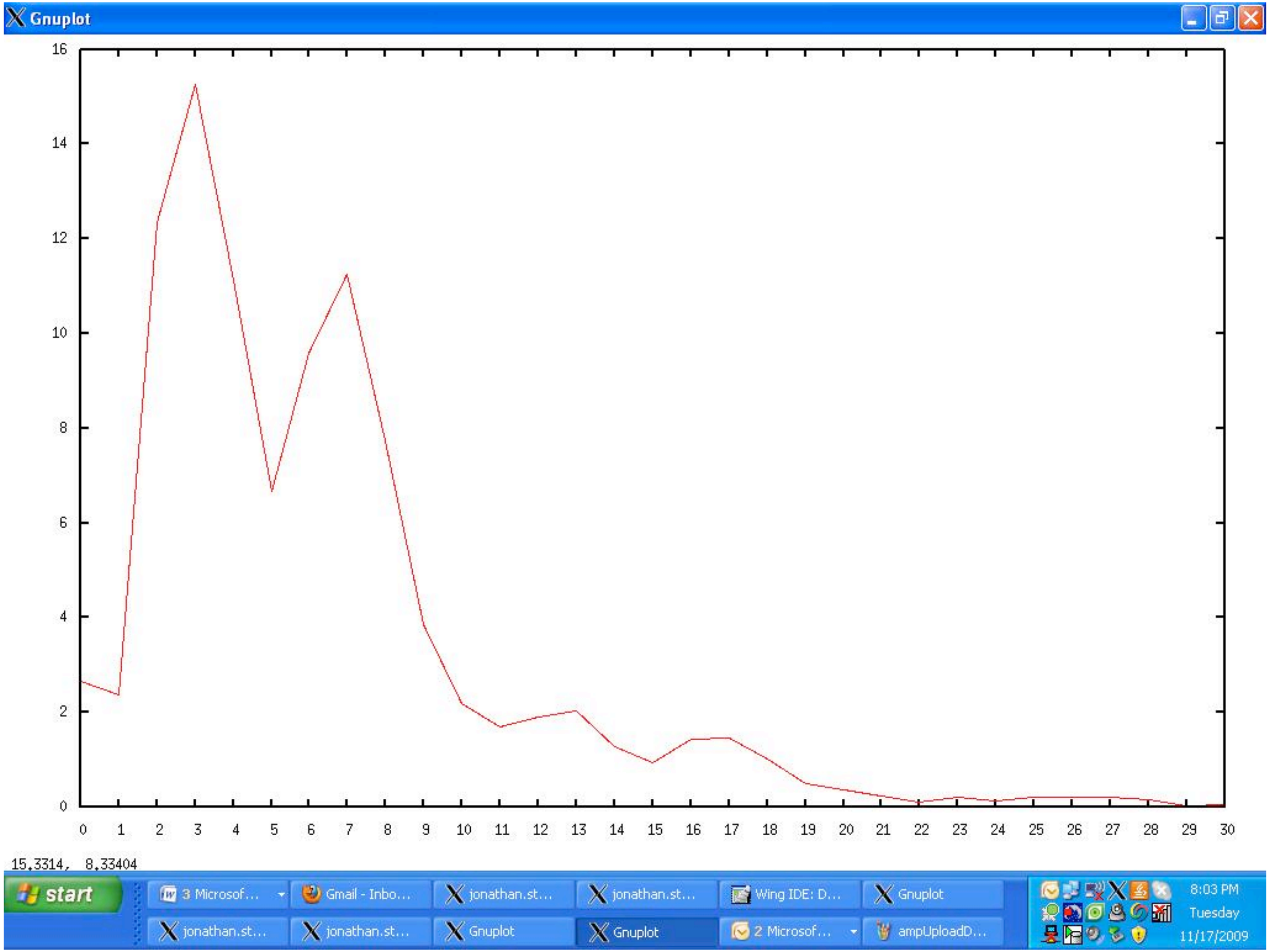
Requirements:

- 500-800Kbps for news/music channels; 800-1.5Mbps for sports; 1.5Mbps to 3Mbps for TVHD experience.
- Flash cloud issues
- Adaptive quality (multiple qualities)
- Rules indicating who can contribute to who.

Requirement implication:

- Since peers can only contribute on average 200Kbps upstream P2P from peers only is limited to 20% of BW needed.
- Additional sources are needed
- These additional sources must contribute much more than they consume thus cannot be ‘typical viewers’ if consuming the entire stream.
- If those sources are ‘CDN nodes’ (hosted by an external CDN as in many ‘hybrid solutions’ or by the P2P provider) the P2P benefits are limited to 20%-30% only.
- Possible but ‘not desired’ solution: ‘free riding’ on high upstream peers such as universities and institutions.
- RayV solution: Adding many additional ‘typical’ nodes streaming to each of them minimal data (2 MTUs/sec) and having those re-distribute to many other peers (we call those ‘amplifiers’)

Upstream available



Quality and the upstream problem

Requirement: Streaming in at least 1Mbps.

Fact: Average upload from typical peer is 200Kbps.

1) Required BW $= N_V \cdot MR$

2) Available BW$= \sum UR_i = N \cdot \overline{UR}$

3) Main goal function to maximize: $P2P_{Static} = 1 - \dfrac{U_S}{N_V \cdot MR}$ where U_S is upload from 'servers'

4) A crucial parameter describing the system is the difference between available bandwidth and required bandwidth namely: $\beta \equiv 1 - \dfrac{N \cdot \overline{UR}}{N_V \cdot MR}$

$\beta < 0$ means that theoretically peers can support themselves.

If $\beta > 0$, β is the minimum needed to upload from servers regardless the method used.

5) Clearly if $N_V = N$ we get that $\beta = 1 - \dfrac{\overline{UR}}{MR} \cong 0.7 > 0$

6) Since the server needs to upload the stream at least once, we can define α as the amount of bandwith for the initial dispersion of the content to peers.

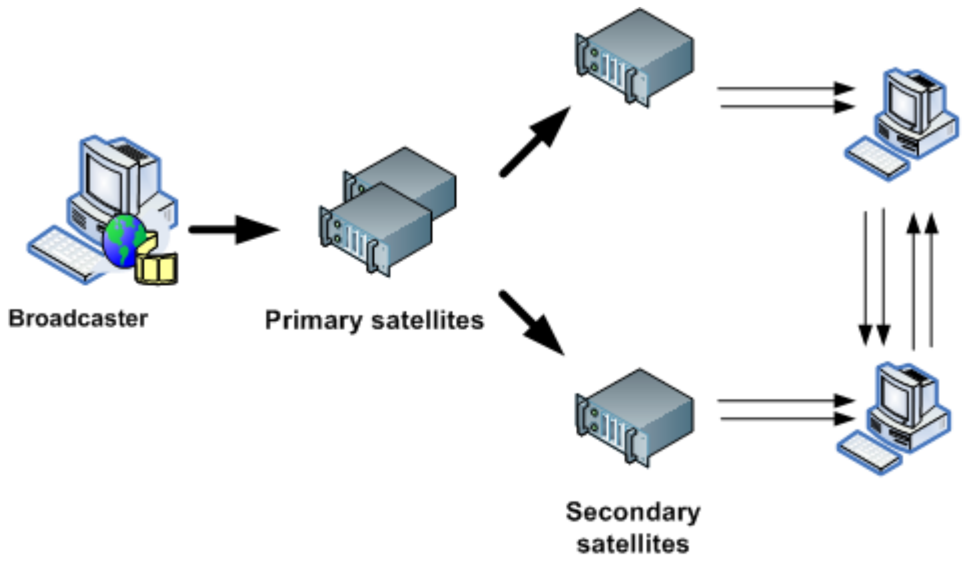
$$\alpha \geq \frac{MR}{N_V MR} = \frac{1}{N_V}$$

7) To summarize: $P2P_{Static} = 1 - \dfrac{U_S}{N_V \cdot MR} = 1 - (\alpha + \max(\beta, 0))$

Customers requirements - Quality

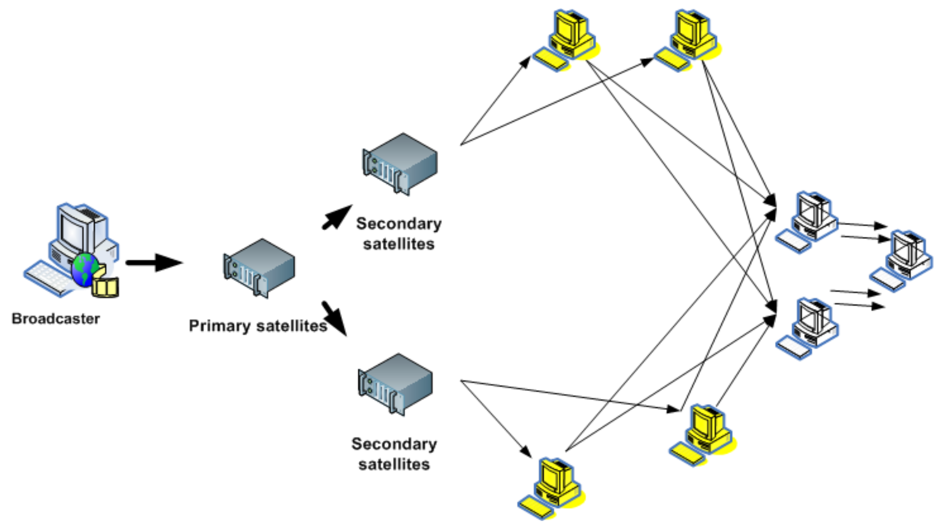
Viewers only:

MR = 4, Us = 4=1M
UR = 2
Nv = 2
Amps = 0



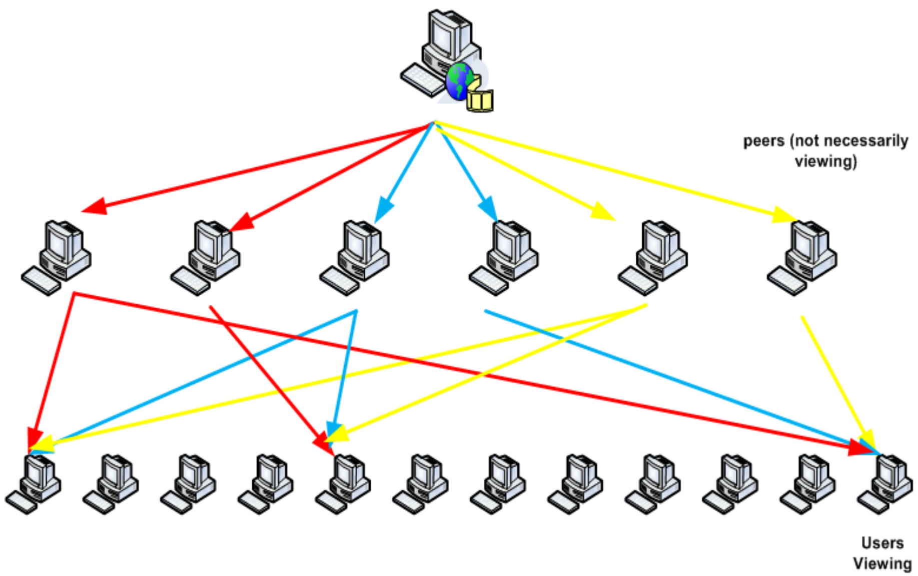
Amplifiers:

MR = 4, Us=4=1M
UR=2
Nv = 3
Amps = 3

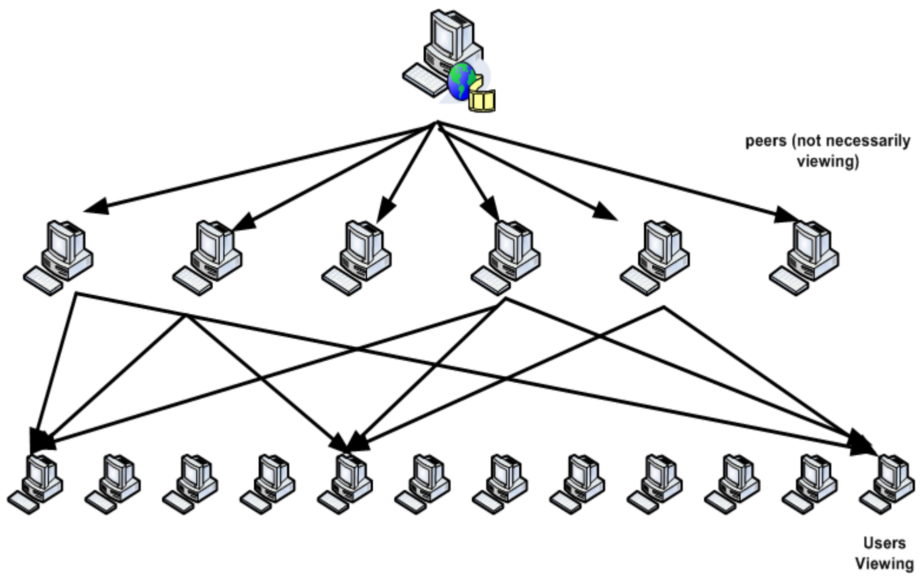


Grid structure – Mash vs. Tree

Tree



Mash



1) Viewer must receive from each branch
2) Branch failure problem
3) Tree dynamic creation
4) Tree management, raising levels
5) Hidden assumption of ‘balanced tree’ or ‘how to balance tree’ and how to solve the ‘weaker branch’ problem?
6) Video layers complex things but solvable

1) Not efficient , how much?
2) Assuming PET/IDA/NC:
   a) Depth problem
   b) Delay due to segment size
   c) CPU
   d) SVC Layers complexity (solvable?)

Network coding and delay

NC

$$A_1 = \alpha_{1,1} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,1} \otimes P_{SZ}$$
$$A_2 = \alpha_{1,2} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,2} \otimes P_{SZ}$$
.
.
$$A_{223} = \alpha_{1,223} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,223} \otimes P_{SZ}$$
.
.

P_i - is a media packet sized MTU
Sz – Segment size
Considerations:
Segment size adds delay and CPU
Each coefficient needs to be sent in the protocol
So new size is MTU+2^8*SZ*bits

Delay

1) Delay from encoder to viewers must not exceed 8-10 seconds
2) Viewers should watch 'simultaneously' with up to 2 sec difference

If a node receives a data chunk of size X every Y seconds, and spends the Y seconds until the next chunk arrives uploading it to its acceptors than :

$$Y \approx D_{Scheduling}$$

There is a maximum total buffer between broadcast and viewing in live streaming which implies a maximum on $D_{Scheduling}$ and thus on Y :

$$(D_{scheduling} + D_{Hop}) \cdot N_{hops} \leq D_{Buffer\max}$$

Moreover, since we want the reliable sources as well for at least 2RTT + const we get :

$$(D_{scheduling} + D_{Hop}) \cdot N_{hops} + 2 \cdot RTT + \text{const} \leq D_{Buffer\max}$$

Delay and hops

Requirements:

1) Delay from encoder to viewers must not exceed 8-10 seconds
2) Viewers should watch ‘simultaneously’ with up to 2 sec difference

If a node receives a data chunk of size X every Y seconds, and spends the Y seconds until the next chunk arrives uploading it to its acceptors than :

$$\mathrm{Y} \approx \mathrm{D}_{\mathrm{Scheduling}}$$

There is a maximum total buffer between broadcast and viewing in live streaming which implies a maximum on $\mathrm{D}_{\mathrm{Scheduling}}$ and thus on Y :

$$(\mathrm{D}_{\mathrm{scheduling}} + D_{Hop}) \cdot N_{hops} \leq D_{Buffer\,\max}$$

Moreover, since we want the reliable sources as well for at least 2RTT + const we get :

$$(\mathrm{D}_{\mathrm{scheduling}} + D_{Hop}) \cdot N_{hops} + 2 \cdot RTT + \mathrm{const} \leq D_{Buffer\,\max}$$

Peer Dynamics

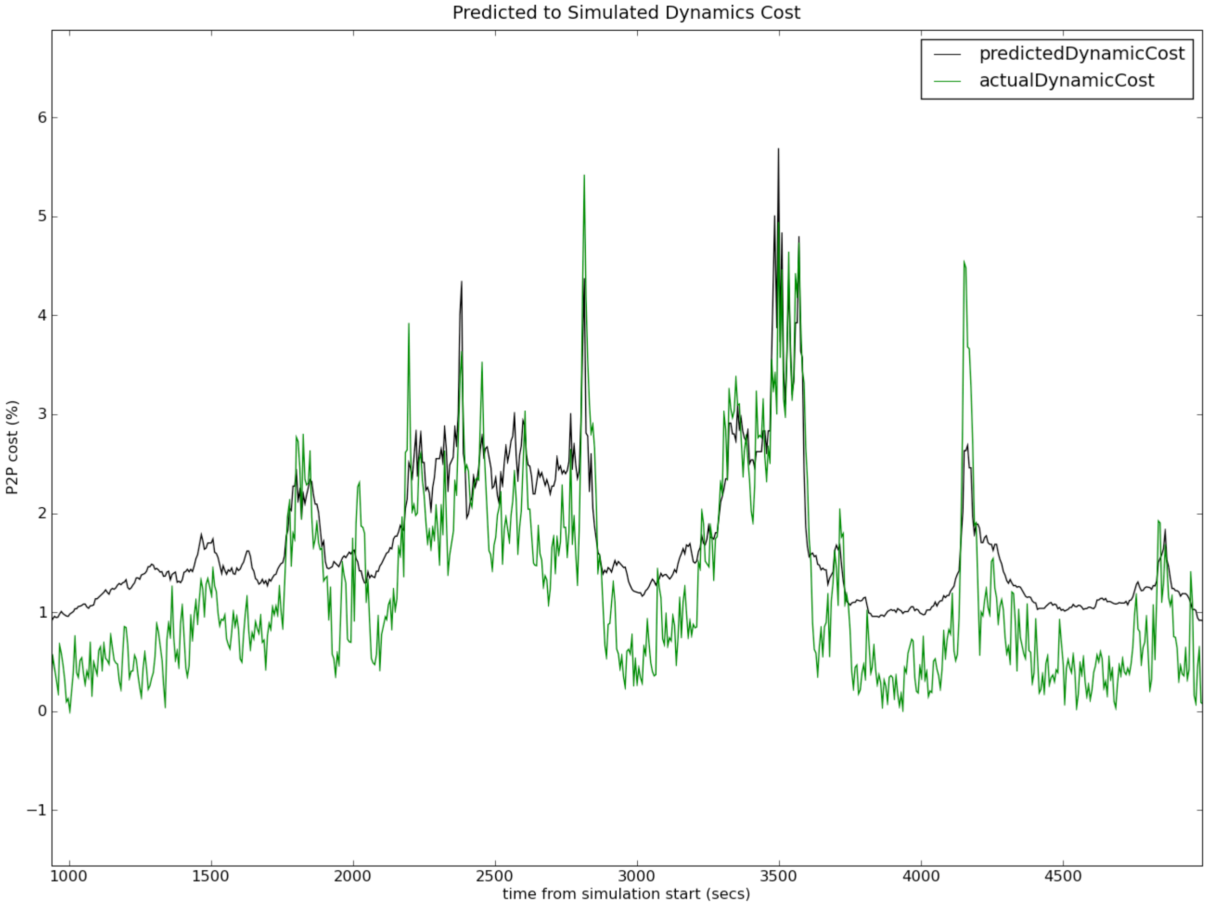
What is the cost of the dynamic behavior? – Peer churn

Ratio A/V = 3:1, 1000 Viewers

average Viewer life time ~10 minutes

No NAT traversal

No delay in peer list

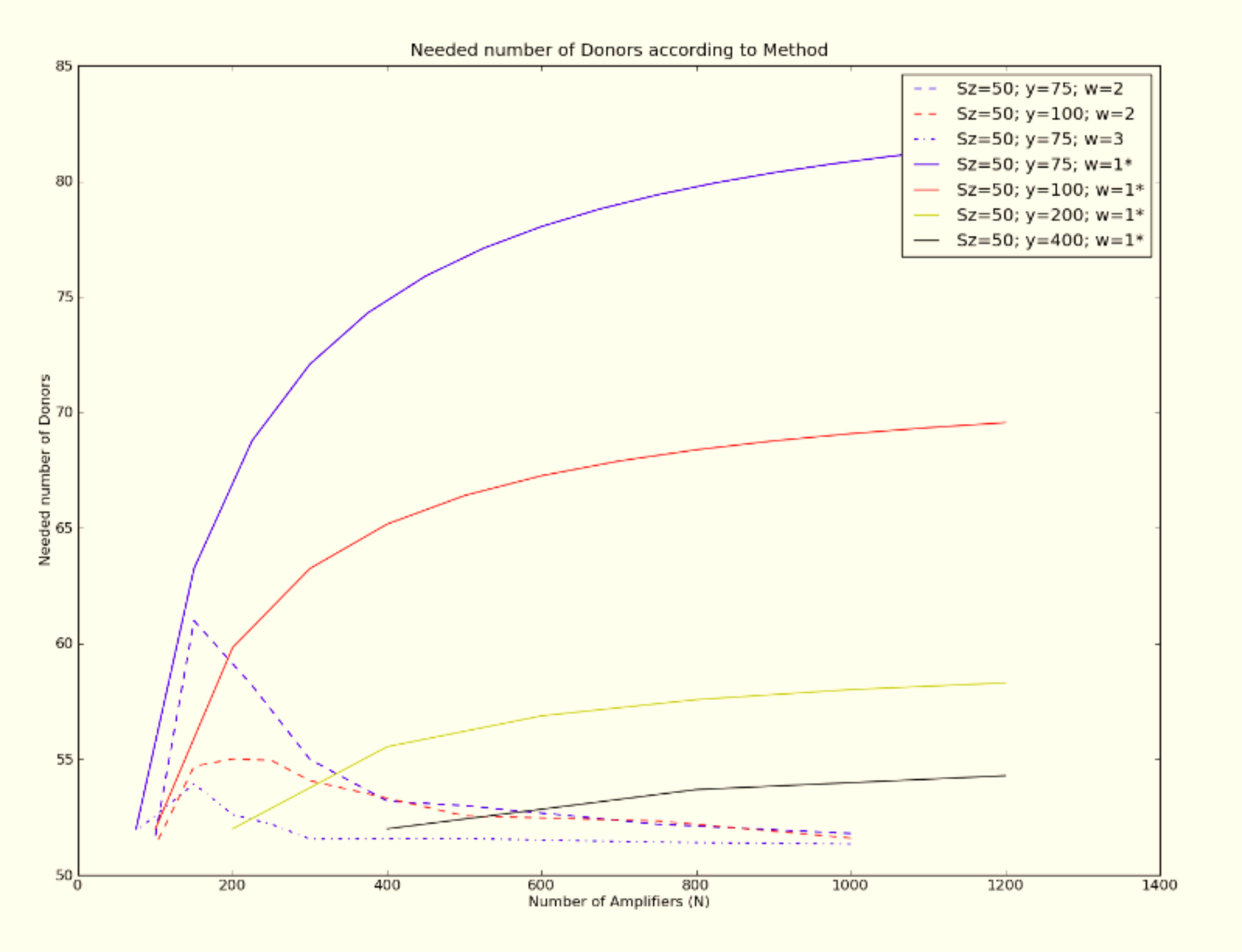


Network coding techniques

Parameters:
Sz - Segment size

y - number of primary amps, which receive their equations directly from the satellite.

w - 'mixing' factor. Each amp takes equations from w donors and generates a new on. naturally w, increases the needed upload from each amp.



Network coding techniques

$$A_1 = \alpha_{1,1} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,1} \otimes P_{SZ}$$

$$A_2 = \alpha_{1,2} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,2} \otimes P_{SZ}$$

.

.

$$A_{223} = \alpha_{1,223} \otimes P_1 \oplus \cdots \oplus \alpha_{SZ,223} \otimes P_{SZ}$$

.

.

P_i - is a media packet sized MTU
Sz – Segment size

Considerations:
Segment size adds delay
Segment size increases CPU
Each coefficient needs to be sent in the protocol
So new size is MTU+2^8*SZ*bits