

Assessing and Improving User QoE of Video Telephony

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Video Telephony

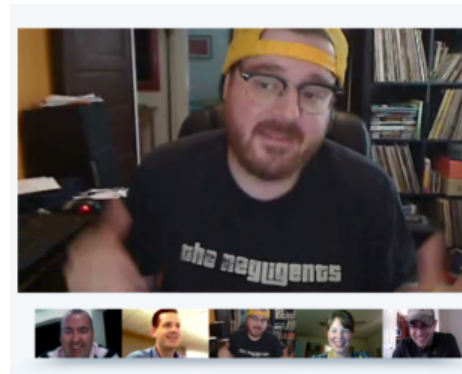
- Video Telephony:
 - conceived in 1920's
 - business solutions



□ Recent Adoptions by End-consumers



iChat/Facetime



Google+ Hangout/Chromebox



Skype

Technical Challenges

- ❖ Realtime voice/video transmission over “best-effort” networks:
 - ✧ high-rate (~Mbps)
 - ✧ low-delay (<350ms)
 - ✧ users highly sensitive to voice/video quality degradation

Measurement Study

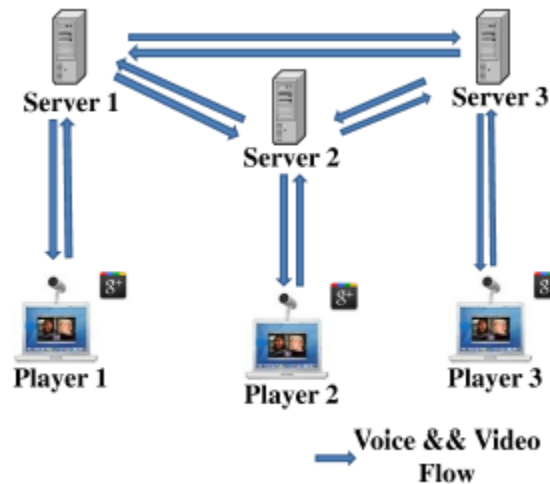
- Application Design Choices
 - system architecture
 - video generation and adaption
 - user perceived voice/video delay performance
 - loss recovery
- Measure each system as black-box through controlled experiments
 - probe black-box under different network conditions
 - record systems' behaviors, user QoE
 - analyze recorded traces to infer their designs

Video Conferencing Architecture

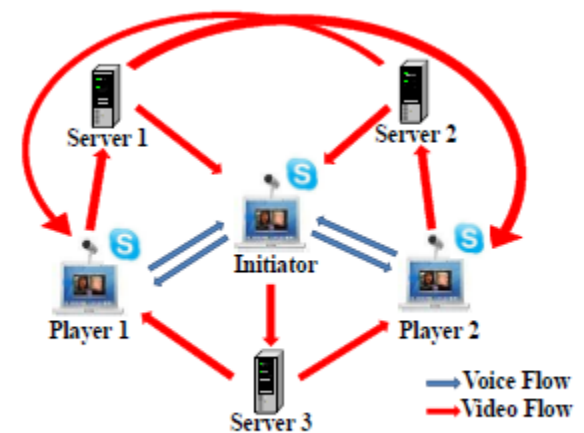
- ❖ iChat: Central Peer-to-Peer
- ❖ Google+: Server-centric
 - ✧ each user connects to his/her local proxy server
- ❖ Skype: Hybrid
 - ✧ two-party call: voice and video using P2P
 - ✧ multi-party: voice using central P2P, video relayed by servers
 - ✧ video relay servers all located somewhere close to NJ/NY area



(a) iChat



(b) Google+ Hangout



(c) Skype multi-party

Realtime Mobile Video Encoding

- ❑ good quality video from mobile
- ❑ Google+ employs layered coding

System	Range (kbps)	Resolution	FPS
Skype	10 - 620	480*360, 320*240	1-12
Google+ Hangout	20 - 800	480*360, 240*180	1-15
FaceTime	10 - 820	??*??	1-30

Table 5: Top-3 CPU-consuming Processes

Process	FaceTime		Skype		Google+	
	Cell	WiFi	Cell	WiFi	Cell	WiFi
mediaserve	52.3%	61.3%	13.2%	12.3%	15.3%	15.5%
backboardd	9.4%	10.5%	8.9%	8.2%	12.0%	12.1%
Skype	-	-	70.1%	86.0%	-	-
EmSea	-	-	-	-	138.2%	134.4%
Total	61.7%	71.8%	92.2%	106.6%	165.5%	161.6%

Loss Recovery

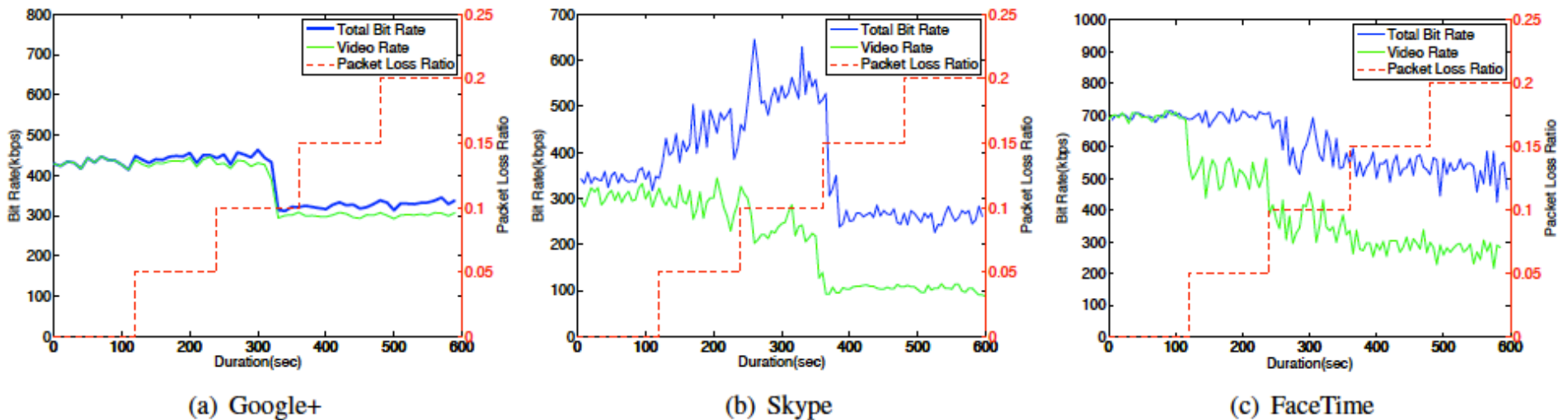
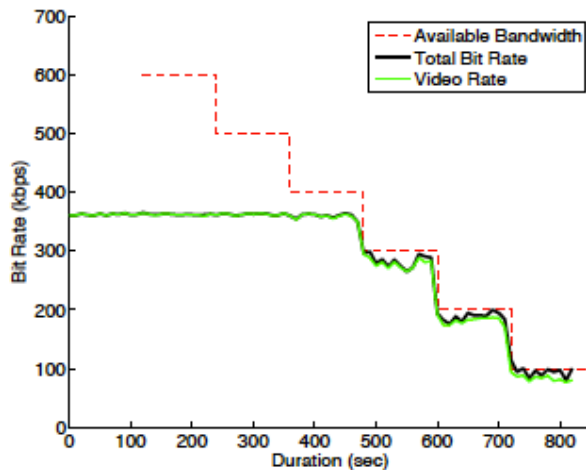


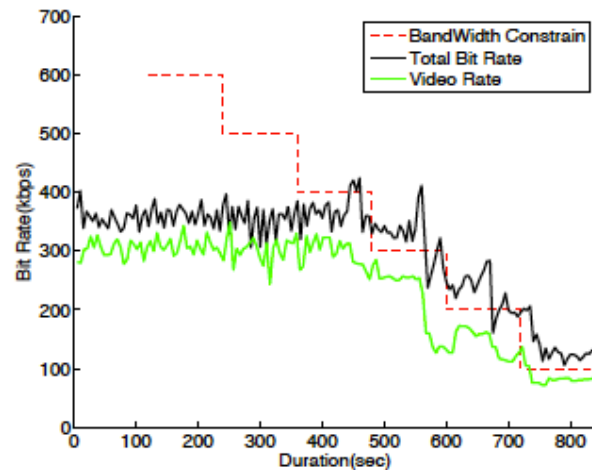
Fig. 4. Redundancy Adaptation as Packet Loss Ratio Increases

- ❑ Google+ uses selective persistent retransmission
- ❑ Skype uses aggressive FEC
- ❑ Facetime uses FEC (vs. iChat uses retransmission)
 - RTP packet trace analysis
 - per-frame FEC
 - upon loss, break long packets into shorter packets

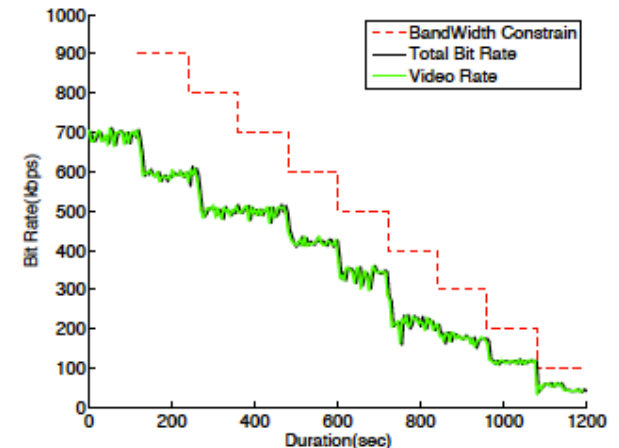
Rate Adaptation



(a) Google



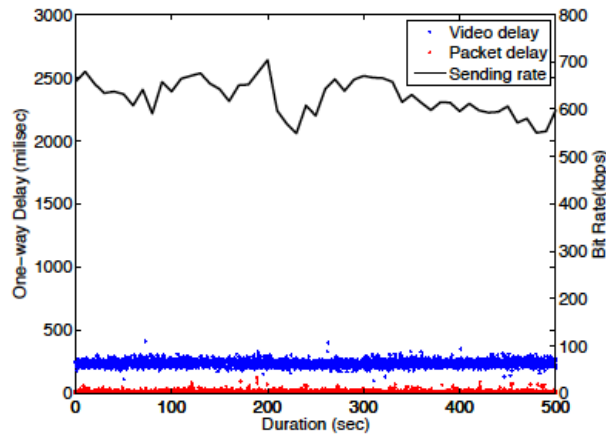
(b) Skype



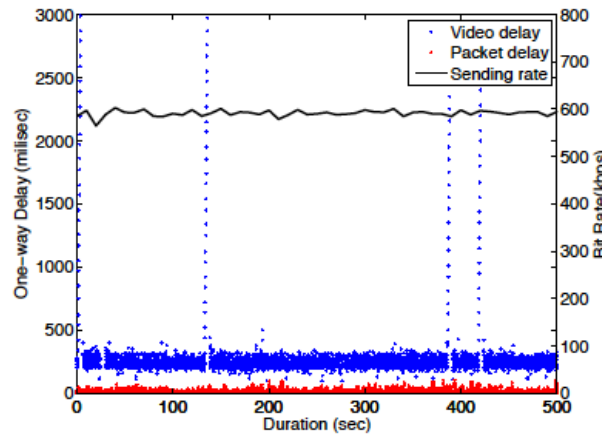
(c) FaceTime

- Google+ keeps track of available b.w. closely
- Skype can be too close, vicious cycles
 - loss -> FEC -> increased rate -> more losses
- Facetime follows b.w. variation with good margin

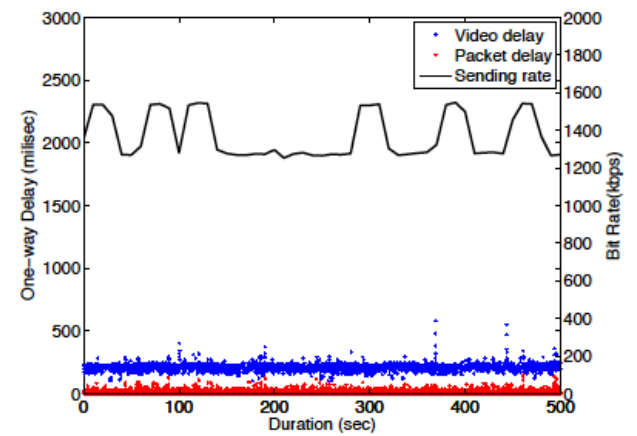
Performance over WiFi



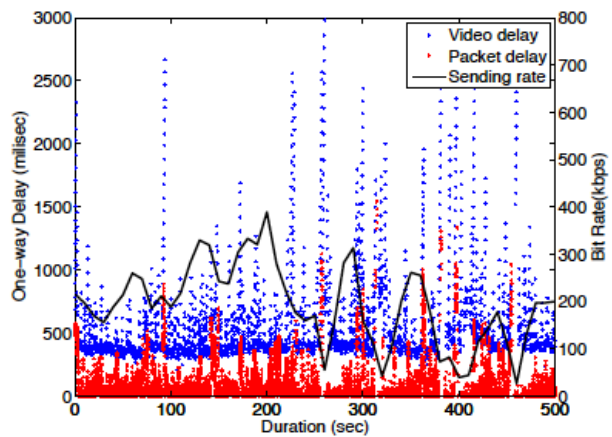
(a) FaceTime - strong signal



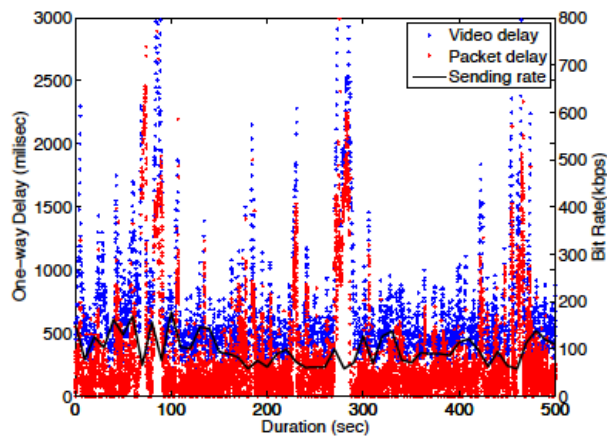
(b) Google+ Hangout - strong signal



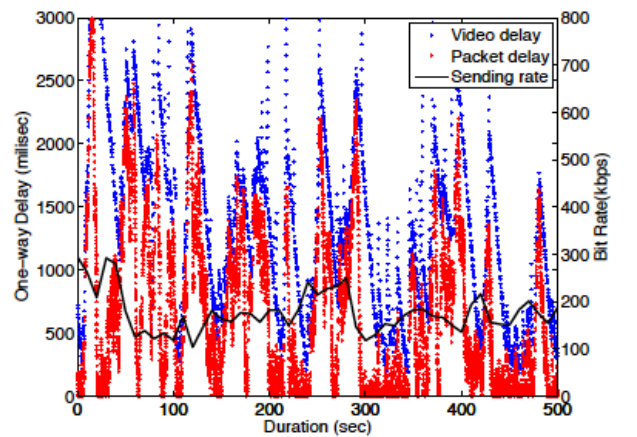
(c) Skype - strong signal



(d) FaceTime - weak signal

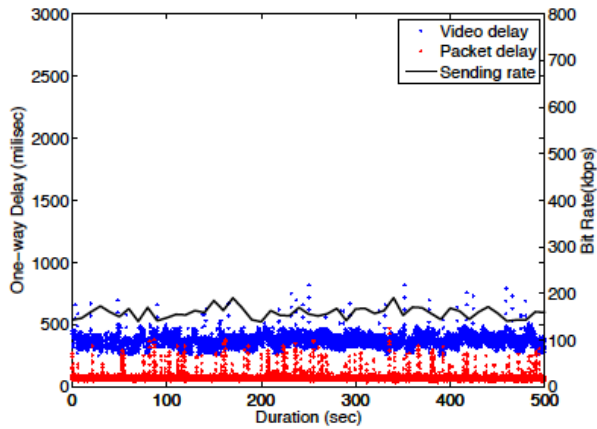


(e) Google+ Hangout - weak signal

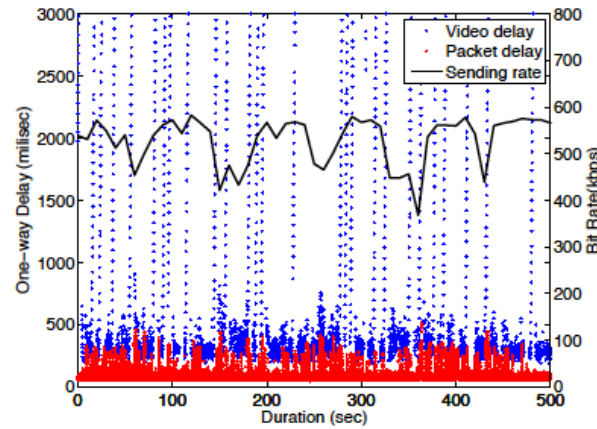


(f) Skype - weak signal

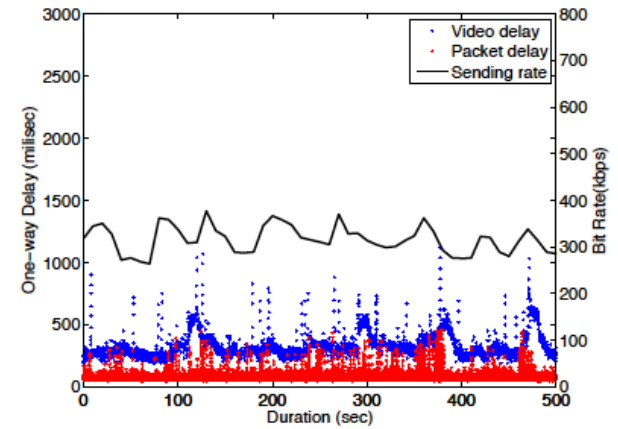
Performance over Cellular



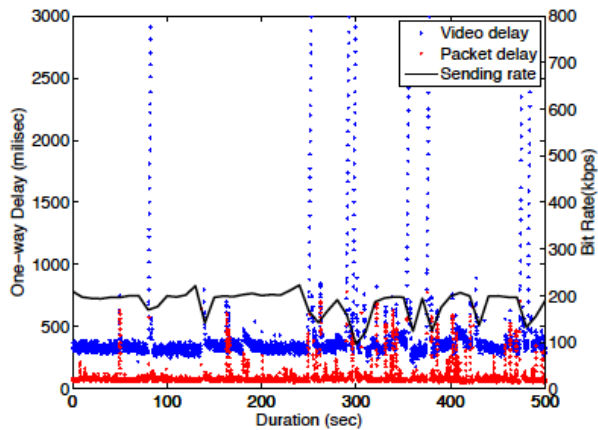
(a) FaceTime - strong signal



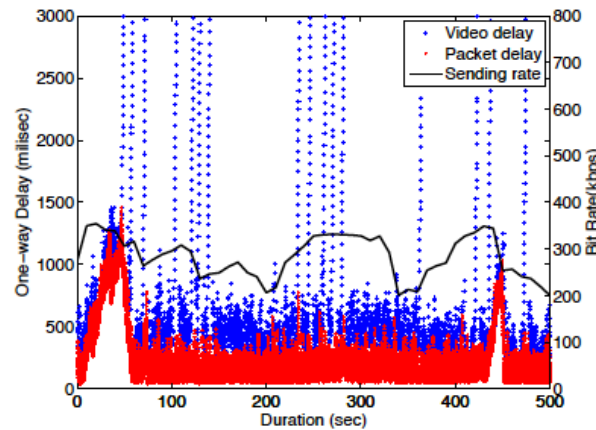
(b) Google+ Hangout - strong signal



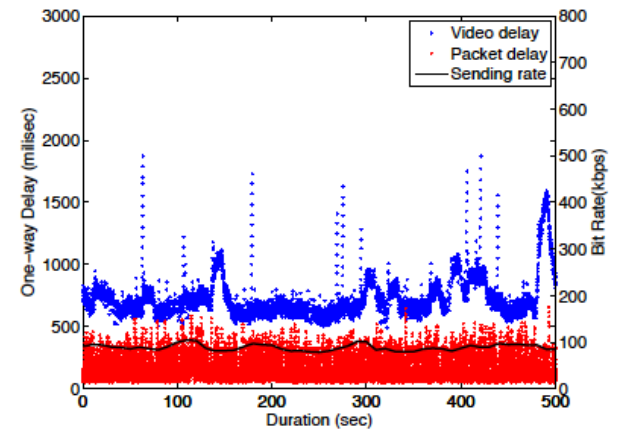
(c) Skype - strong signal



(d) FaceTime - weak signal



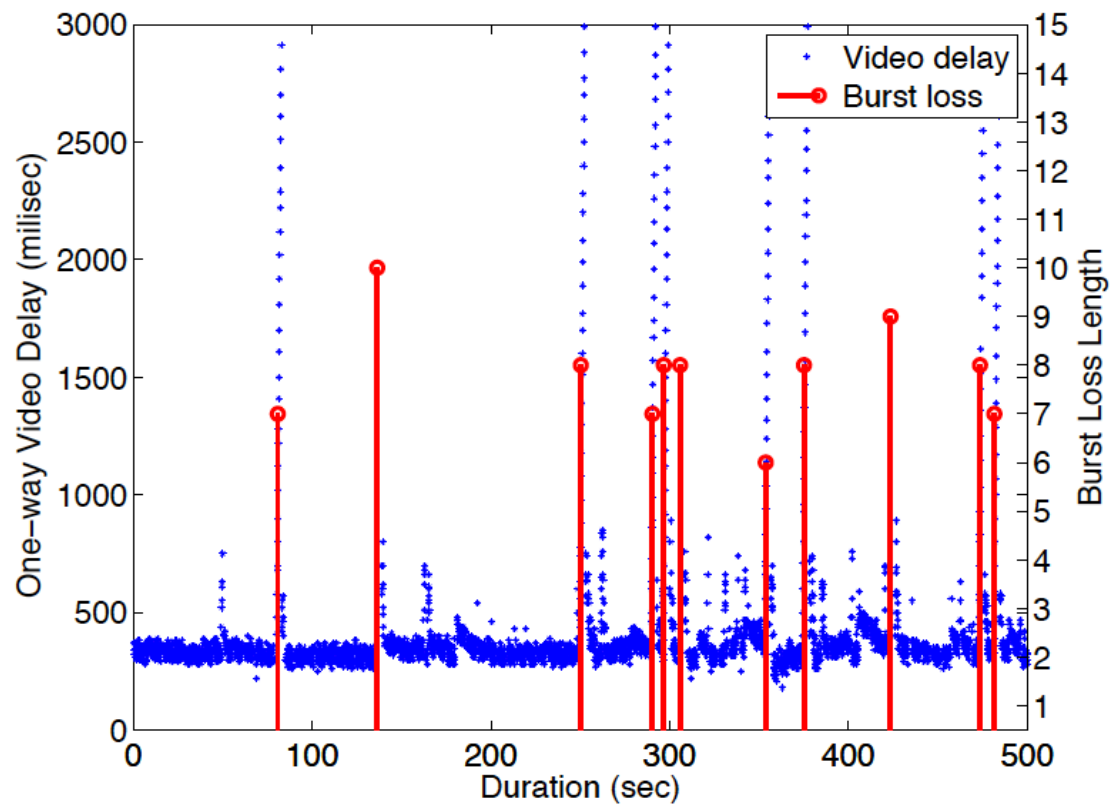
(e) Google+ Hangout - weak signal



(f) Skype - weak signal

Impact of Bursty losses

FaceTime over weak Cellular



Video delay vs. packet delay

- cross-correlation at different time lags.

$$\gamma_{v,p}(\tau) = \frac{E[(D_v(t + \tau) - \bar{D}_v)(D_p(t) - \bar{D}_p)]}{\sqrt{E[(D_v(t) - \bar{D}_v)^2]E[(D_p(t) - \bar{D}_p)^2]}}$$

TABLE VII
CORRELATION BETWEEN PACKET DELAY AND VIDEO DELAY

Systems	WiFi		Cellular	
	Strong	Weak	Strong	Weak
Facetime	0.06	0.61	0.48	0.41
Google+	0.13	0.54	0.33	0.46
Skype	0.22	0.74	0.19	0.59

Open Challenges

- ❑ Subjective User QoE Study
 - perceptual video quality
 - tolerance of frame delay, freeze
 - sensitivity to temporal quality/delay variations
- ❑ Integrated Realtime Video and Networking
 - video encoding, protection
 - bandwidth estimation, video adaptation
 - optimizing for user QoE
- ❑ Mobile and wireless video calls
- ❑