



# Research Review

Rudra Dutta, CSC, NCSU

April, 2014



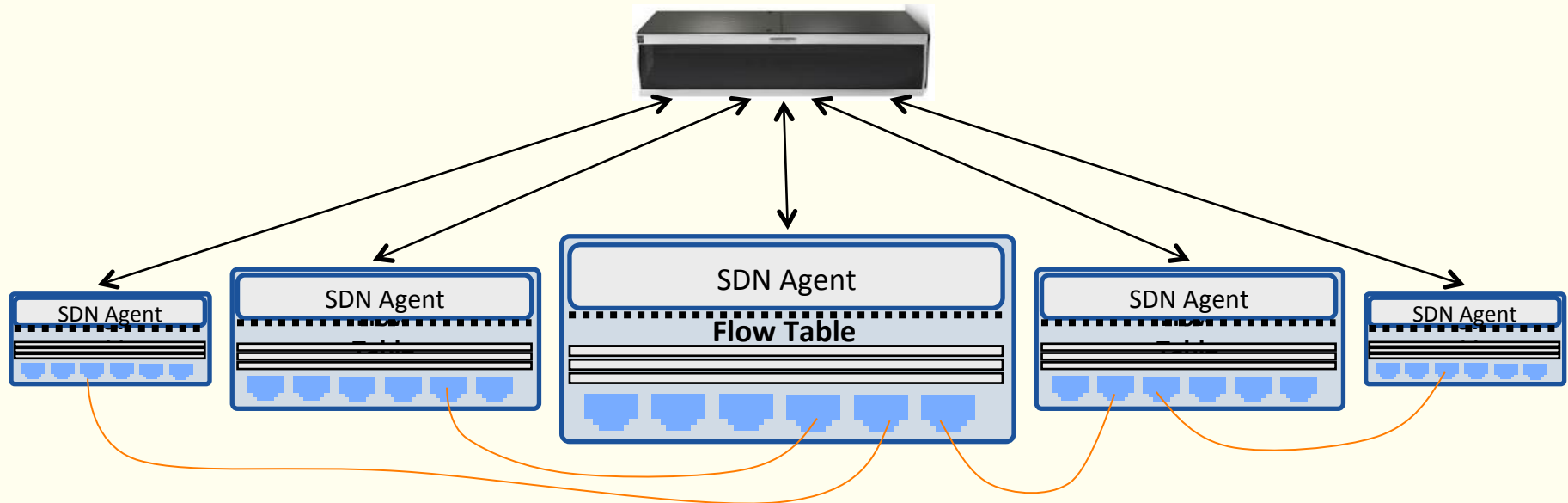
# Networking Frontiers

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- Ubiquity
  - Mobility, Addressing, Binding
  - Dependability, Confidentiality, Availability
  - Cyber-physical computing, sensing/actuating
- Software
  - “Up the stack” phenomenon
  - Down the stack, also – virtualization
  - And sideways – policy, measurement, economics, analytics
  - Democratization of networking functionality (chaotic?)
- Architecture
  - All of the above
  - Design tweaks won’t do it all
- Some work in above areas



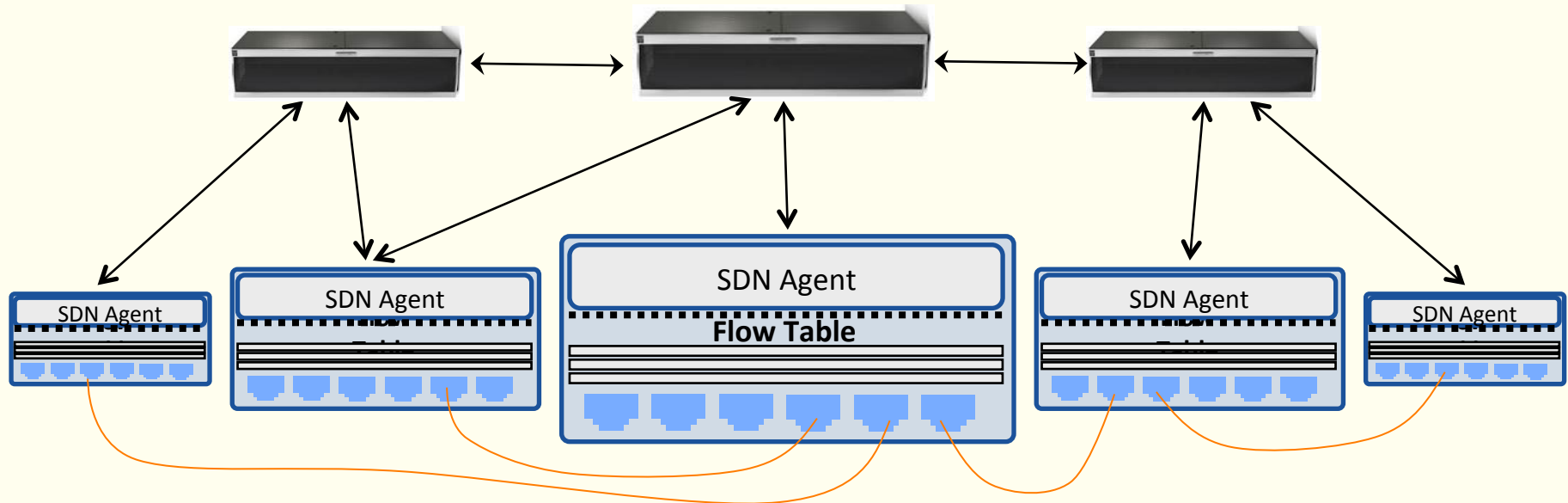
# Software Defined Networking



- Embodiment of policy box
  - Forwarding policy (routing), security policy, energy policy, economic policy, ...
  - Realized in hardware or software
  - Or platform running software “policy programs”



# Controller Federation

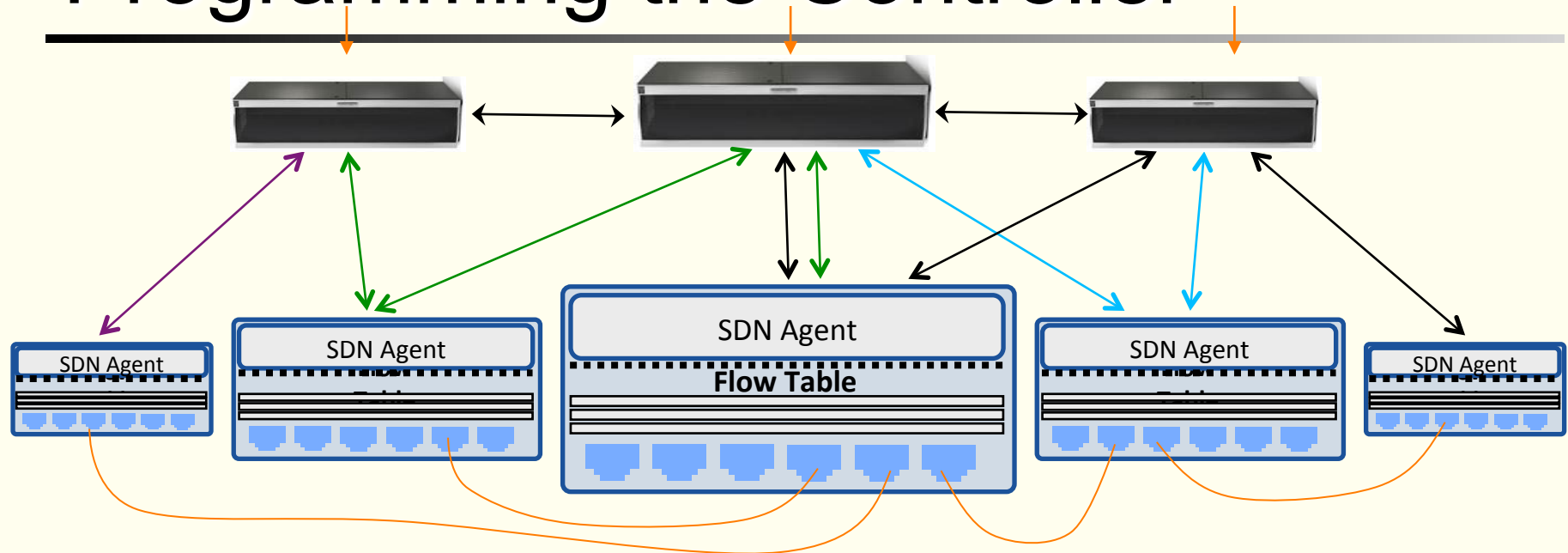


- Different datapaths belong to different entities
  - Controlled by different controllers
- Flows route through multiple domains
  - Controllers must coordinate among themselves
  - Possibly exchange limited privileges on datapaths





# Programming the Controller



- Controller application must be written in some language
  - northbound API of controller
- Not well standardized in OpenFlow
- OpenDaylight – a proposal by an industry consortium
  - Multiple southbound API support
  - Standardized single northbound API



# Network Virtualization (Many Faces of)

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- No “added functionality”, but “moving around”
  - Makes functionality available where it was not
  - An architectural distinction
- An attempt to define complex network functions as abstractions:  $NF \rightarrow VNF$ 
  - That can then be implemented to produce similar behavior on diverse platforms
  - Orchestrated without knowing underlying platform
  - Possibly as software, on VMs  $\rightarrow NFaaS$
- “Software Networking” ?



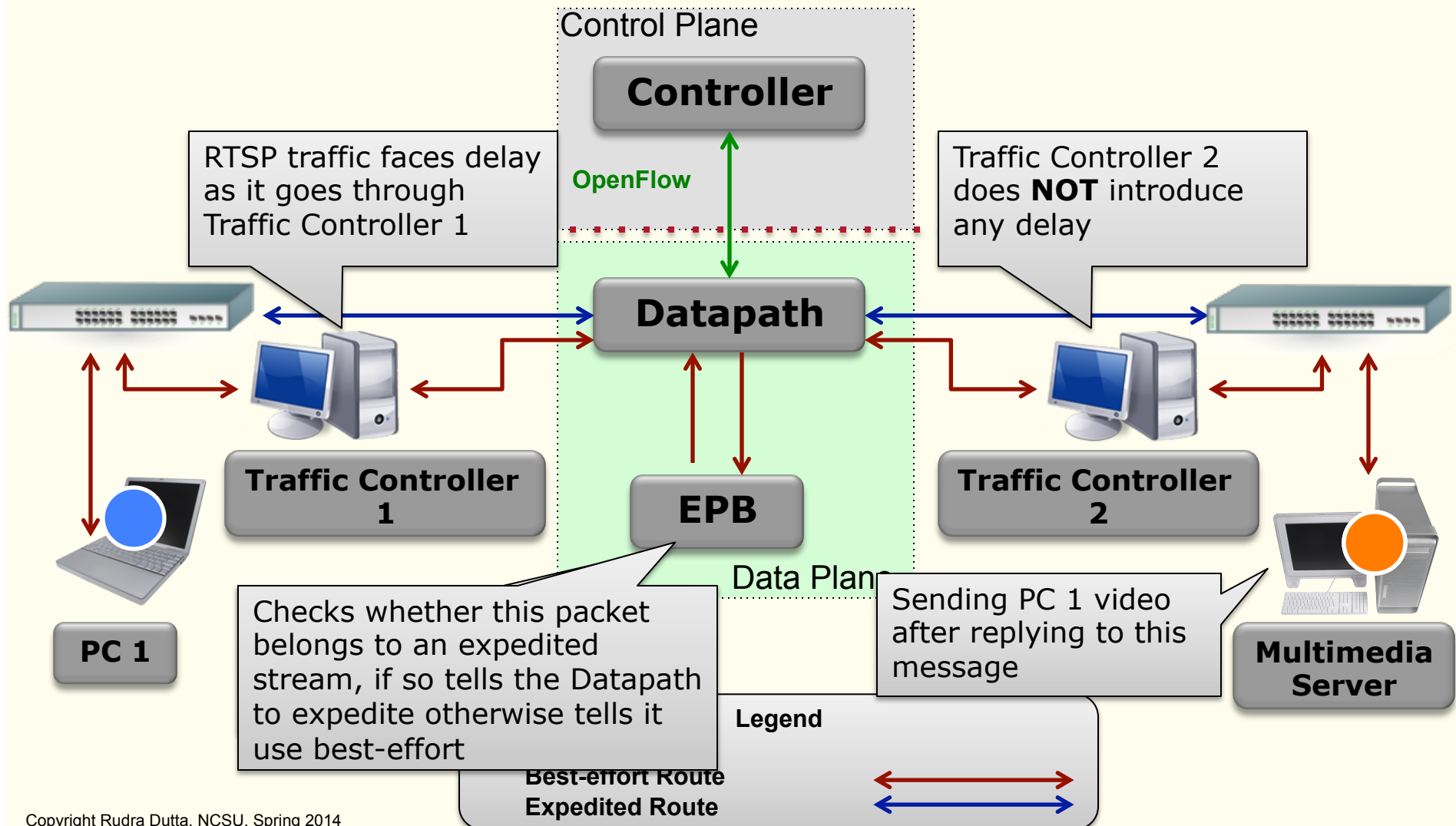
# SDN Lab

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# Experiment – Traffic Flow: Best-Effort Model



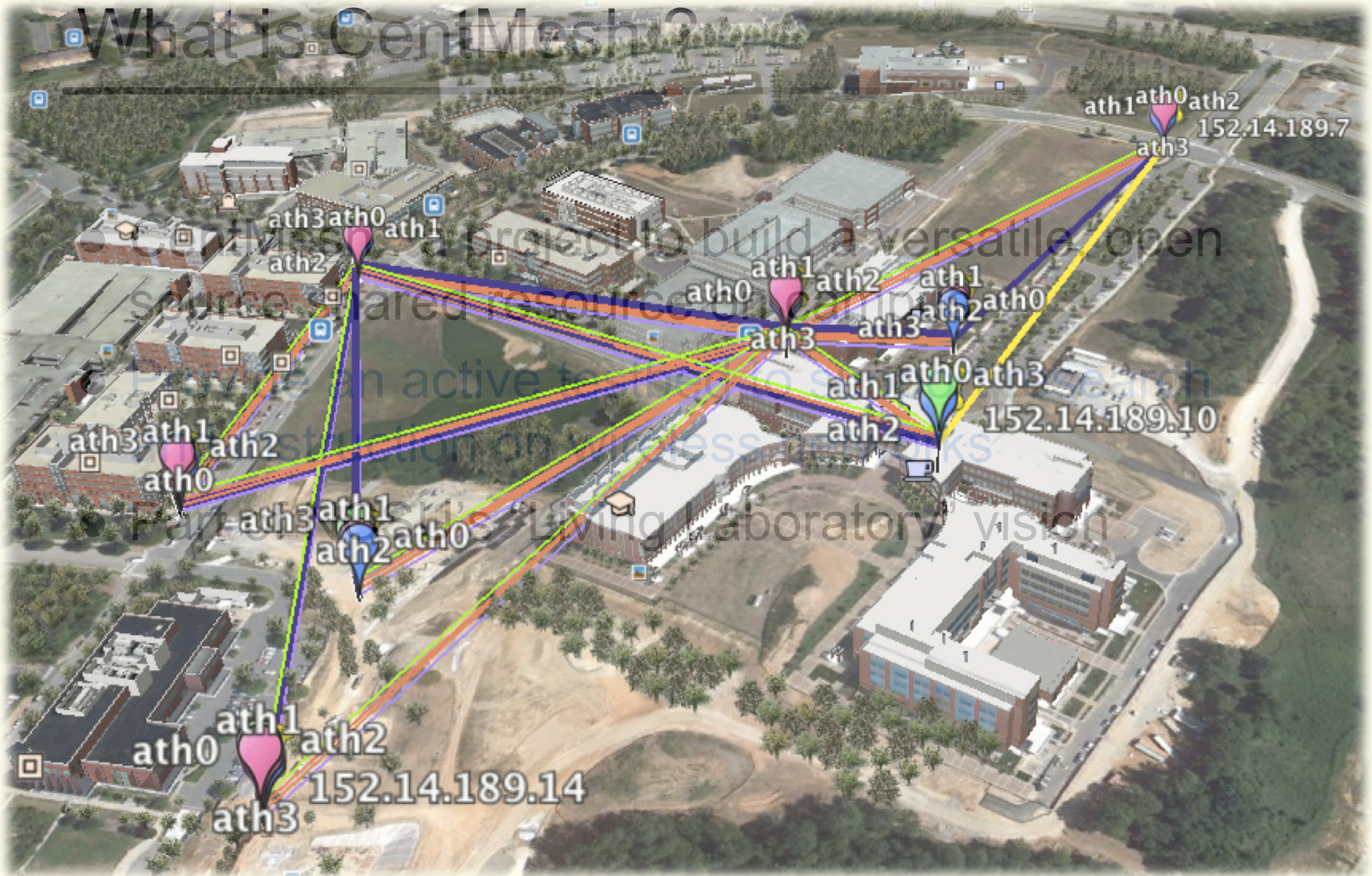


# Network Management Evolution

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- Networking management processes need study
  - Especially in light of the coming SDN revolution
- Processes are human processes - not crisp and clear
- Data-driven = human-centered, here
- Goal: use analytics to spot vulnerable process points, opportunities
  - Automation of SDN management
  - Vulnerability elimination









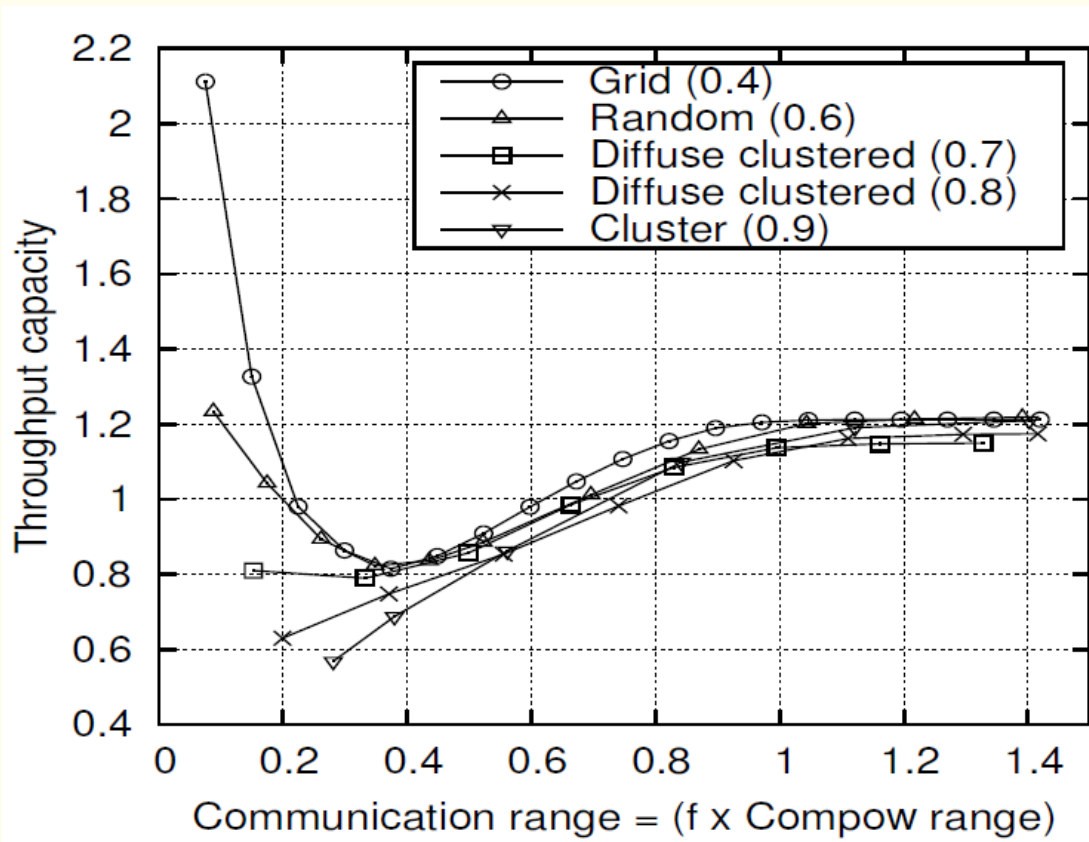
# Who Built CentMesh ?

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- **Homemade !**
  - Built by NCSU student researchers
  - Guided by NCSU faculty
  - Funded by Army Research Office and NCSU
  - Operationalized by Institute of Technology of Next Generation (ITng), NCSU



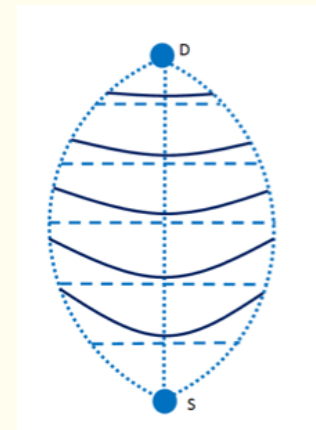
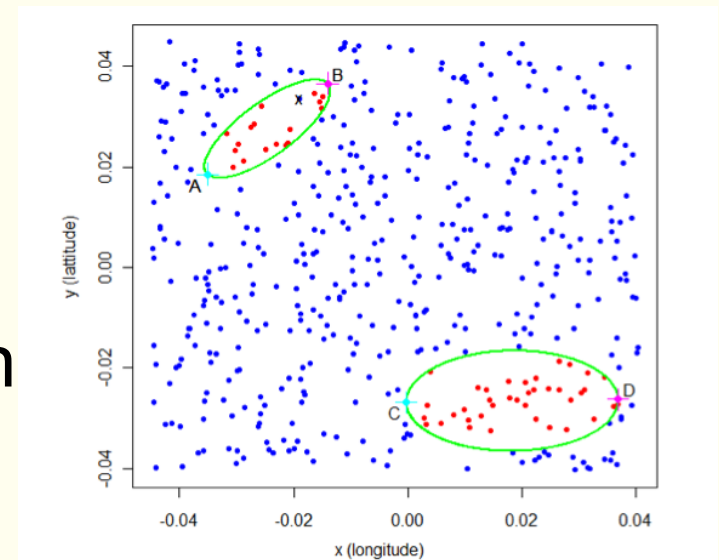
# Impact of Power Control in Mesh





# Geodiffuse Routing

- A form of limited flooding
- Nodes over an area form a diffuse path
- Ready to forward transmission if most direct path seems to have difficulties
- Can coordinate with heuristic mechanisms, and fine tune



# CentMesh

The NCSU Centennial Wireless Mesh Project

## Drones Challenge 2014



R Kasyap Marmavula,  
Vaidy Ananthanarayan,  
Dr. Mihail Sichitiu,  
Dr. Rudra Dutta



Hmm..what can you do? Can you traverse a path?

Certainly – I can even avoid obstacles !

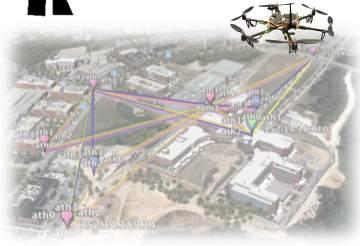
Take sensor readings or video, stream it back ?

Yes – I tie into the NCSU CentMesh sesnornet !



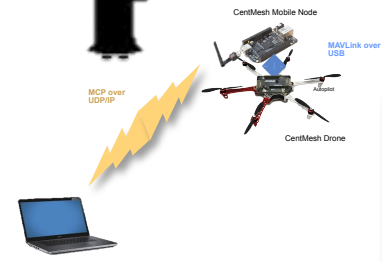
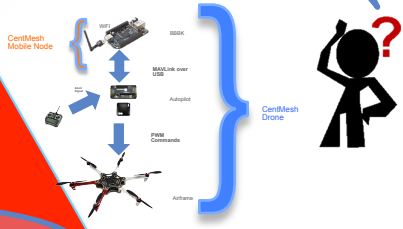
Where did they get you from ?!

NCSU faculty and students fabricated me – and put in a computer to make me autonomous ! (Thanks) 😊



So can I use you for teaching course XYZ or research ?

I don't know what that is but I can if you program me to do it !



**Come fly with me !**  
**Join the programming challenge**



[go.ncsu.edu/drones\\_challenge\\_2014](http://go.ncsu.edu/drones_challenge_2014)  
Qualifying challenges: March 31<sup>st</sup>, online  
Final challenge: April 12<sup>th</sup>, Centennial Oval

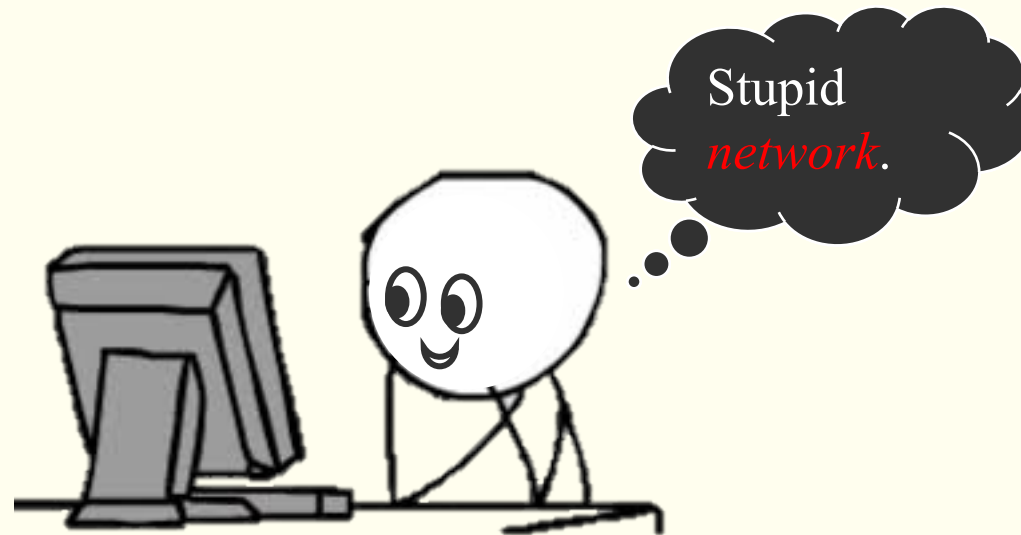


Drones Challenge 2014 Grand Sponsor: Aruba Networks  
CentMesh funded by: Army Research Office



# Network Innovation through Choice

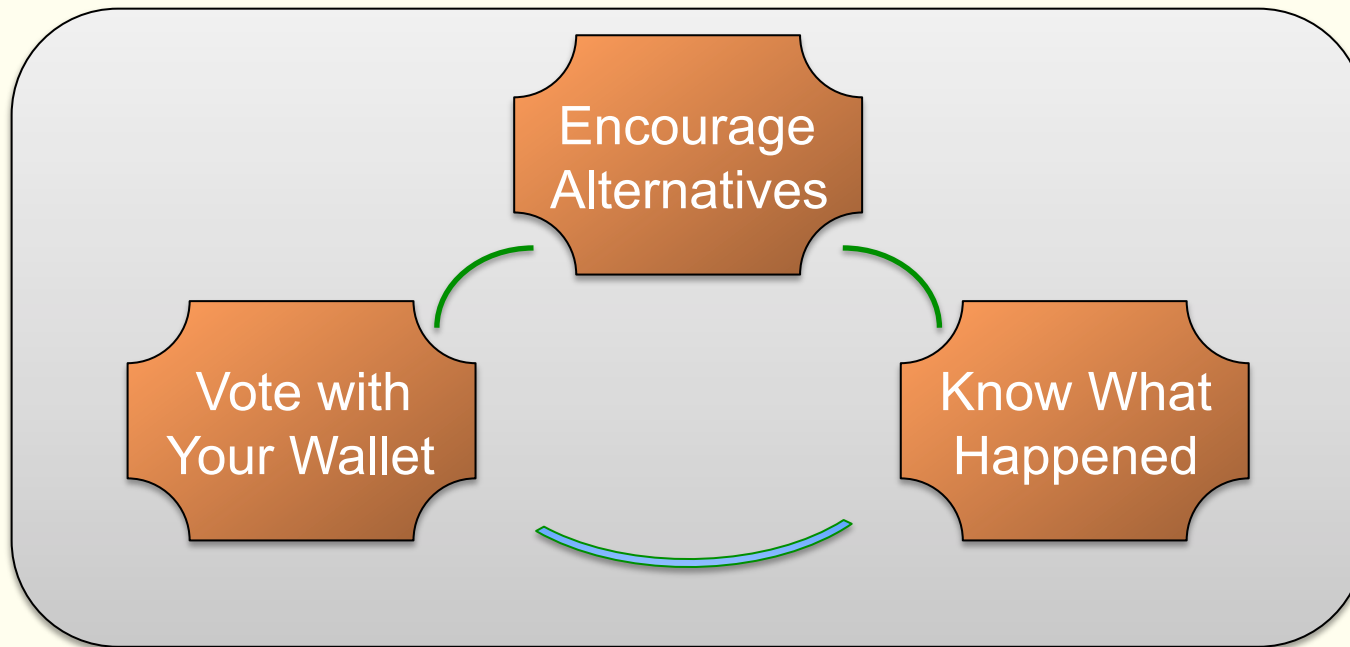
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- Informed exercise of choice (backed by money) can reward providers with good performance
- Select for helpful providers, beneficial ecosystem



# Architectural Need





- Informed exercise of choice (backed by money) can reward providers with good performance
- Select for helpful providers, beneficial ecosystem





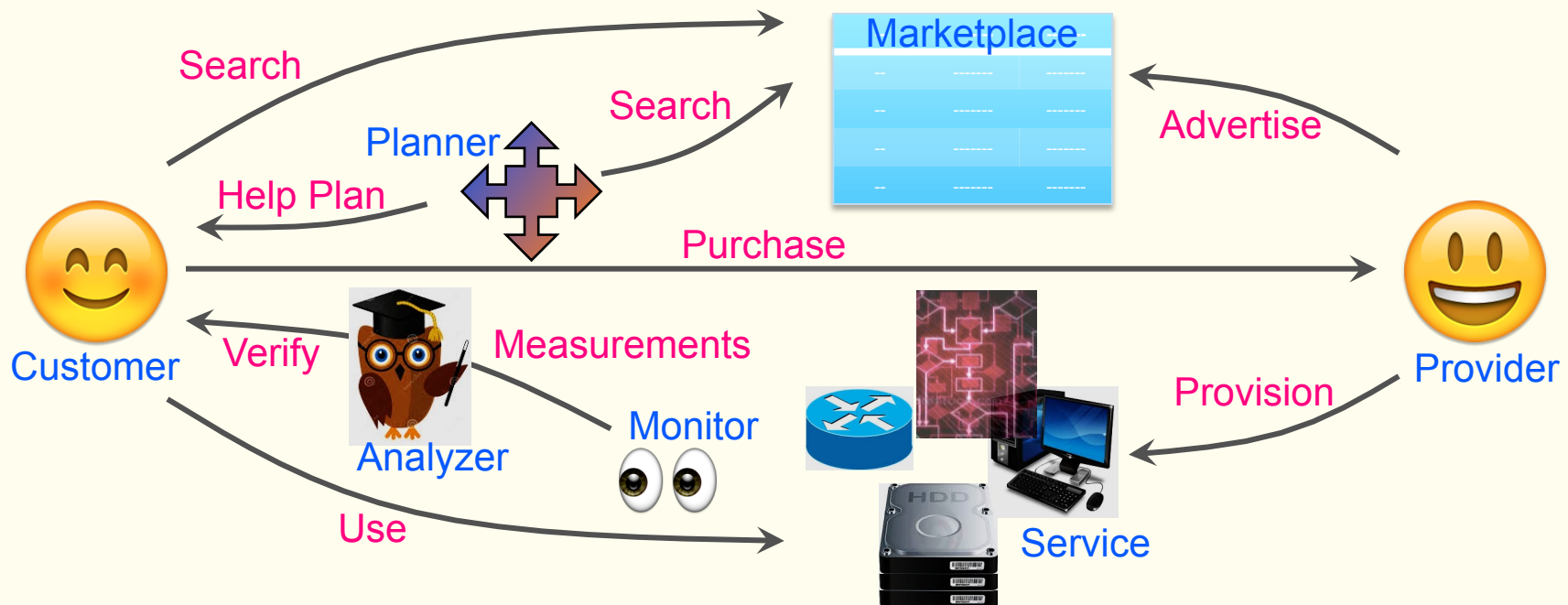
# ChoiceNet Entities / Interactions

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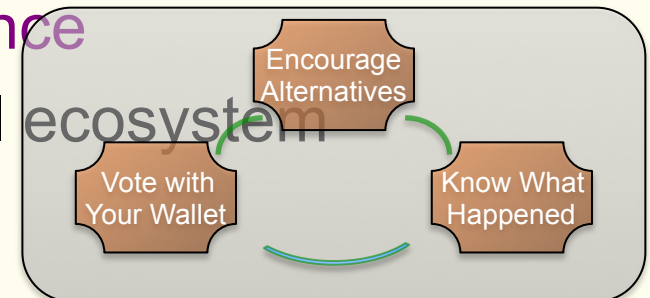
- Consumer – willing to exchange consideration for services deemed of value
  - User who exercises choice → “chuser” 
- Provider – provides services in exchange of consideration 
  - HW/SW infrastructure provider (path service)
  - Marketplace provider
  - Composition provider
  - Verification provider



# Entities and Interactions



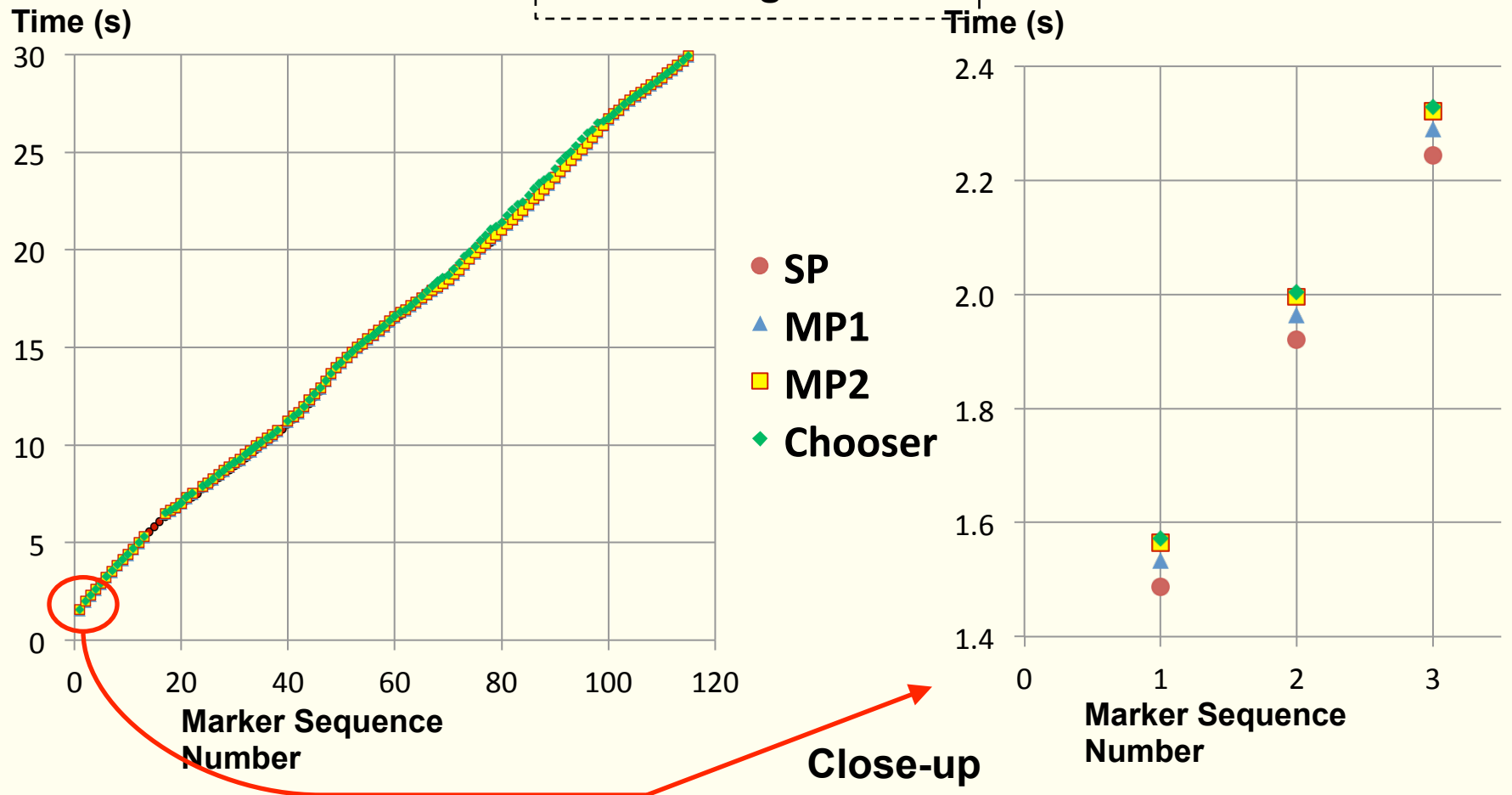
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# Jitter Apportionment for Video UX

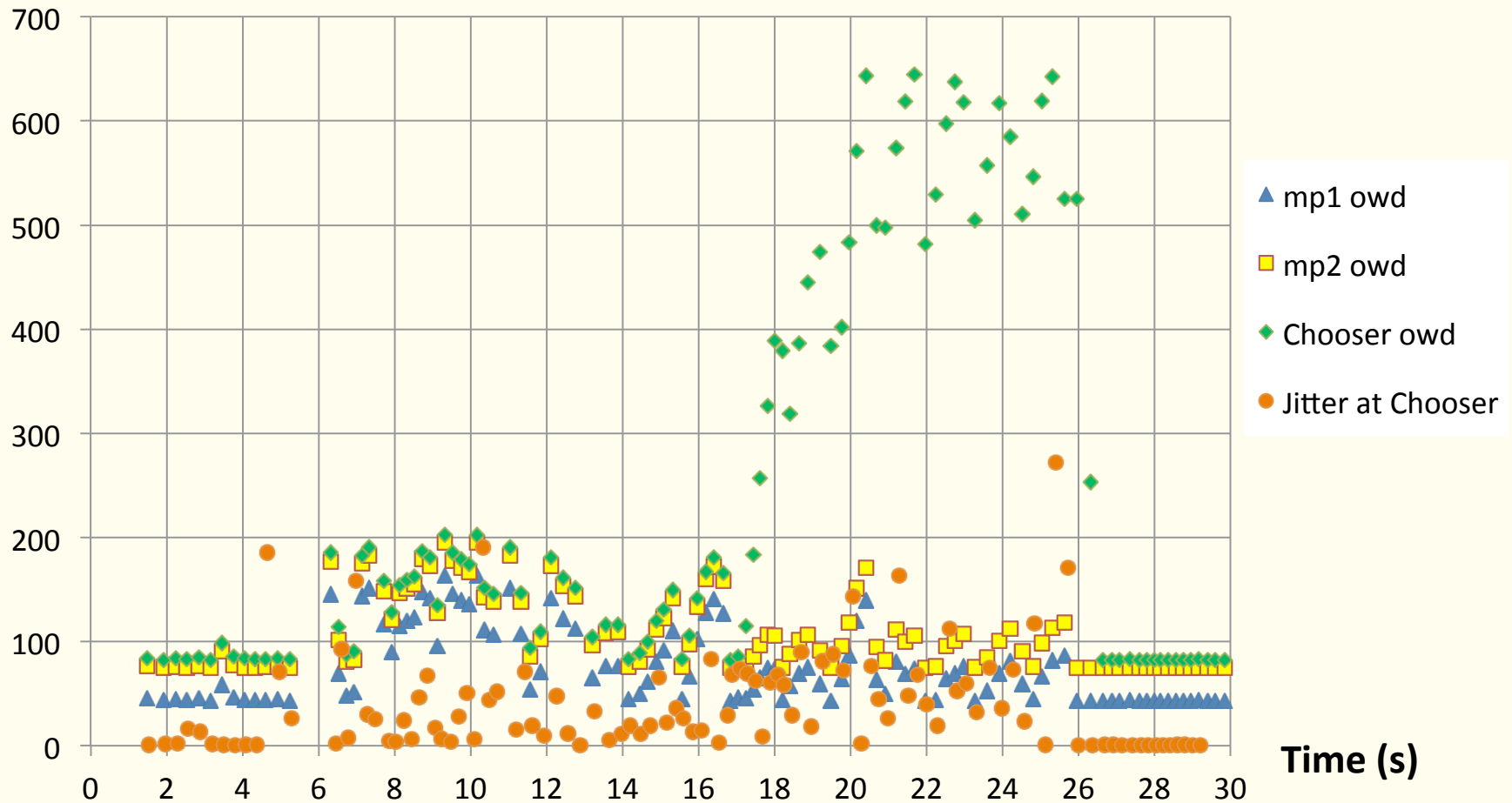
Raw MD Figures





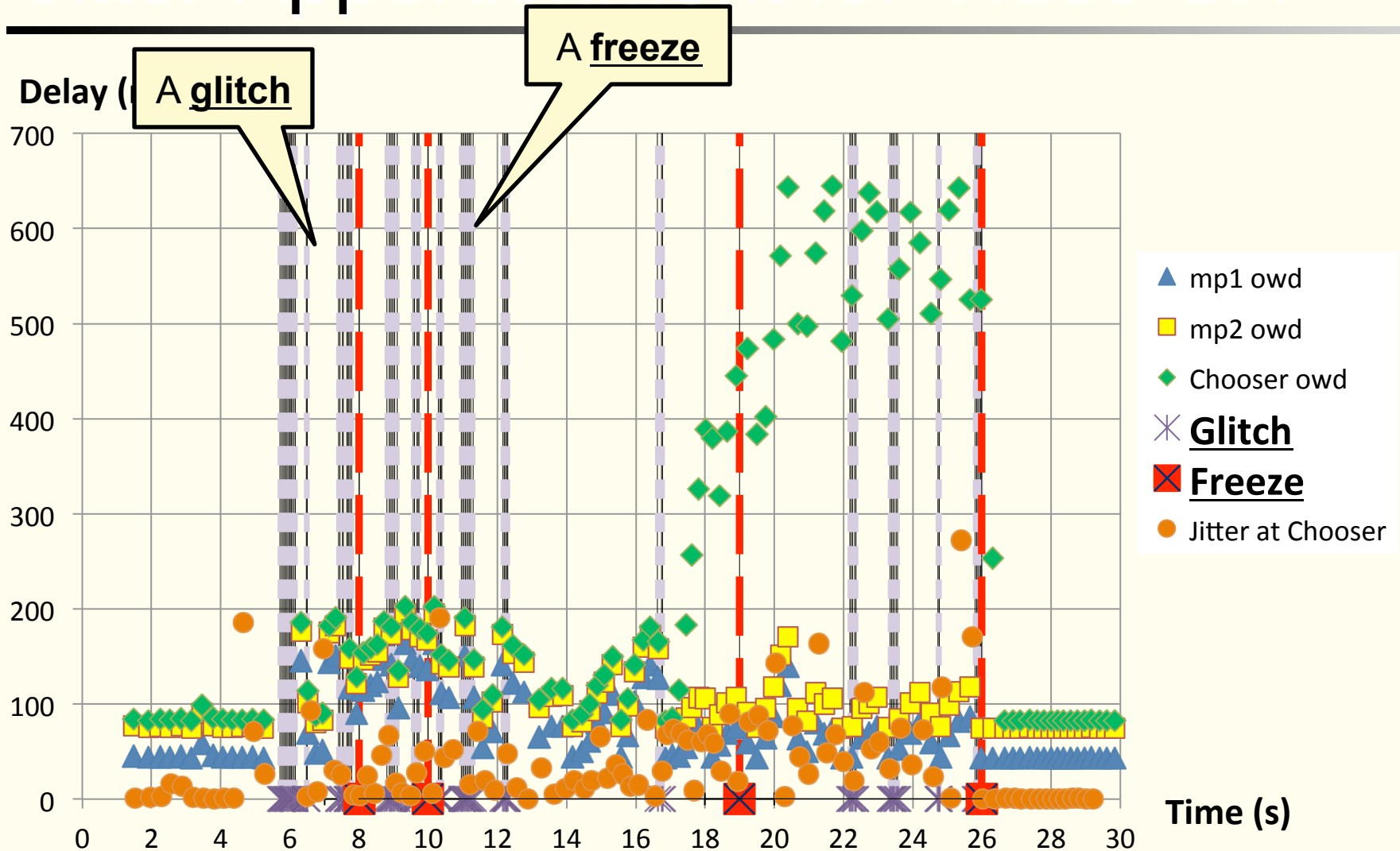
# Jitter Apportionment for Video UX

Delay (ms)





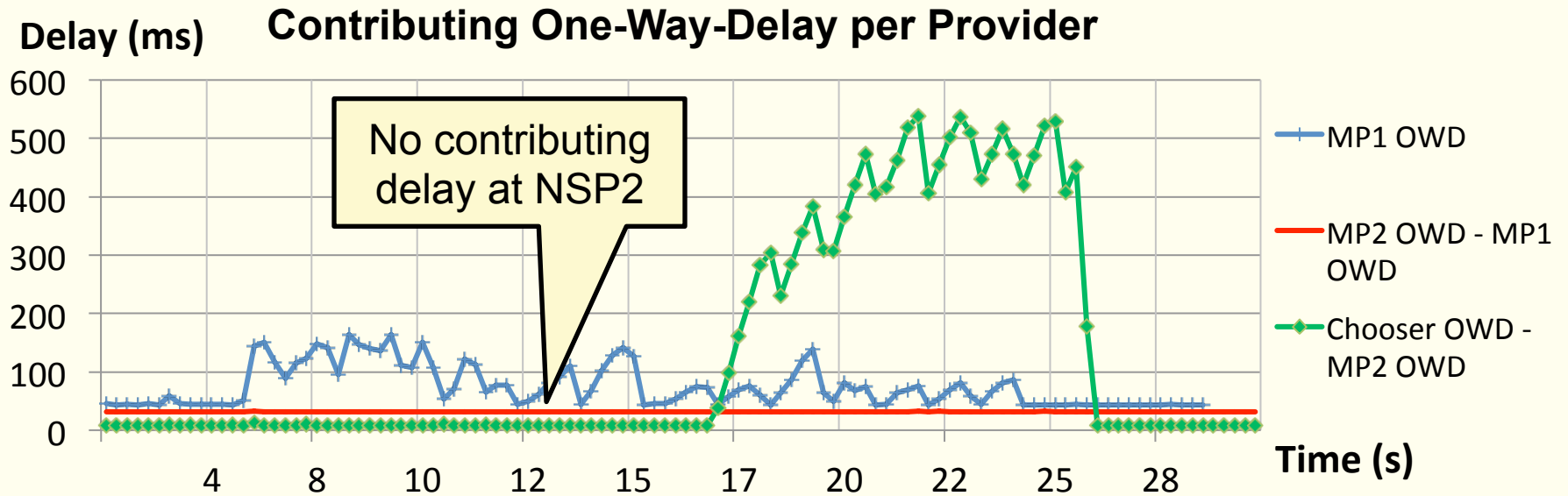
# Jitter Apportionment for Video UX



**Glitches** denote the losses and **Freezes** denote video playback freezes



# Jitter Apportionment for Video UX



## Basic Analysis Results

Provider	Mean Jitter %	Std. Dev. Jitter %	Max Jitter %
NSP1	44.6 %	32.8 %	25.3 %
NSP2	0.2 %	0.3 %	0.2 %
NSP3	55.2 %	66.9 %	74.5 %





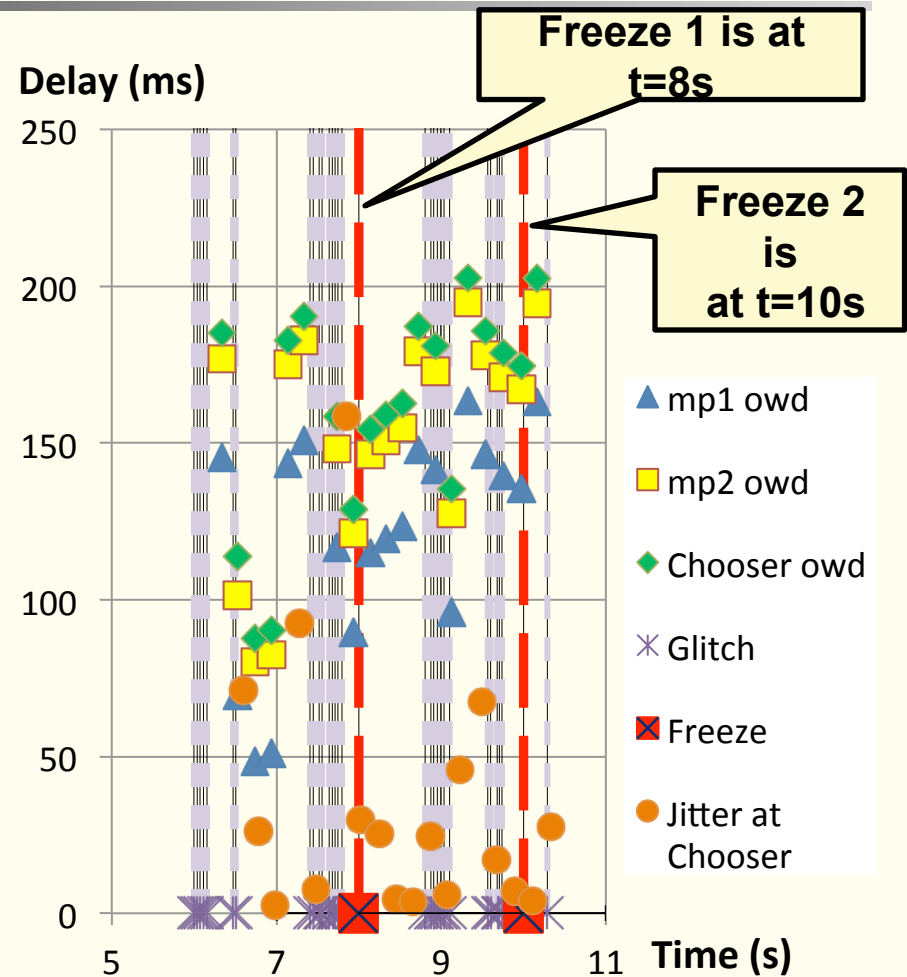
# Jitter Apportionment for Video UX

## Analysis for freeze 1 [t=6 and t=10]

	Mean %	Std dev %	Max J %
<b>NSP1</b>	<b>96.7 %</b>	<b>93.8 %</b>	<b>94.7 %</b>
<b>NSP2</b>	0.2 %	0.6 %	0.2 %
<b>NSP3</b>	3.1 %	5.6 %	5.1 %

## Analysis for freeze 2 [t=8 and t=12]

	Mean %	Std dev %	Max J %
<b>NSP1</b>	<b>98.5 %</b>	<b>97.2 %</b>	<b>97.2 %</b>
<b>NSP2</b>	0.0 %	0.0 %	0.0 %
<b>NSP3</b>	1.5 %	2.8 %	2.8 %





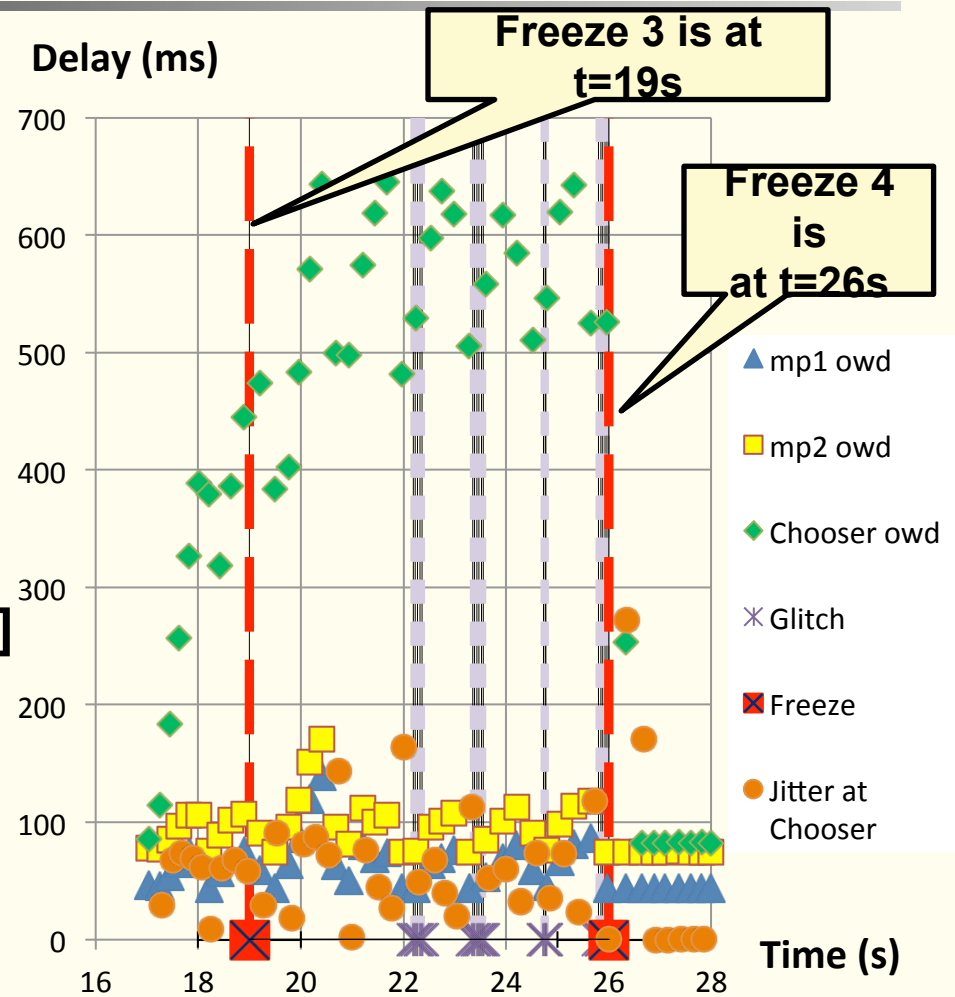
# Jitter Apportionment for Video UX

## Analysis for freeze 3 [t=17 and t=21]

	Mean %	Std dev %	Max J %
NSP1	27.7 %	42.2 %	50.2 %
NSP2	0.2 %	0.4 %	0.3 %
NSP3	72.1 %	57.4 %	49.5 %

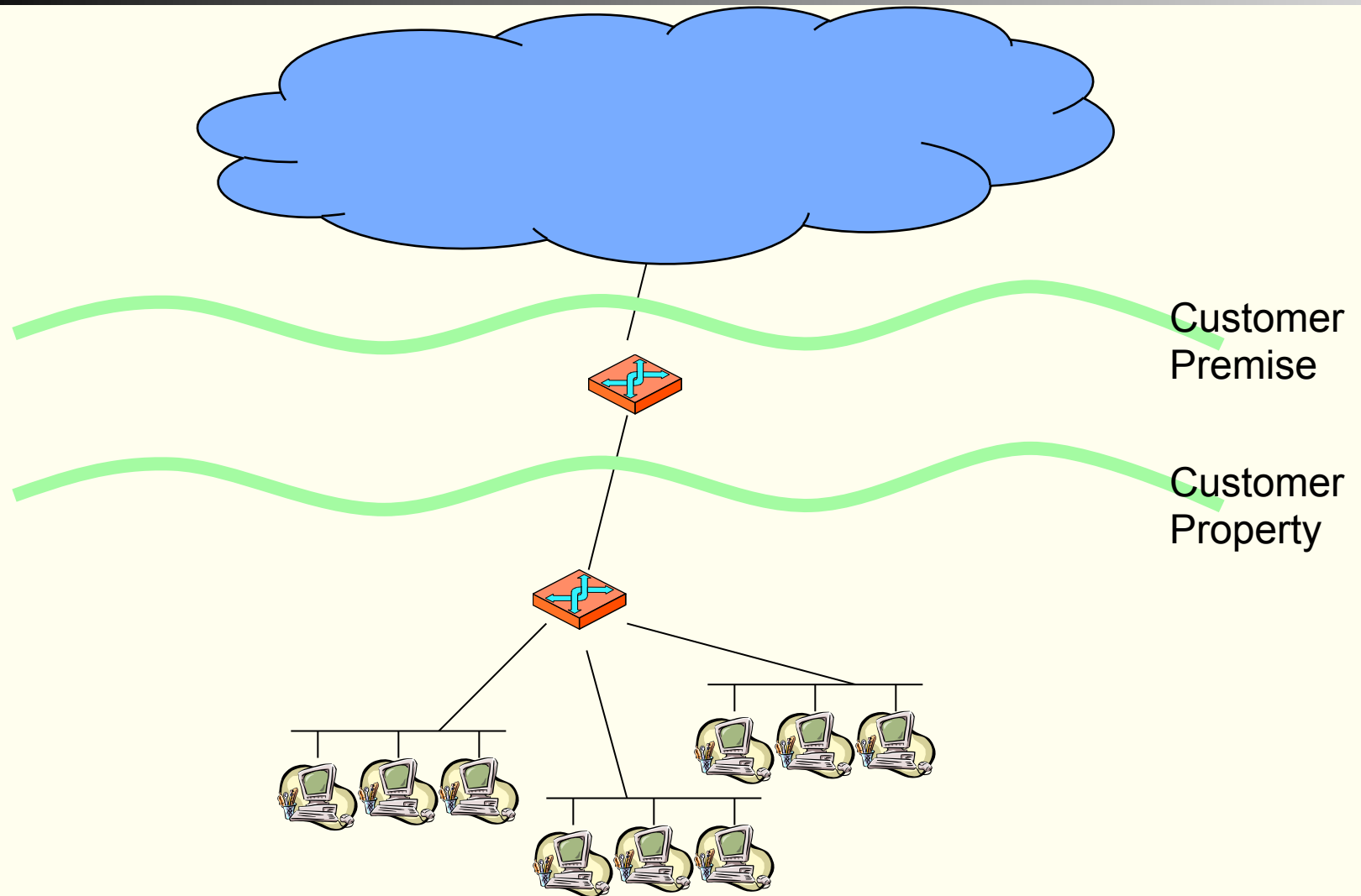
## Analysis for freeze 4 [t=24 and t=28]

	Mean %	Std dev %	Max J %
NSP1	14.0 %	13.8 %	13.6 %
NSP2	0.2 %	0.2 %	0.2 %
NSP3	85.8 %	86.0 %	86.2 %





# Security in the Cloud – Cost Points





# Industry Research Relationships

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- Challenges

- Industry needs *applicable* research partnerships
  - Good deal of specificity
  - Time and effort to acclimatize
- Faculty and students need to do research
  - Discovery of new knowledge, all that
  - Publish papers, pass PhD milestones – three years or so

- Opportunities

- Computing is roaming free in the world
- Real-world problems, like it or not
- New problems, like it or not
- Synergy