Reaching Carrier Class Quality of Service

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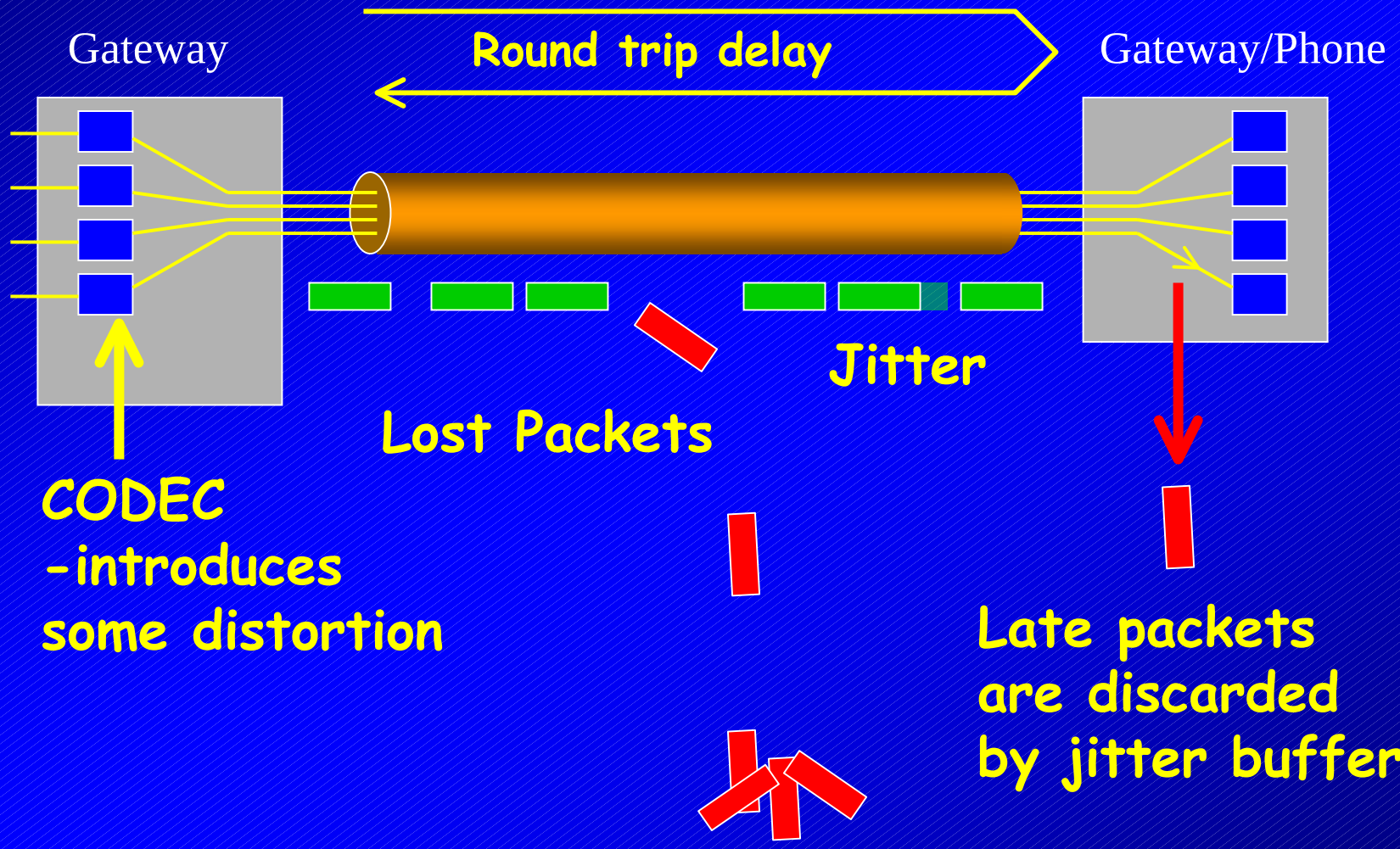
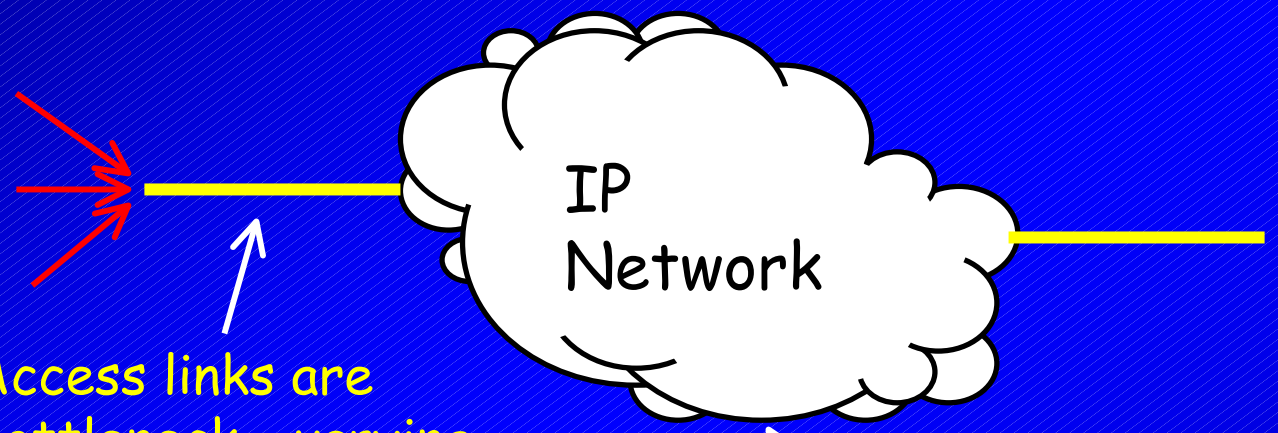
Factors impacting quality



Sources of packet loss & jitter

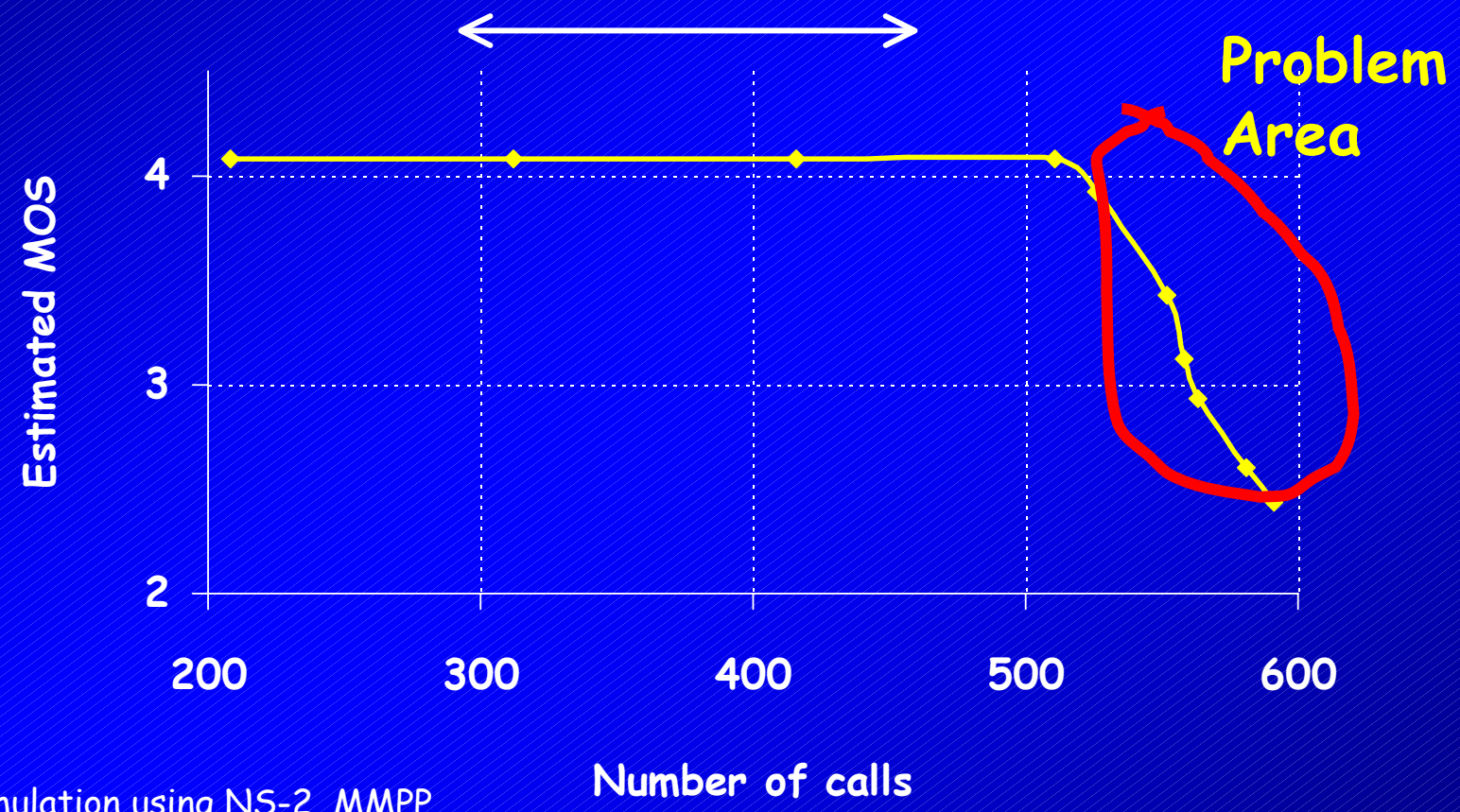


Access links are bottleneck – varying traffic load causes packet loss and jitter

IP Network typically has high capacity – problems are often due to route oscillation, link failures…

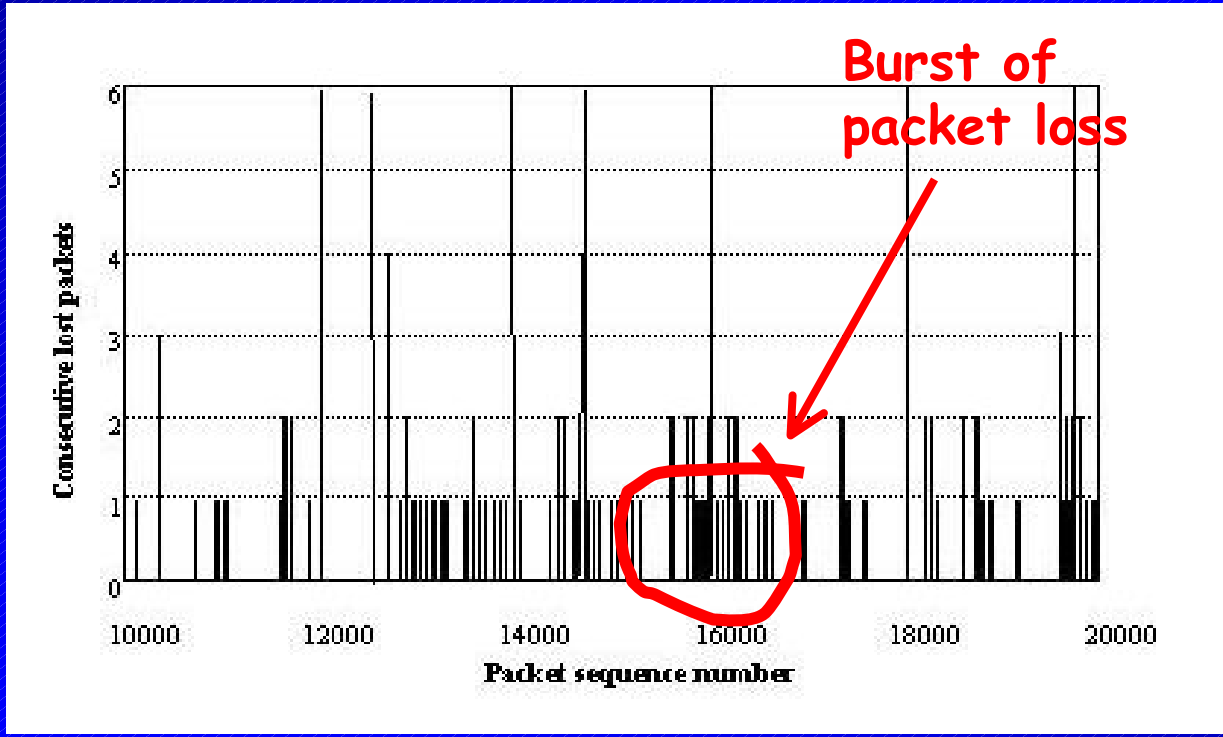
Effects of overloading network

Quality depends on traffic level – time varying



Simulation using NS-2, MMPP traffic models and VQmon

Recorded burst loss pattern

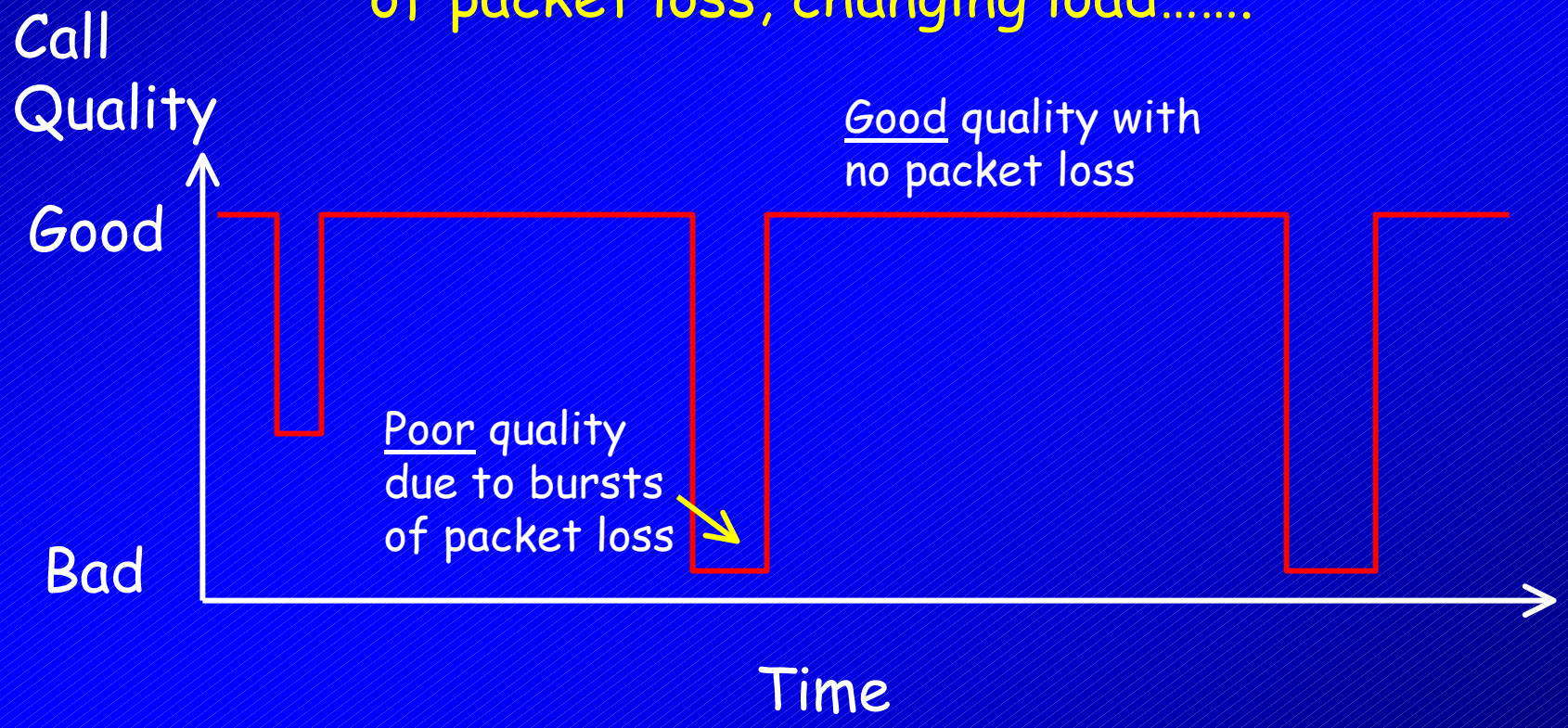


Shows distribution of lost packets from a Recorded Internet session

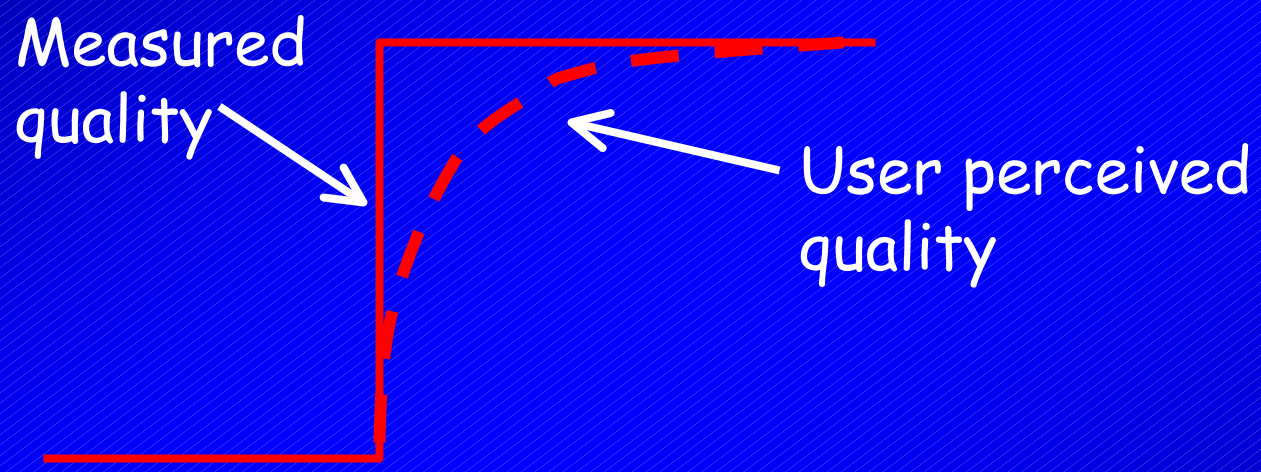
Source University of Massachussetts

Call Quality is Time Varying

Call quality can change from good to bad during a call, due to bursts of packet loss, changing load……



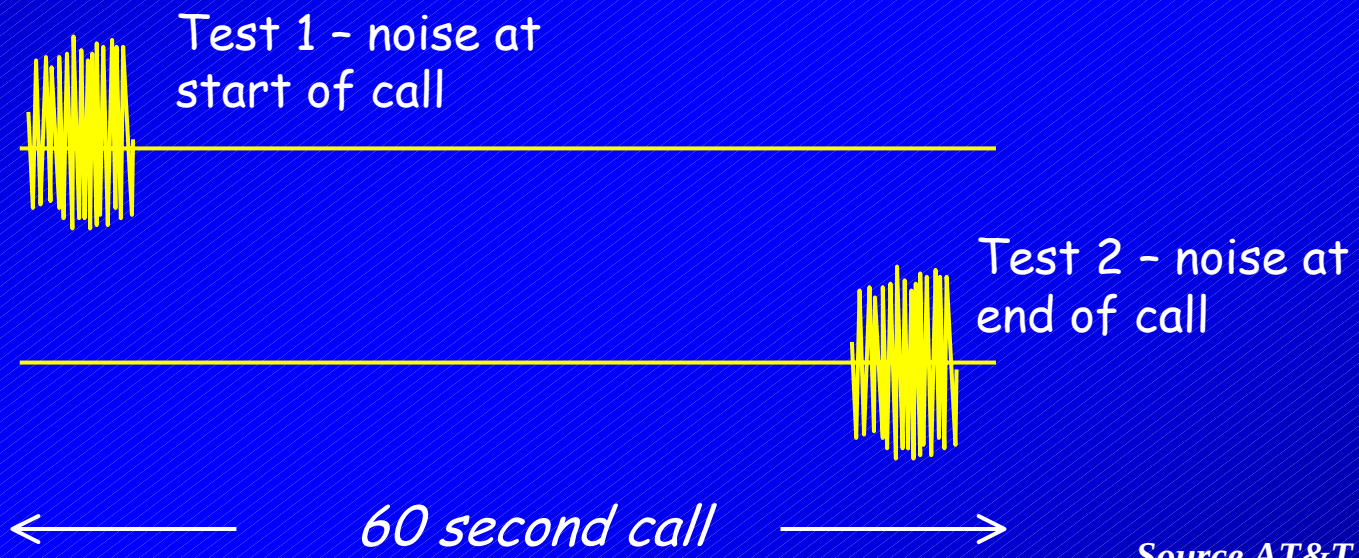
Subjective effects of change



Although "measured" quality may change suddenly it takes several seconds for perceived quality to "*catch up*"

"Recency" effect

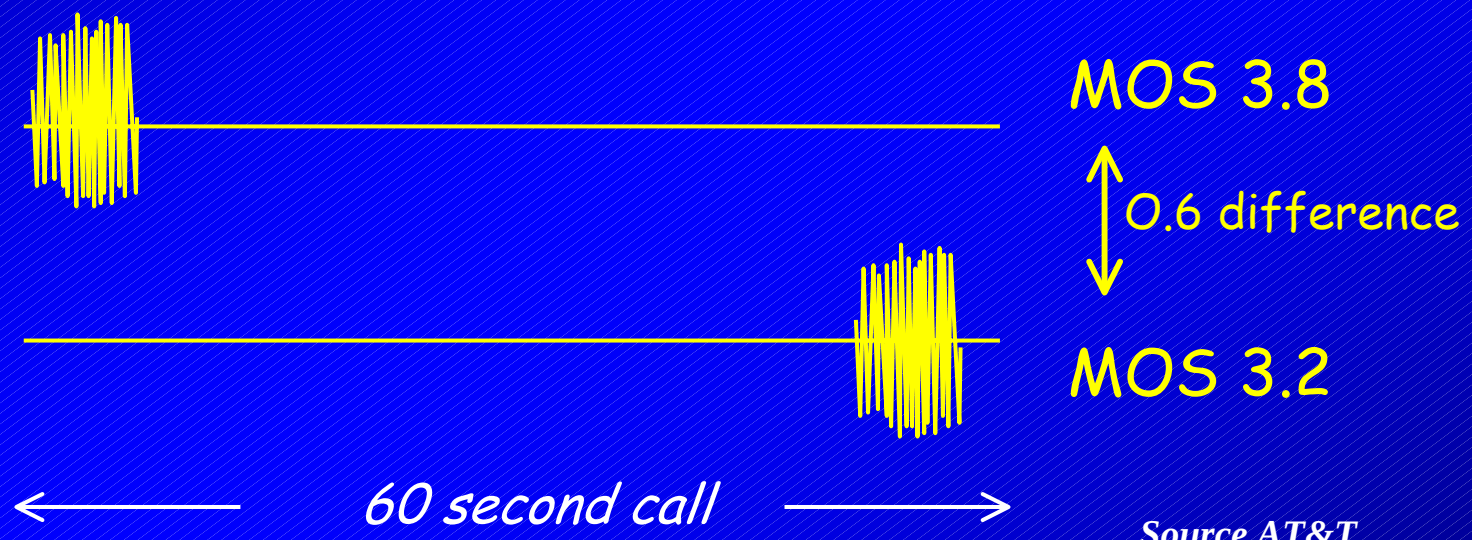
Result of AT&T test – moved a burst of noise from the start to the end of a call and used a group of people to get a quality score



Source AT&T T1A1.7/98-031

"Recency" effect

Location of noise burst caused a difference of 0.6 in score – which is <u>very</u> large. (*MOS scores less than 3 are considered poor and 4 is "toll quality"*)

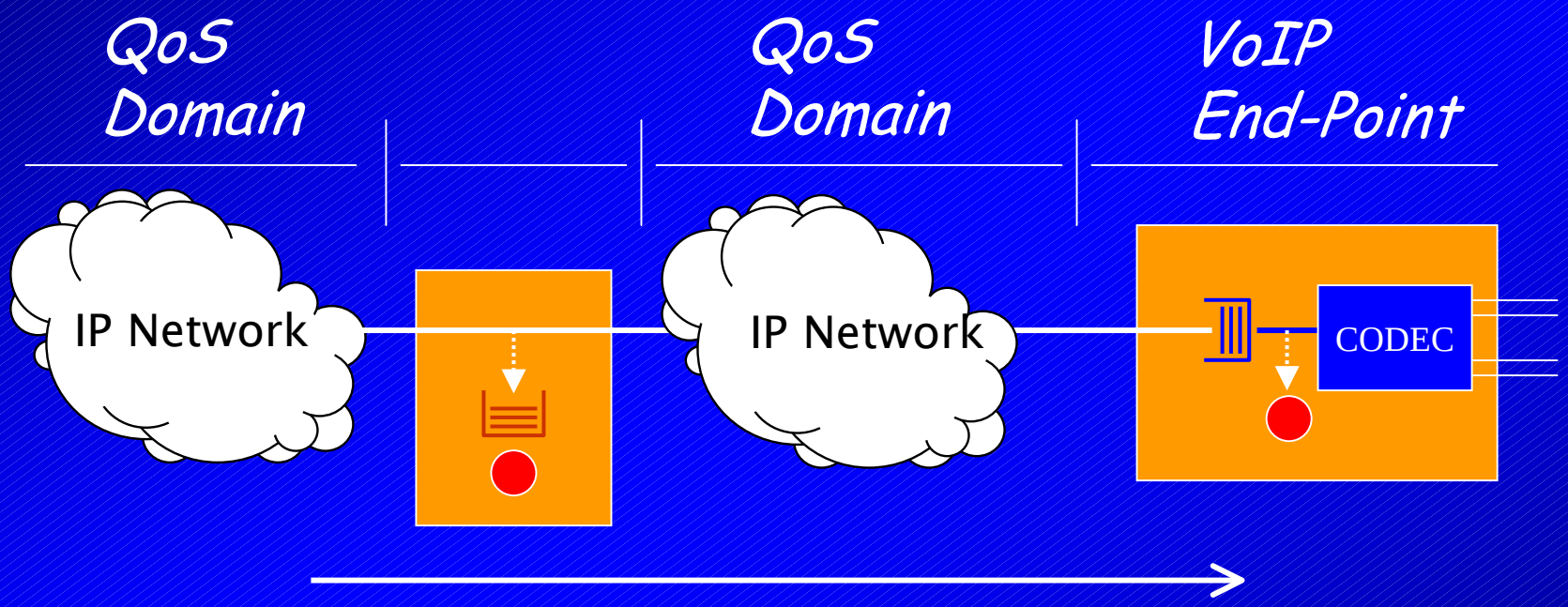


Source AT&T T1A1.7/98-031

Accurately estimating QoS

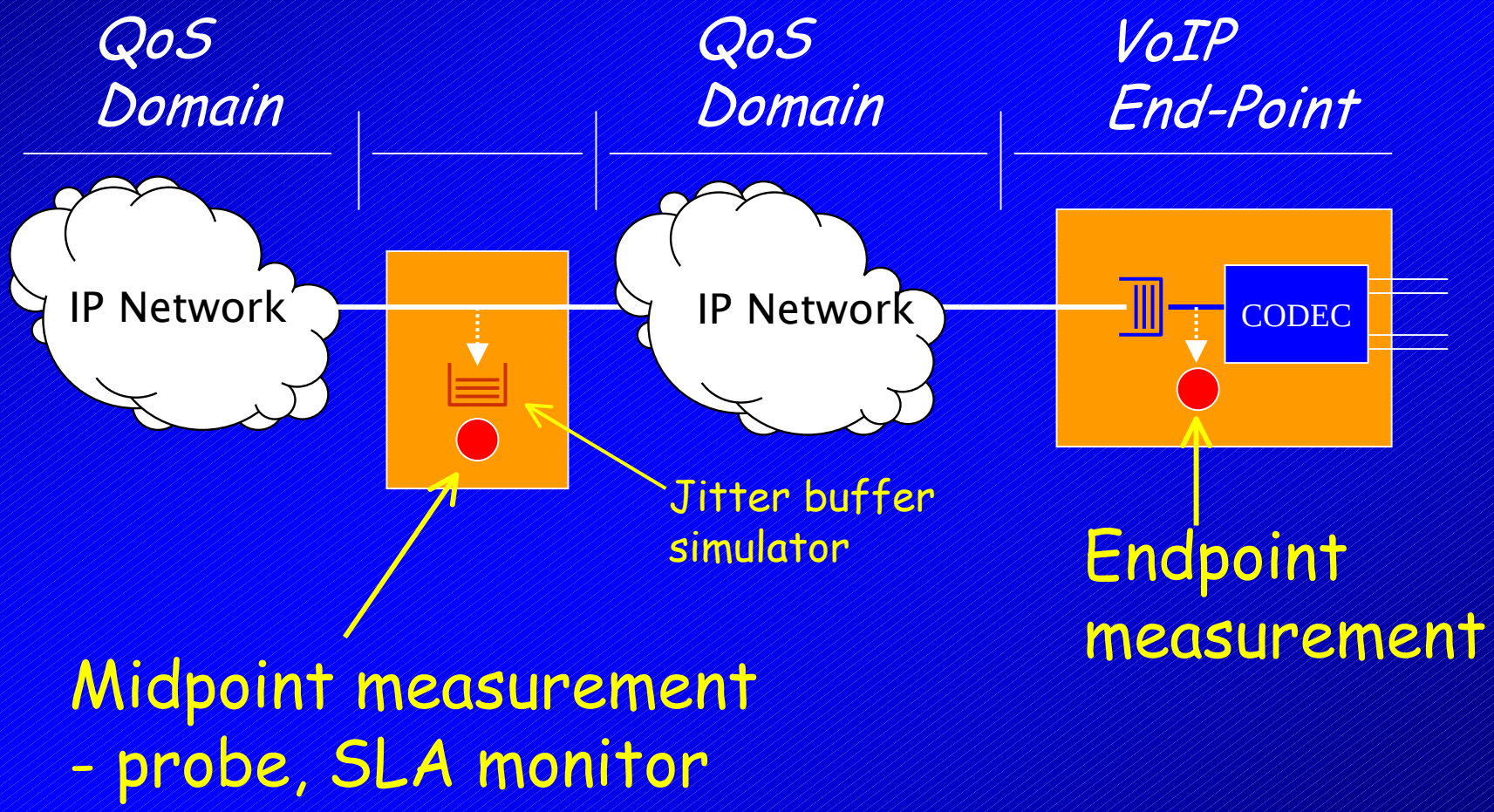
- Need to consider CODEC, delay, jitter, packet loss and other effects
- Packet loss is most significant factor
- Need to measure distribution of packet loss and location of bursts (notably those near the end of a call)
- Need to reflect the subjective effects of time varying quality

Call quality monitoring

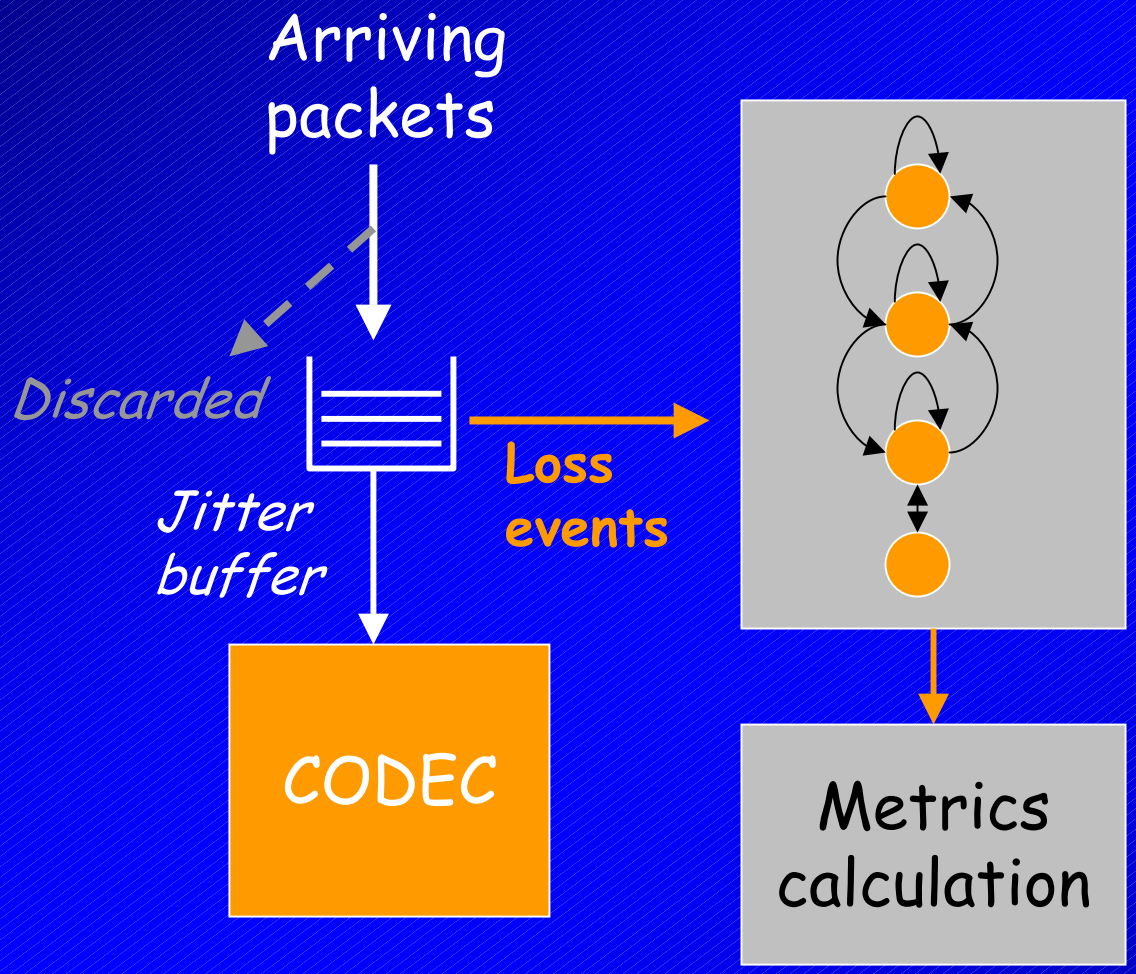


Non-intrusively monitor live calls
- ideally monitor ALL calls

Call quality monitoring



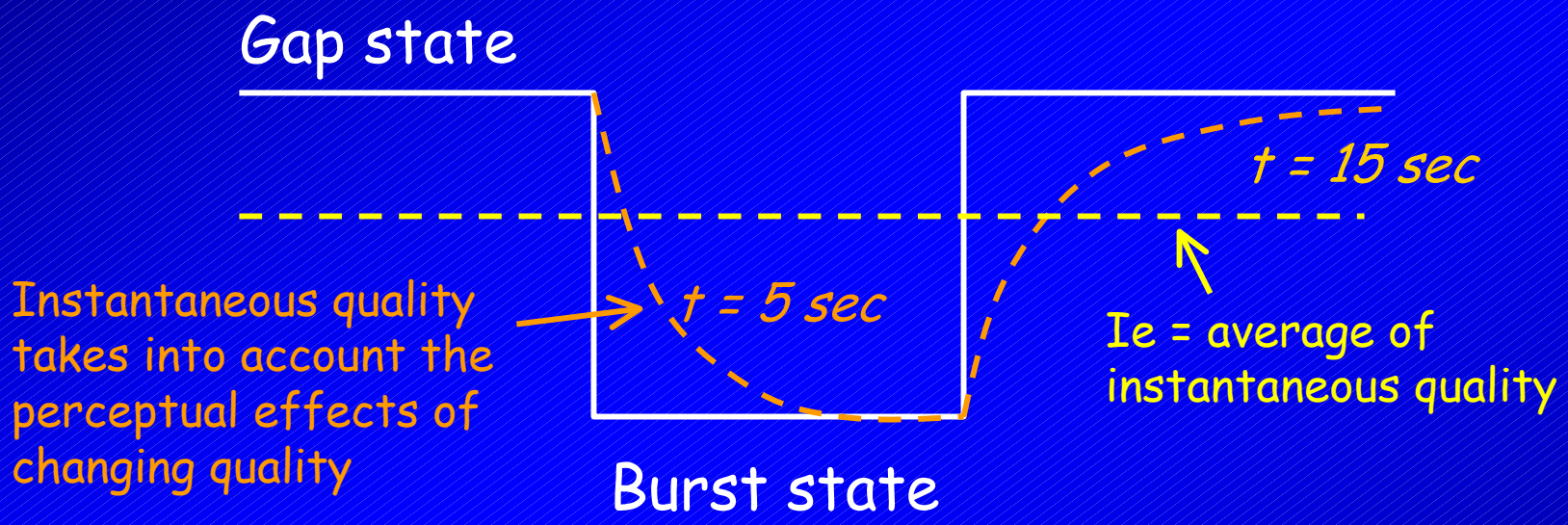
VQmon – Extended E Model



<u>Markov model</u>
Gathers detailed packet loss info in real time

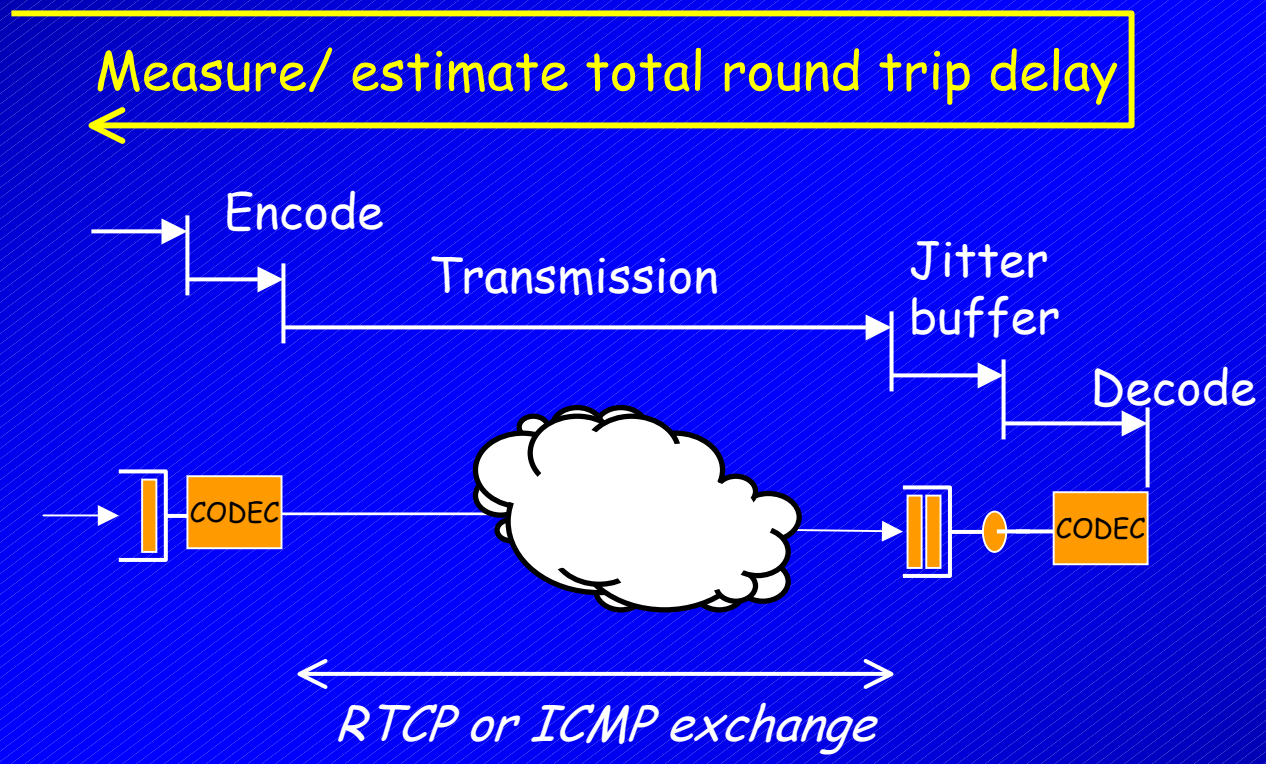
Calculate call quality metrics at end of call

From Markov Model to "Ie"



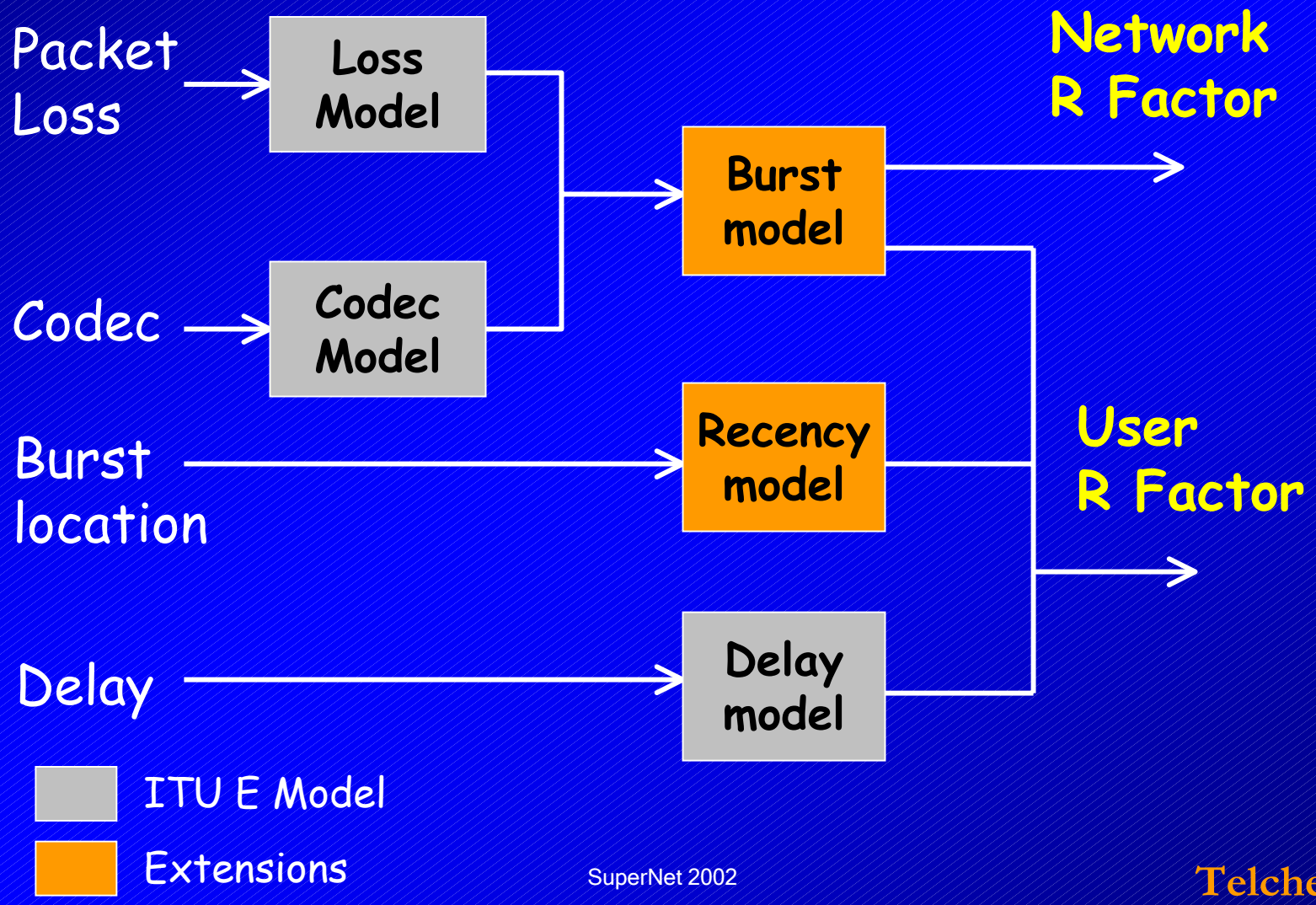
R factor = Ro – **Ie** – Is - Id

Delay measurement



R factor = Ro – Ie – Is - **Id**

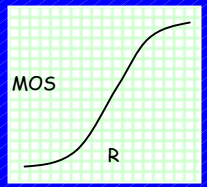
Extended E Model



R Factors and MOS Scores

→ **Network R Factor (0-100)**

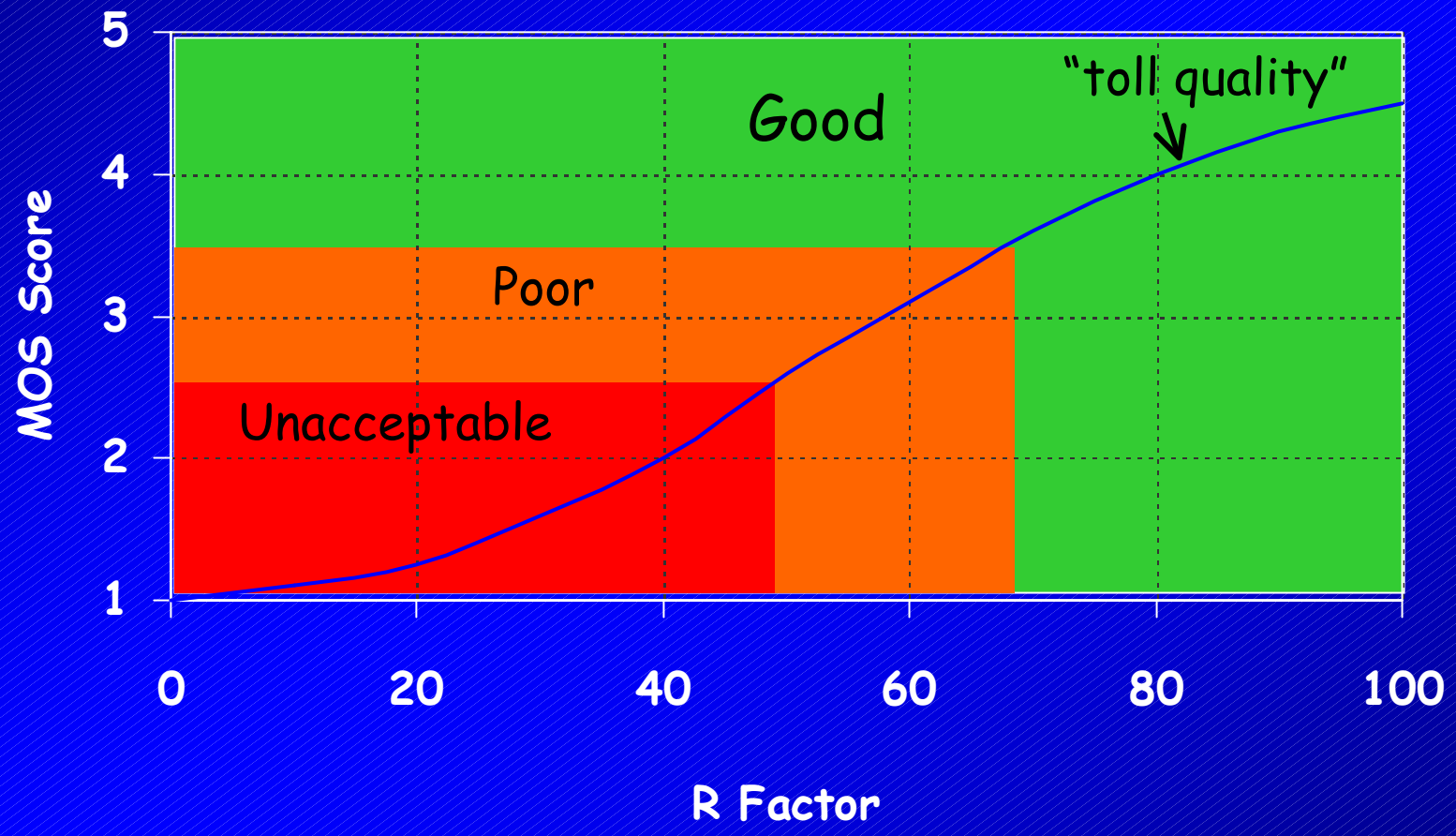
Does not include Recency Or Delay, intended for Network Management use

→ **User R Factor** → 

→ **Estimated MOS score**

Includes Recency and Delay, intended for billing uses

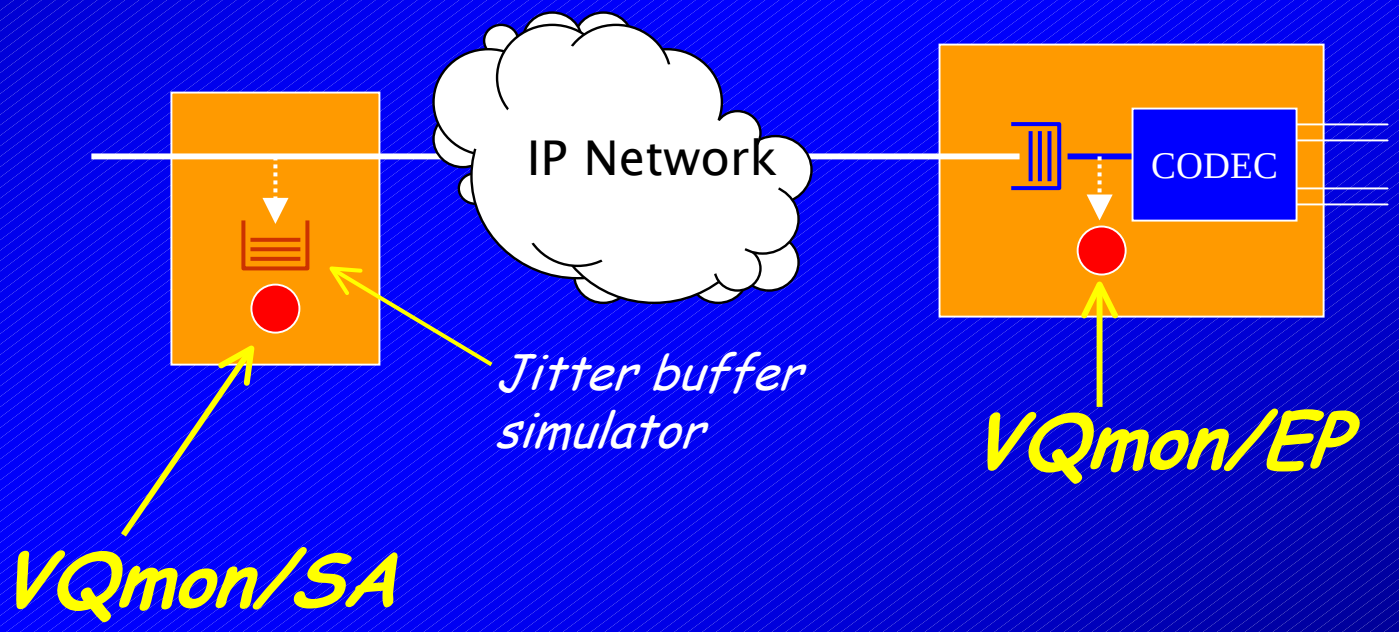
What the scores mean



Lightweight Operation

Stream monitor
approx 0.0075 MIPS
(50,000 instances on PII/400)

Port monitor
0.000075 MIPS
(5M instances on PII/400)



VQmon Accuracy Test

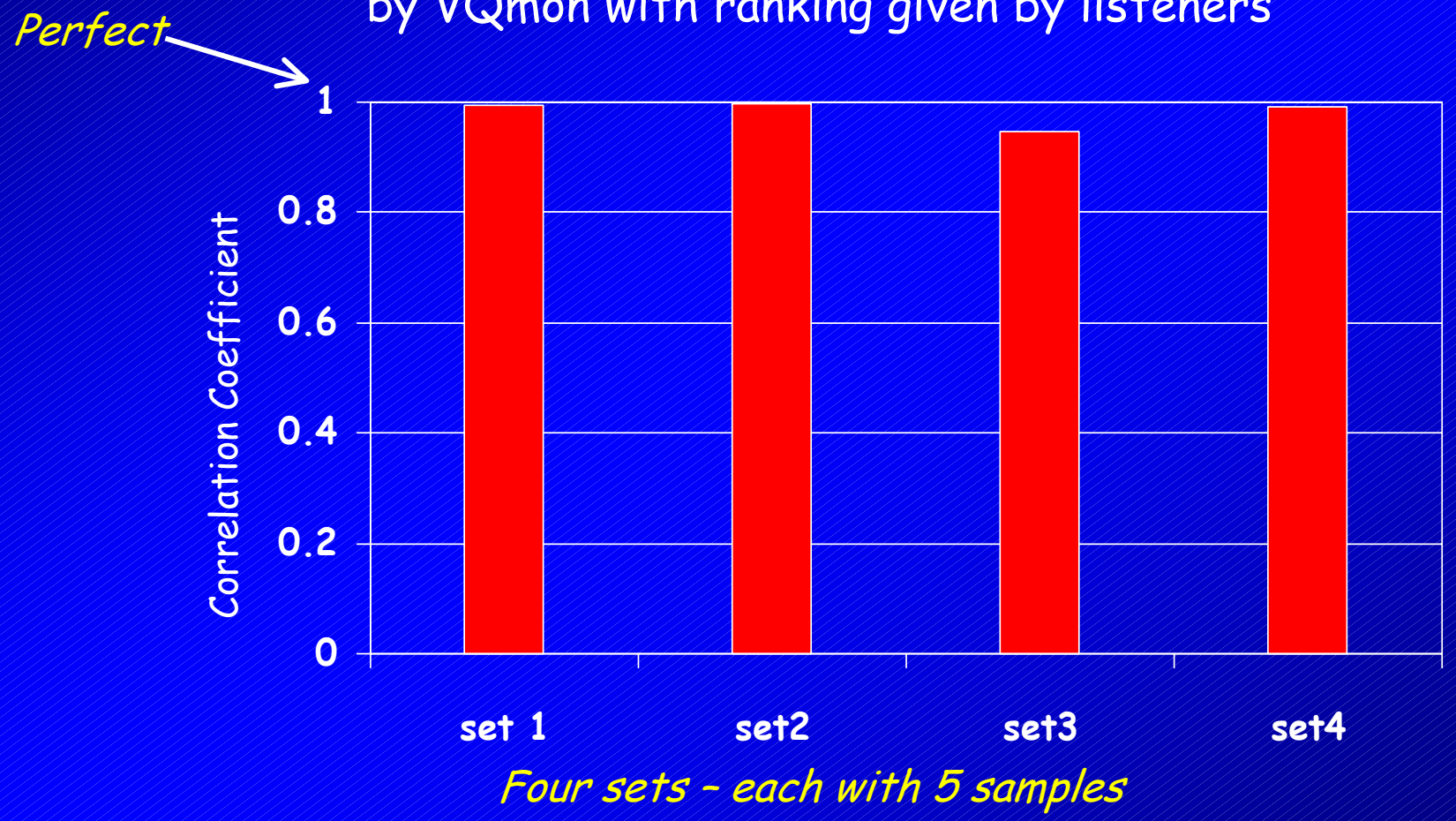
File set 1

Sample 4	Ranked 1
Sample 3	Ranked 2
Sample 1	Ranked 3
Sample 5	Ranked 4
Sample 2	Ranked 5

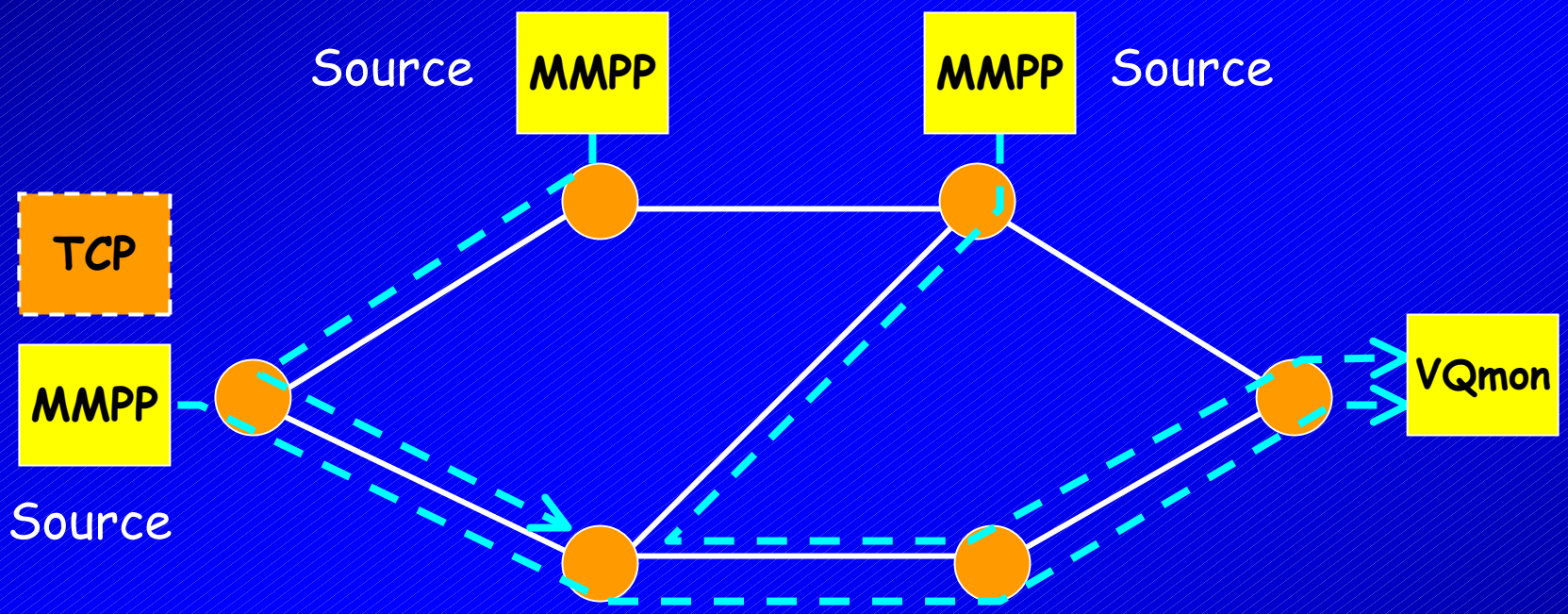
- Panel of listeners ranked sets of files from best to worst
- Used VQmon to obtain a score for each file and predict user ranking
- Calculated correlation of predicted ranking to actual – correlation coefficient of 1 = perfect

VQmon Accuracy Test

Chart shows correlation of ranking predicted by VQmon with ranking given by listeners

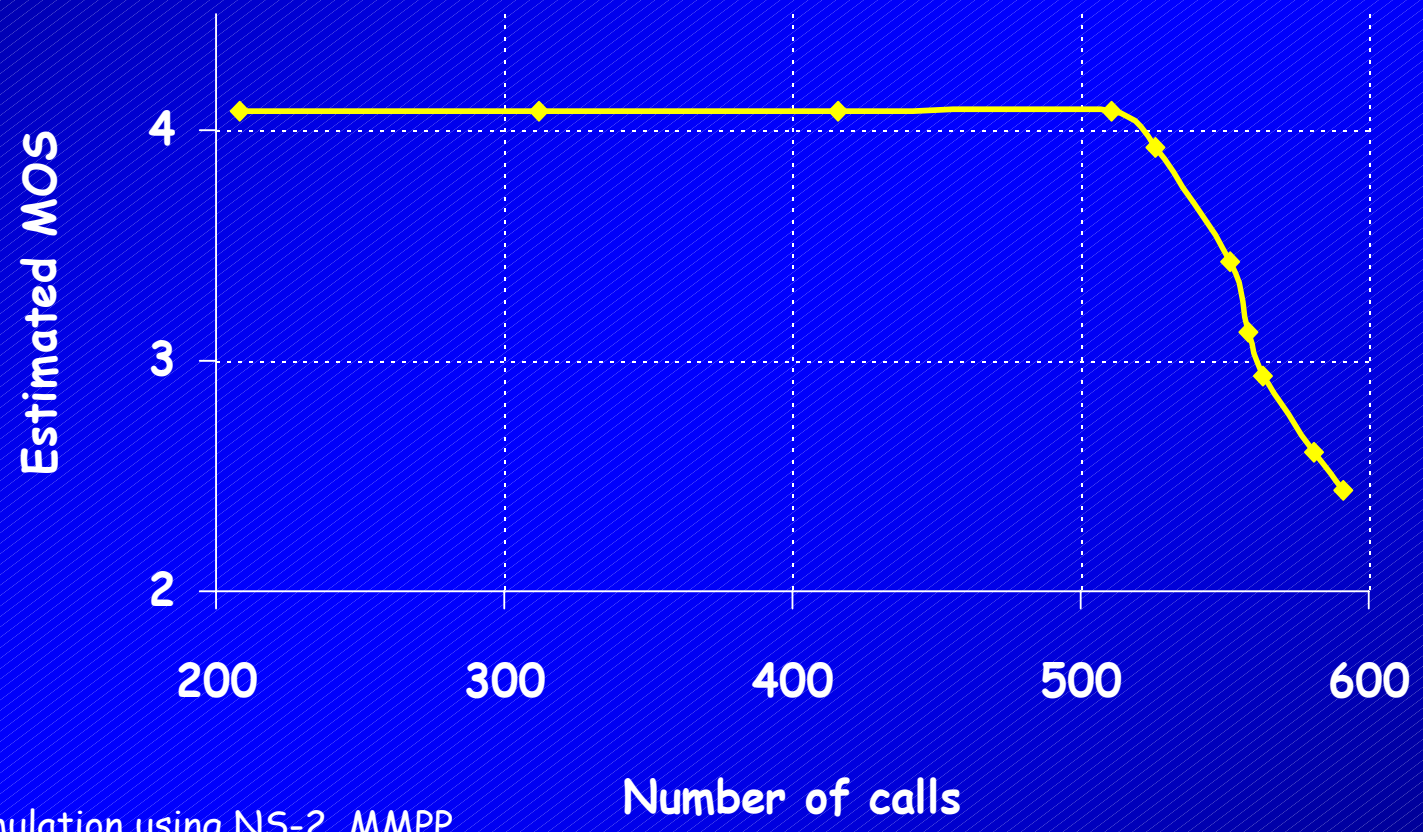


Application to Service Modeling



IP network simulator (NS-2)

Application to Service Modeling



Simulation using NS-2, MMPP traffic models and VQmon

About Telchemy

- **Focus** – *deliver end-user perceived QoS with minimum use of network resources*
- **Approach** – *open architecture, software based, integrate with any VoIP systems*
- **First products** – *lightweight call quality monitoring software for integration into VoIP Gateways, and SLA monitors.*
- **New development** – *expert analysis of voice quality, video quality monitoring, products to actively control and improve call quality*