

Exploiting Just-Noticeable Difference of Delay for Improving Quality of Experience in Video-Conferencing

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March 1, 2013

Quality of Experience in Video Conferencing

- Signal Quality



Video



Audio

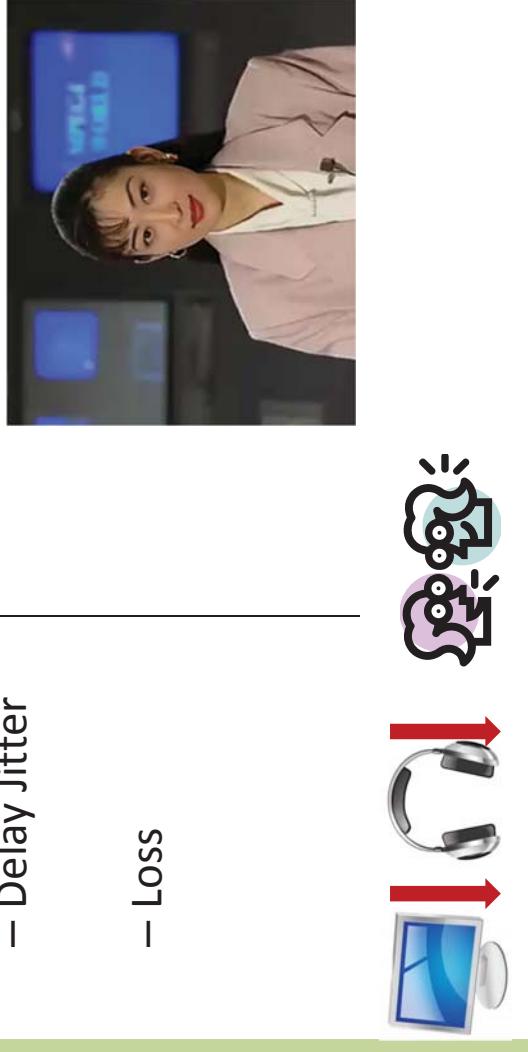
- Interactivity



Ease in communication

Video Conferencing over IP

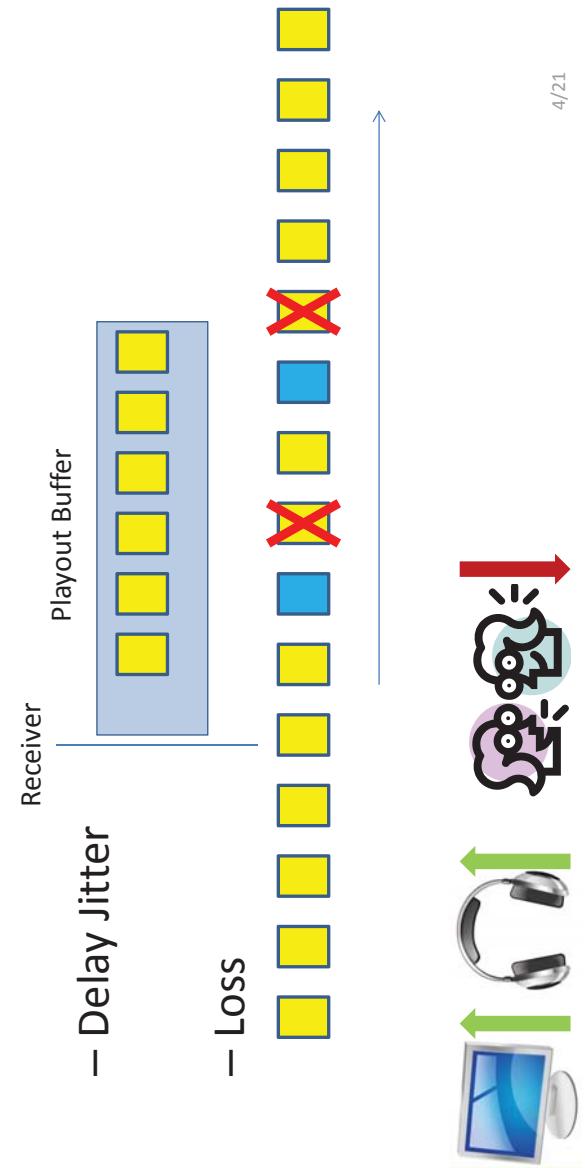
- Quality cannot be assured in best-effort IP network
 - Delay Jitter
 - Loss



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Video Conferencing over IP (cont'd)

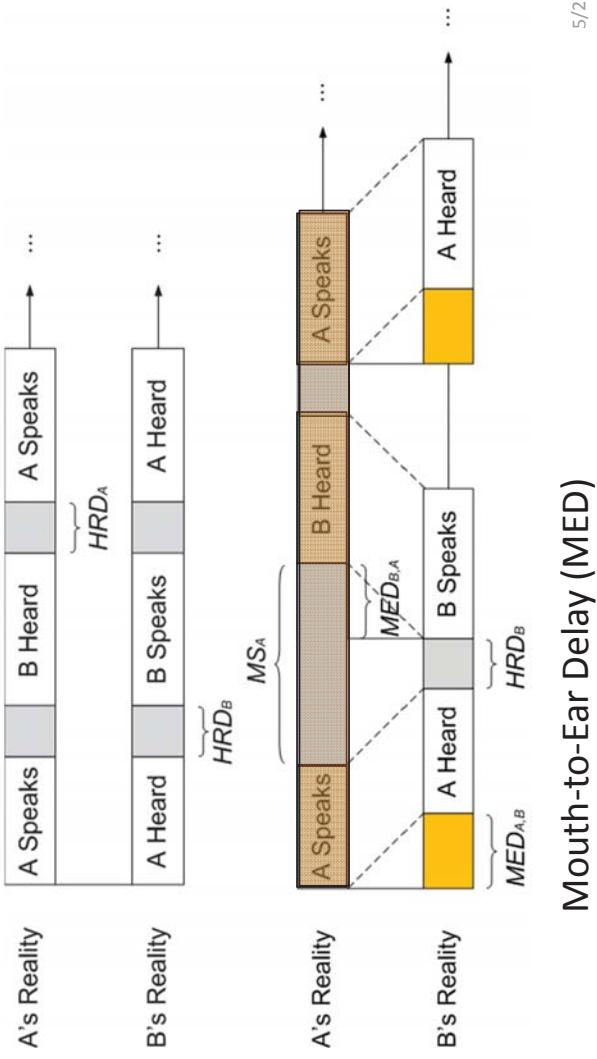
- Channel Level Methods



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Effects of Delay

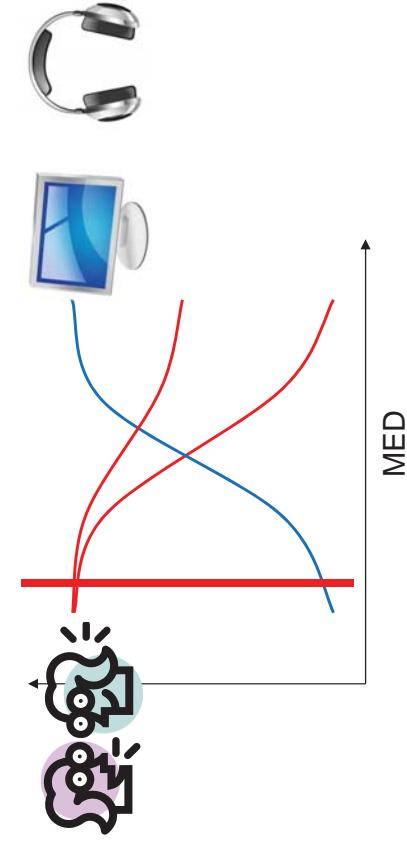
- Conversational interactivity



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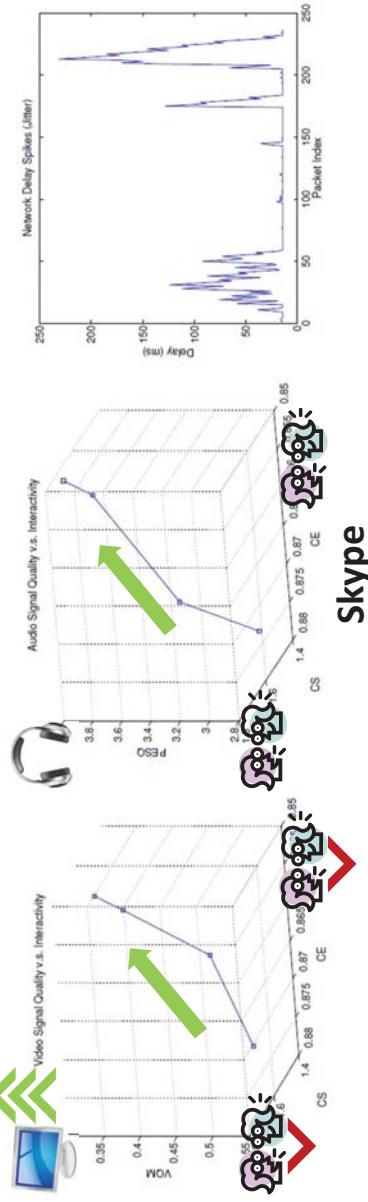
Trade-offs: Delay and Interactivity

- MED need not be constant
 - Adjusted to attain best perceptual quality under lossy network



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Problem: Suboptimal Operations of Existing Systems



Key Idea

- Increase buffering time (and MED) for packets
 - To improve signal quality: validated in many Internet connections
 - Without degrading interactivity **How?**
- Just-noticeable difference
 - A concept from psychophysics
 - Human cannot perceive small difference
- **Increase MED by JND**

Network Behavior

- A detailed study on the current Internet
 - From more than 10,000 traces from PlanetLab

Description	Fraction	Loss Rate	Delay Mean (ms)	Jitter (ms)	Congested
Good	45%	0.02%	23	6	
	22%	0.10%	94	7	N
	9%	0.05%	153	2	
Lossy	7%	2.18%	45	13	N
	4%	0.09%	57	83	
	5%	0.21%	1691	545	Y
Jittered	1%	0.43%	2490	714	
	24%				
	4%	11.34%	701	257	
Lossy and Jittered	2%	9.39%	63	47	Y
	1%	3.22%	85	61	

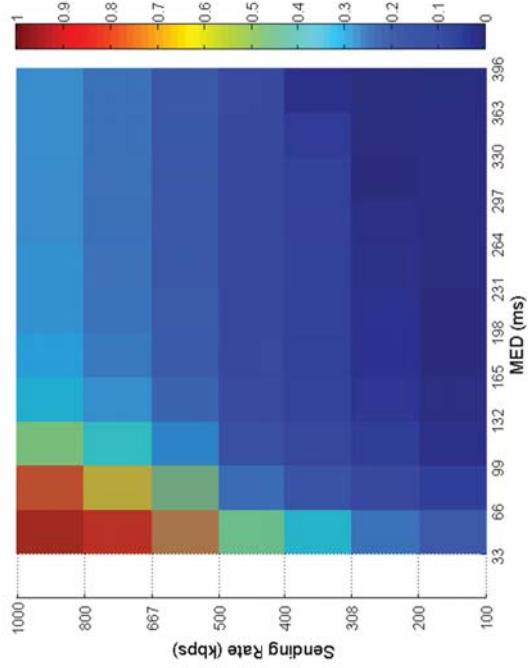
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Network Behavior

- Loss rate, delay and jitter
 - Monotonically non-decreasing with sending bit rate (supported by hypothesis test):
 - Traditional rate control
 - However not changed in some links even though sending rate is reduced:
 - Rate control does not work

Network Behavior with Buffering

- A longer MED helps
 - Buffering
 - Recovery
 - Thus red within the



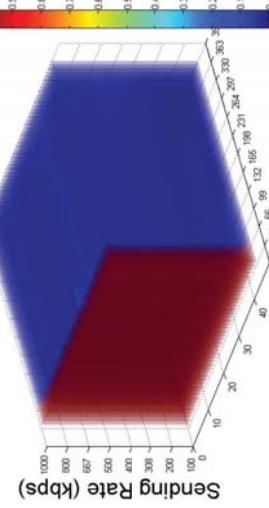
Ohio ⇒ North Carolina

Network Behavior with Buffering

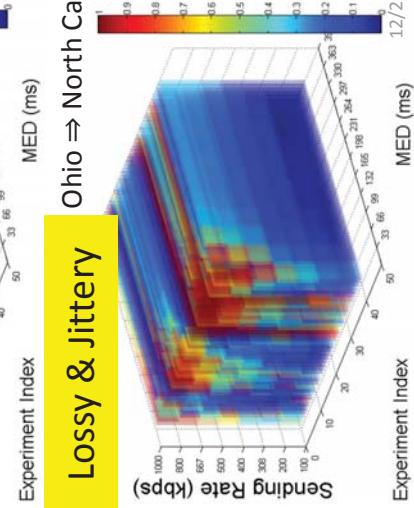
Good Oklahoma ⇒ South Florida



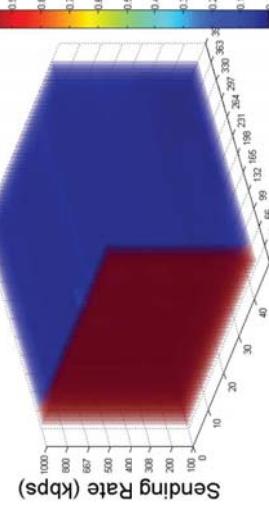
Jittery California ⇒ Minnesota



Lossy & Jittery Ohio ⇒ North Carolina



Lossy Massachusetts ⇒ France



Lossy & Jittery Ohio ⇒ North Carolina

Just-Noticeable Difference of Delay

- Definition
 - Let ρ_0 = fraction of subjects who correctly find the difference of the two given sessions
 - 75% JND of delay MED_A
 - maximum $|MED_B - MED_A|$ with which $\rho_0 \leq 0.75$
 - Why 75% rather than 50%?
 - User can guess to get 50%, but should really perceive the difference to get 75%

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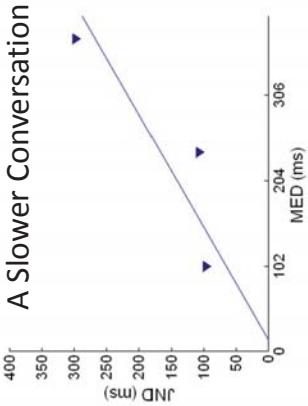
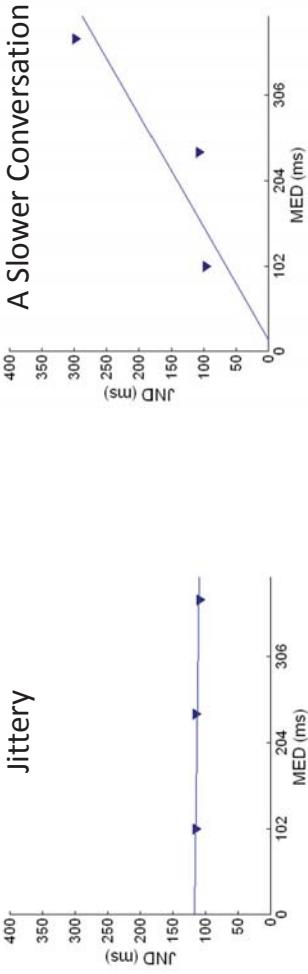
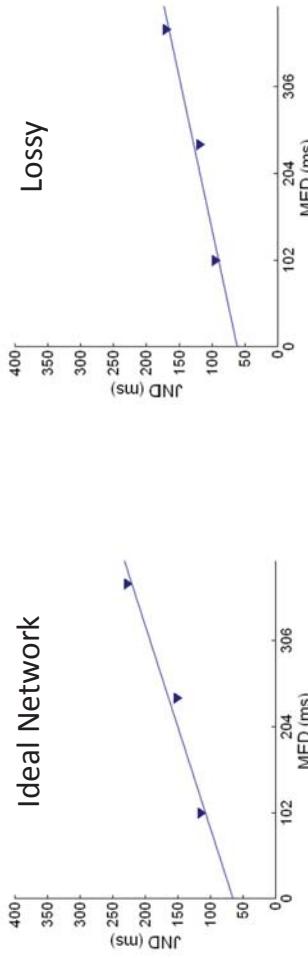
Measuring JND

- Comparative Subjective Test



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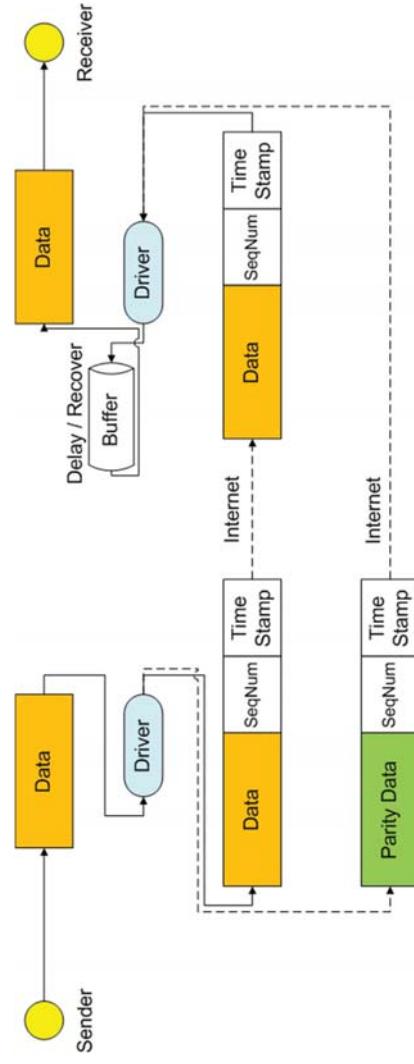
Results



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Experimental Results with Real Systems

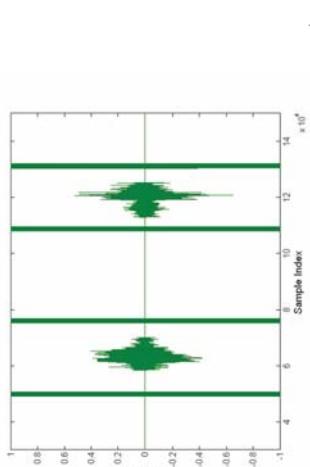
- Deploy interceptor in Windows to make buffer
 - A kernel driver developed with Windows Filtering Platform



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Experimental Results with Real Systems

- Measure the QoE with our *Real/Talk* testbed



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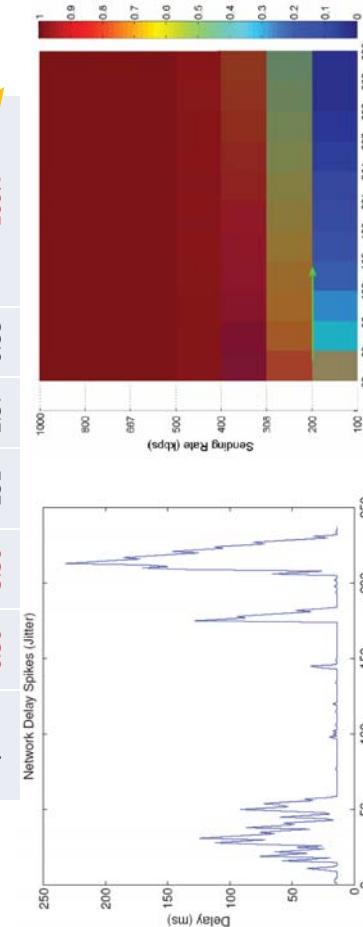
Demonstration

- Skype

- Trace based emulation (TCN): Jittery Connection: California \Rightarrow Minnesota

	VQM	PESQ	MED (ms)	CS	CE	% of Subjects preferring Scheme
Original	0.54	3.77	239	1.54	0.88	0%
Proposed	0.36	3.36	251	1.57	0.88	100%

Subject's Choice!

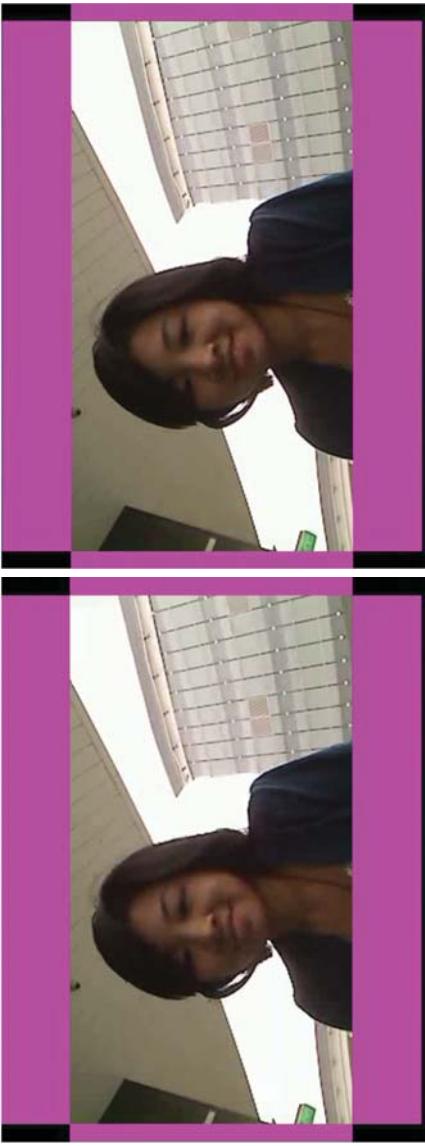


- Randomly generated jittery trace (NISTNet):
Informal subjective tests also show that the proposed scheme > Skype's

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Demonstration

- Skype



Original Operating Point

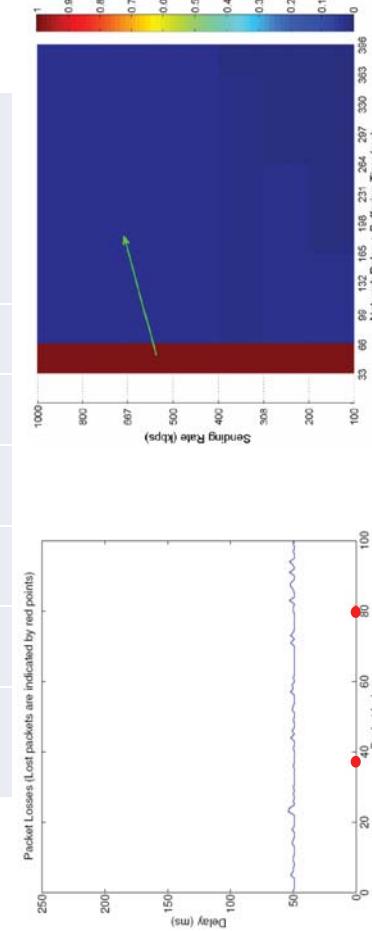
Increased MED within JND

Jittery Connection: California \Rightarrow Minnesota

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- Windows Live Messenger
- Trace based emulation (TCN): Lossy Connection: Massachusetts \Rightarrow France

	VQM	PESQ	MED (ms)	CS	CE	% of Subjects preferring Scheme	Subject's Choice!
Original	0.76	3.08	276	1.63	0.87	0%	
Proposed	0.41	3.72	363	1.82	0.83	100%	



- Randomly generated lossy trace (NISTNet):
Informal subjective tests also show that the proposed scheme > Skype's
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Demonstration

- Windows Live Messenger



Original Operating Point

Increased MED within JND

Lossy Connection: Massachusetts ⇒ France

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Conclusion

- Problem
 - Suboptimal operations of Existing Systems in QoE
 - Skype, Windows Live Messenger
- Holistic approach
 - Network properties of the Internet
 - JND: perceptual effects to drive tradeoffs
 - Validation: traffic interceptor in Windows
 - Measurement: *RealTalk* testbed

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Thank you

Question?