Improving VoIP Quality through Path Switching

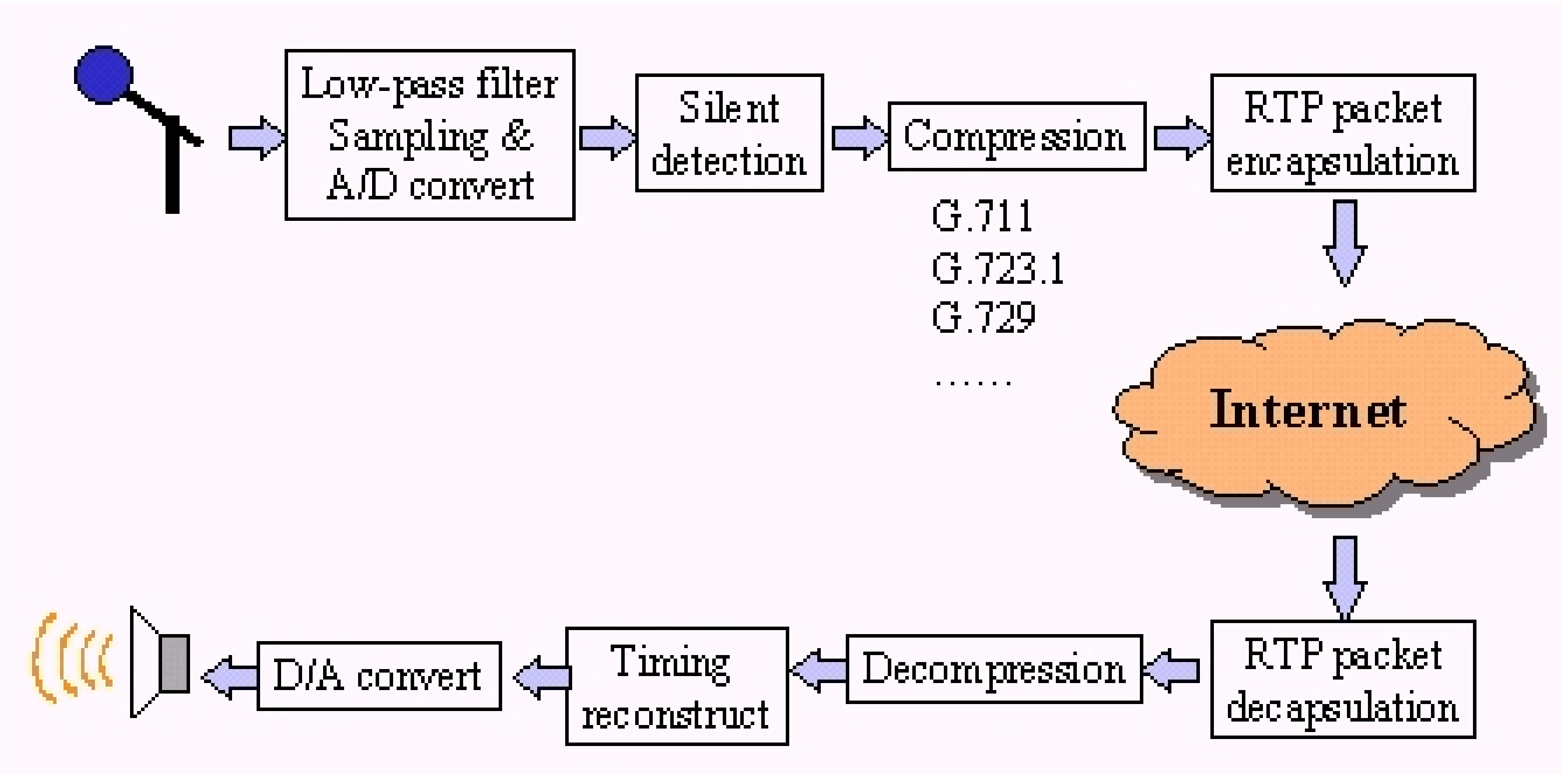
IEEE INFOCOM 2005

Presented by Chun-Chieh Chang

Outline

- Introduction
  - VoIP
  - Factors affecting VoIP Quality
- Architecture of Path Switching System
- How Path Quality is Estimated
- Issues about Path Switching
- Performance Evaluation

Example of VoIP



圖一 VoIP流程之簡單示意圖

From http://www.itpilot.org.tw/email/itis/55/55-05.htm

Introduction

- VoIP requires minimum service guarantees that go beyond the best-effort structure of today's IP networks.

Factors Affecting VoIP Quality

- Network Factors
  - Packet Loss
  - Delay Jitter
  - Network Delay
- Application Factors
  - Playout Buffer
  - Codec Performance

Factors Affecting VoIP Quality (cont.)

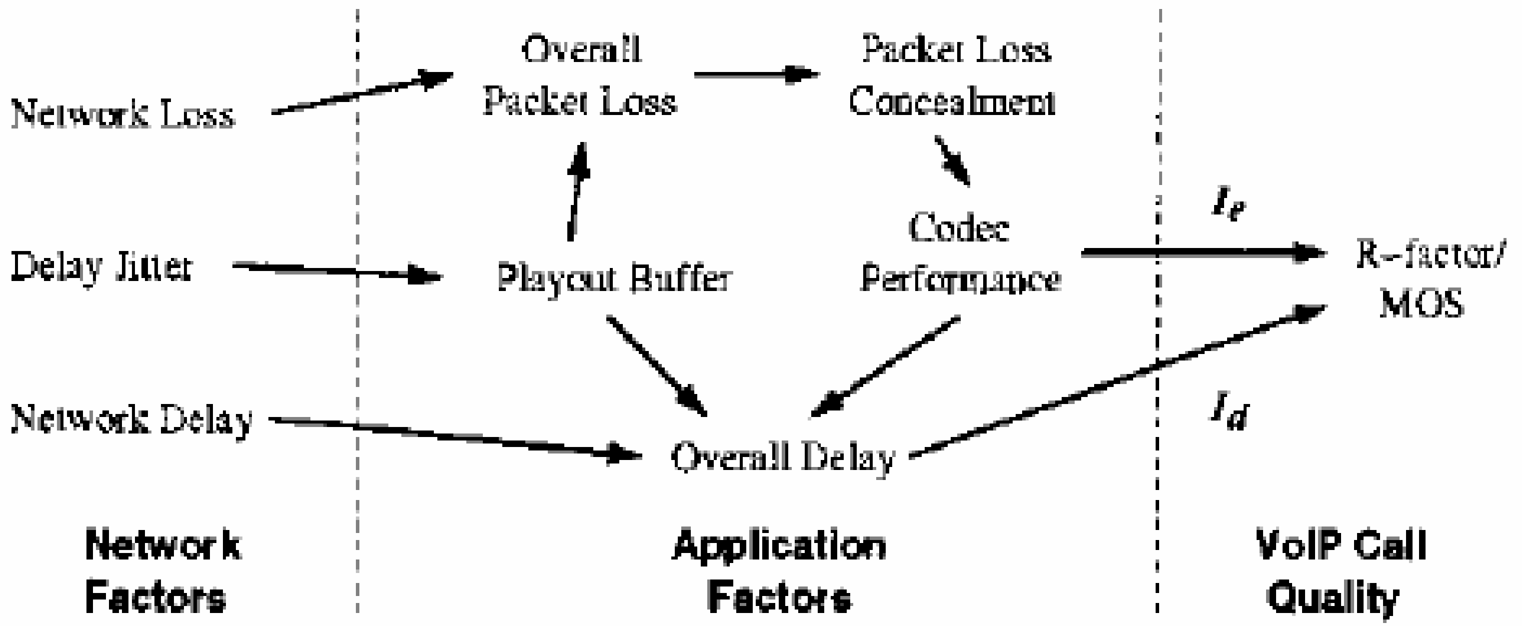
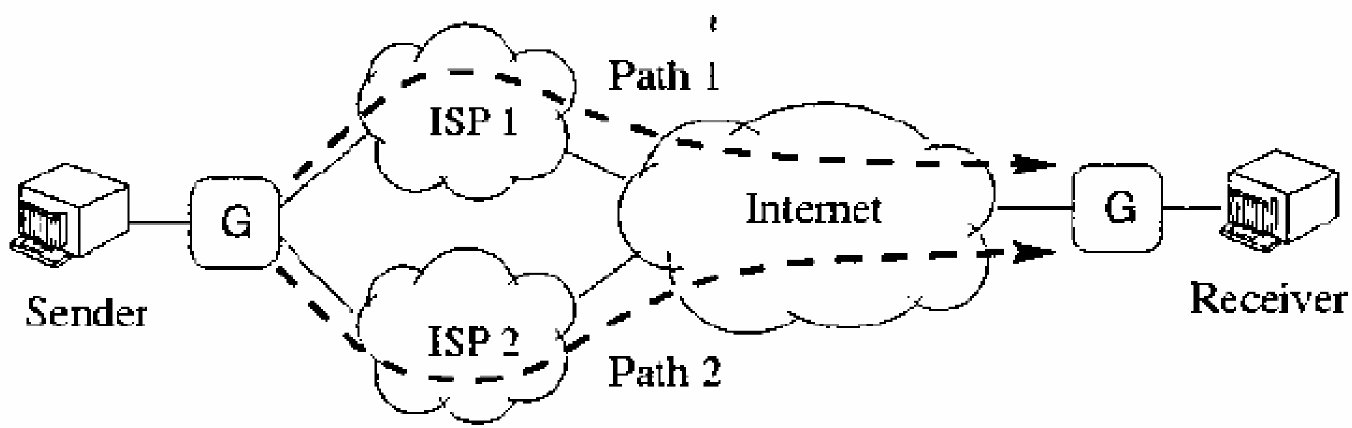


Fig. 2. Factors affecting overall loss and delay and their relations to voice quality.

Architecture of Path Switching System



G APS Gateway (Application-driven Path Switching Gateway)

Fig. 1. A typical application scenario of our path switching scheme.

APS Gateway Components

- Path Prober
  - Send UDP probes ,which are generated to emulate the behavior of a VoIP call ,on each available path periodically
  - Receive feedbacks containing the delay and loss statistics
- Path Quality Estimator
  - Translate network path measurements into application quality estimates using the E-model

APS Gateway Components (cont.)

- Path Selector
  - Dynamically decide the best performing path for each voice call
- Packet Forwarder
  - Integrated with the path selector
  - Forward the voice packet along the corresponding path

APS Gateway Architecture

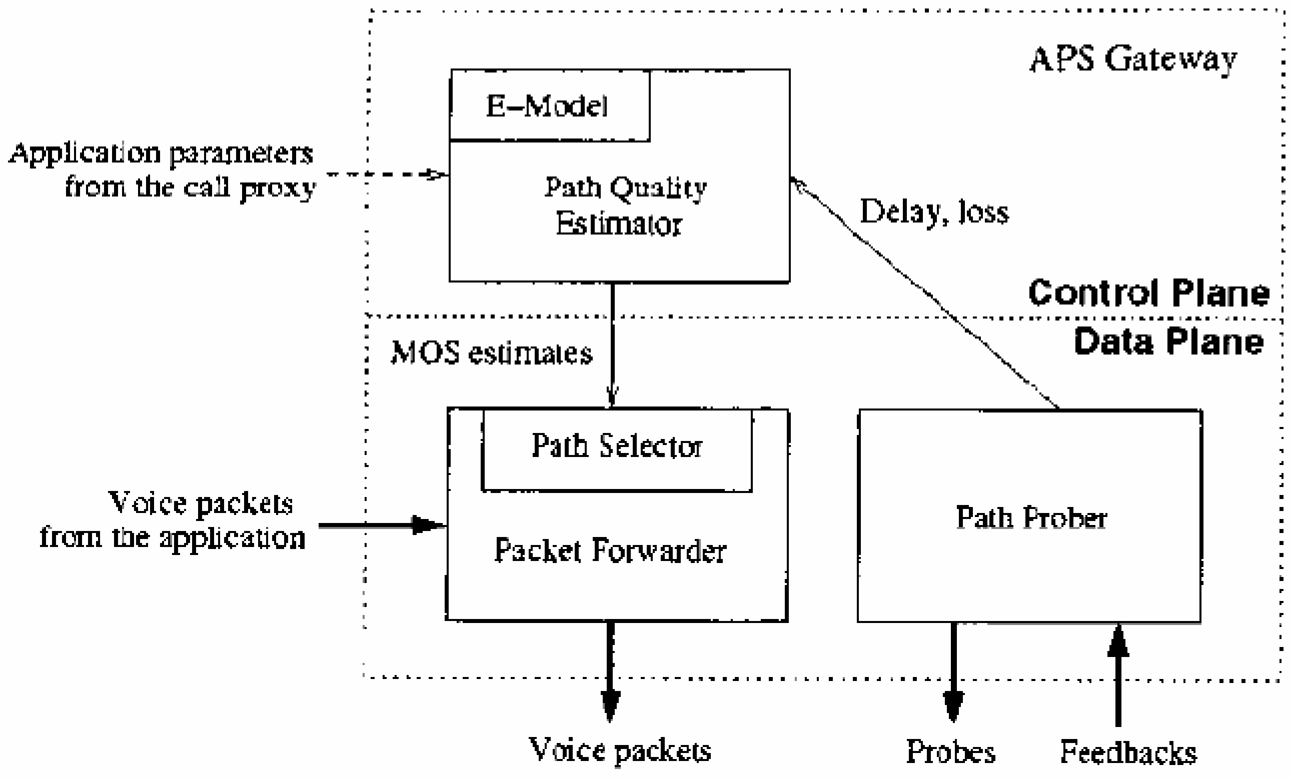


Fig. 3. The architecture of an application-driven path switching gateway.

Path Quality Estimation

- Perceived voice quality is typically measured by the Mean Opinion Score (MOS), a subjective quality score that ranges from 1 (unacceptable) to 5 (excellent).
- The MOS method is from “Methods for subjective determination of transmission quality”, ITU-T Recommendation P.800, August 1996.

Path Quality Estimation (cont.)

- The ITU-T E-Model defines a R-factor, which that ranges from 0 to 100, combines different aspects of voice quality impairments:

$$R = R_0 - I_s - I_e - I_d + A \qquad (1)$$

- The E-Model method is from “The e-model, a computational model for use in transmission planning”, ITU-T Recommendation G.107, March 2003.

$$MOS = 1 + 0.035R + 7 \times 10^{-6} R(R - 60)(100 - R).$$

Path Quality Estimation (cont.)

- Among all of the factors in Eq.(1), only I_d and I_e are typically considered variable in a VoIP system. Using default values for all other factors reduces the model to

$$R = 94.2 - I_e - I_d$$

- When R = 94.2, the value of MOS is 4.4

Estimating the Impact of Loss

- I_e accounts for impairment caused by both encoding and transmission losses.

$$I_e = \gamma_1 + \gamma_2 \ln(1+\gamma_3 e)$$

$$e = E_{network} + E_{playout}$$

γ_n is constant (n=1,2,3)

Estimating the Impact of Delay

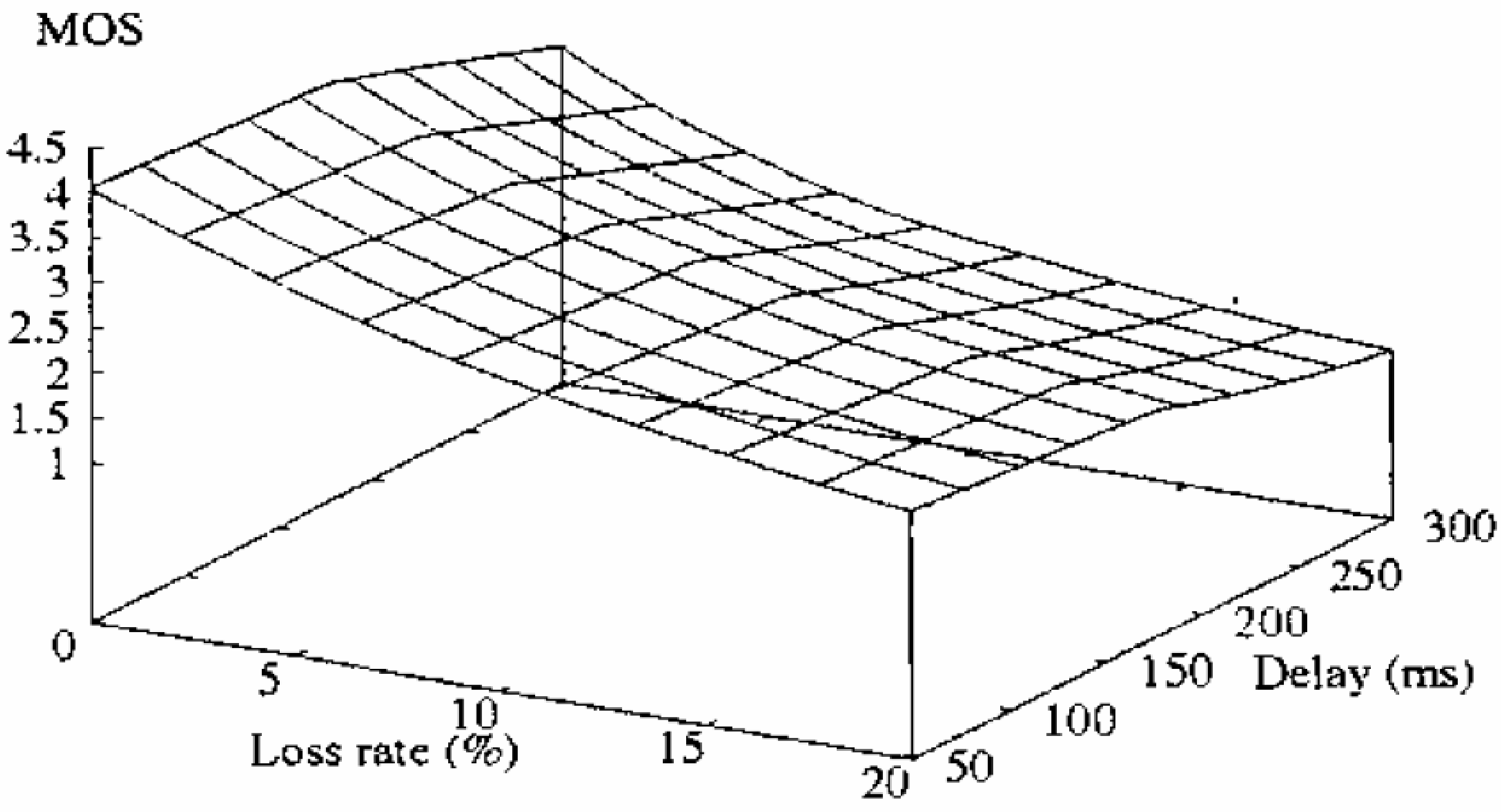
- I_d accounts for impairment caused by network delay, codec-related delay and playout buffering delay.

$$I_d = 0.024d + 0.11(d-177.3)I(d-177.3)$$

$$d = D_{network} + D_{codec} + D_{playout}$$

$I(x)$ is 0, if $x<0$. Otherwise, $I(x)$ is 1.

VoIP Quality as a function of end-to-end loss rate and delay



Issues about Path Switching

- Path Quality Prediction
- Estimating the Benefits of Path Switching
- Time-Scale Adaptive Path Switching Algorithm

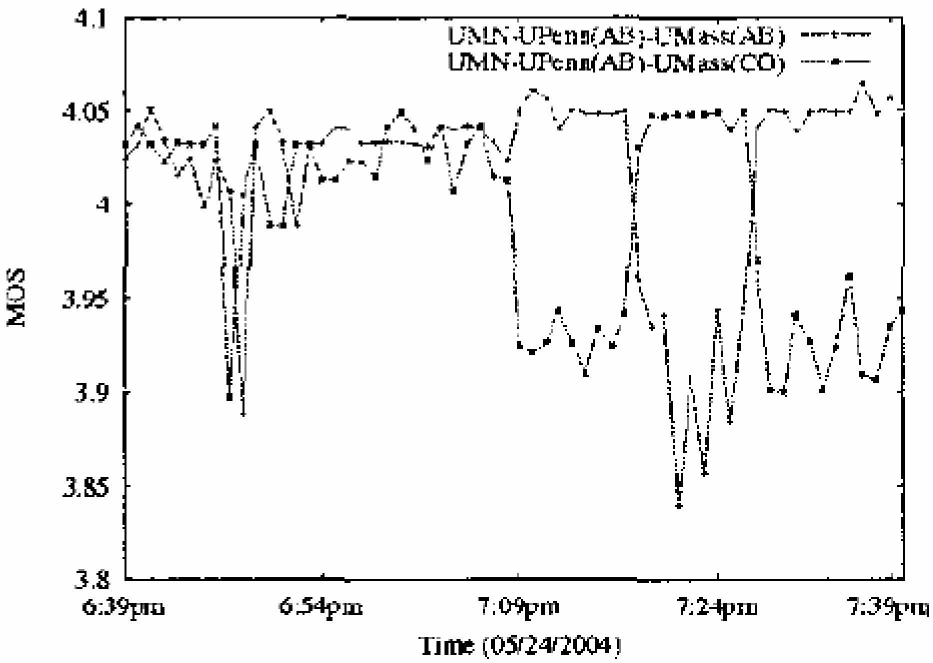
Time-Scale Adaptive Path Switching Algorithm

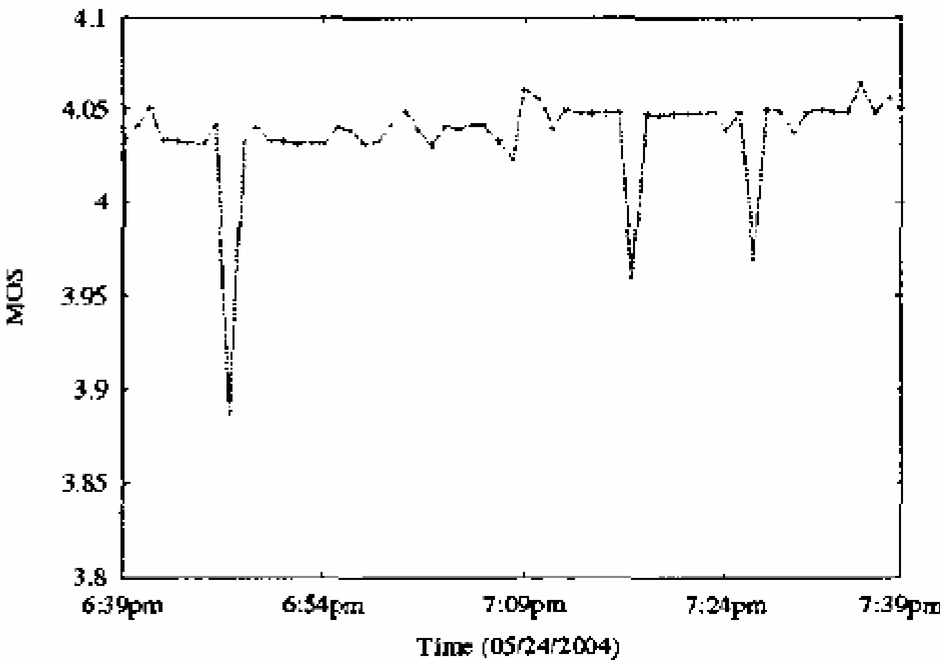
Algorithm 1 Path switching

for each unit of time **do**
    for $n = 1$ to N **do**
        update $\tilde{\rho}(t_n)$
    end for
    $t \Leftarrow \arg\max\{\tilde{\rho}(t_n)\}$
    if clock = t and $\tilde{\rho}(t) > 0$ **then**
        if $Q_i - Q_s > \Delta, i \neq s$ **then**
            $s \Leftarrow i$, start using path s
        end if
        clock $\Leftarrow 0$
    end if
    clock $\Leftarrow$ clock + 1
end for

$t_n = 15 * 2^{n-1}$

Performance Evaluation





A typical example that shows how path switching avoids quality degradations: (a) quality variations on the two paths (left), and (b) the resulting quality when path switching is applied (right).