

Content Adaptation and the use of SVC in the OPTIMIX project

Presentation at the 6th FP7
Networked Media concertation meeting



Why is adaptation needed?

- Multimedia communication can be very bandwidth consuming
- Quality of the wireless communication is time-variable
 - » Varying modulation scheme and thus maximum throughput
 - » Varying loss and bit error rate
- Compression done at the application layer has to be coupled with redundancy inserted for error correction
 - » Need of dynamic selection of coding and protection parameters

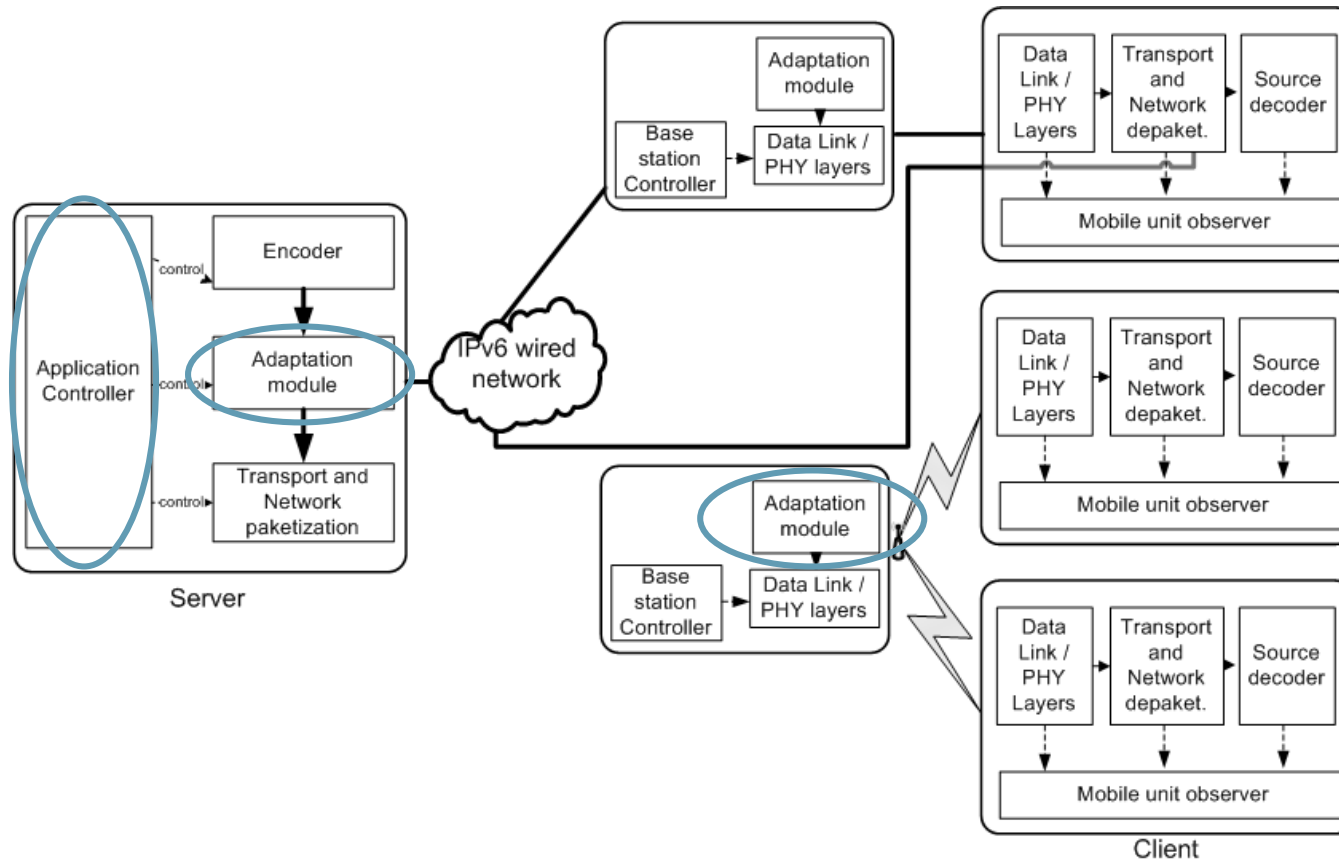


Project approach

- Introduction of two separate controlling units:
 - » An Application Controller adapts in real-time the source coding parameters and the protection rates
 - » A BS Controller allocates the shared radio resources among the users and the different kind of traffic
- Design of signalling architecture allowing:
 - » The transfer of cross-layer information within network nodes and over different RATs
 - » The transfer of feedbacks and commands among different entities
 - From clients to controllers
 - Among controllers



The architecture at a glance



» Application Controller:

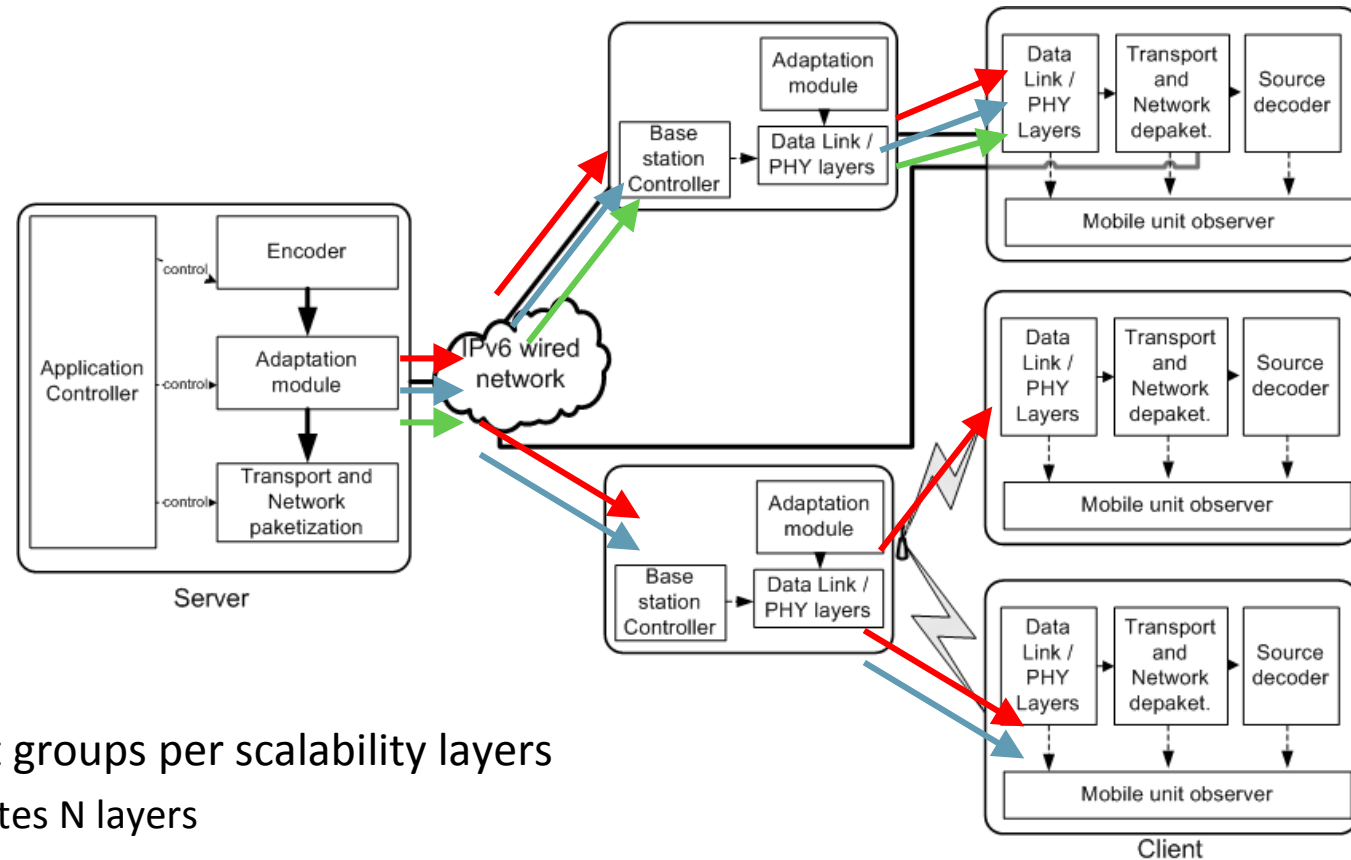
- adapt in real-time source coding parameters and protection rates

» Adaptation module:

- Adapt a pre-coded stream



SVC stream: P-to-MP distribution

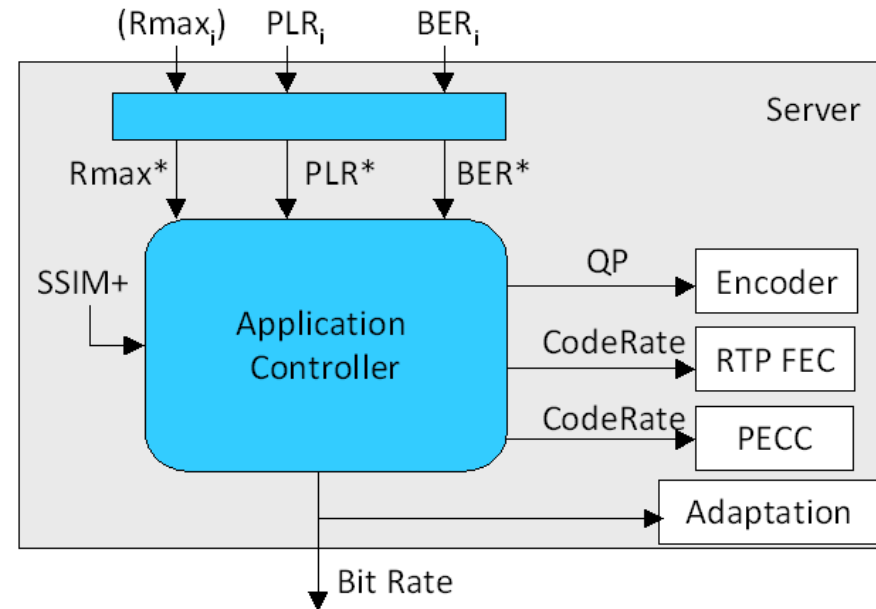


- Different multicast groups per scalability layers
 - » Server generates N layers
 - » Clients register to a group of layers depending on device capabilities
- Adaptation done at the BS:
 - By filtering groups corresponding to layers exceeding the bandwidth
 - By further reducing bandwidth occupancy if needed



SVC Application Controller

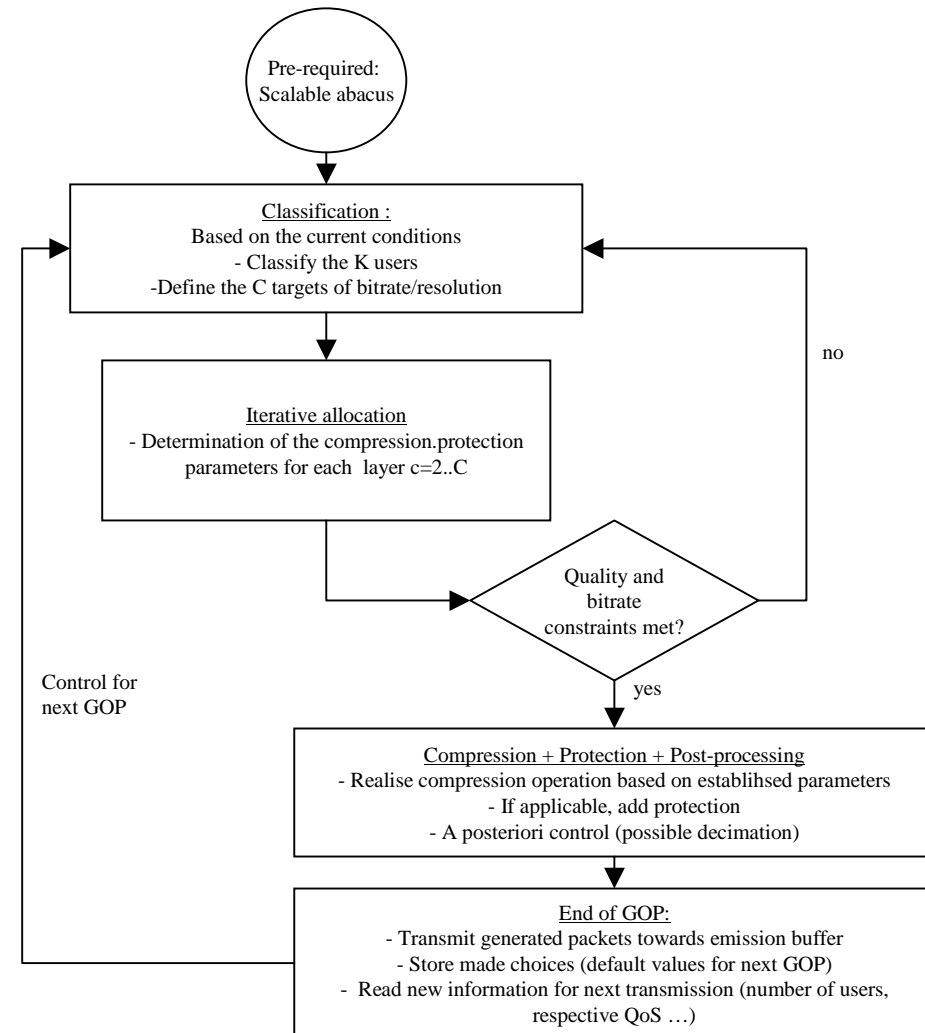
- Goal: control the compression and protection levels of video/audio streams based on the feedback information
- Inputs:
 - » maximum bit rate
 - » packet loss and bit error rate
 - » SSIM based video quality estimation
- Outputs:
 - » QP to video encoder
 - » code rate to RTP FEC
 - » bit rate, frame rate
 - » layers priority (in IP headers)
- Optimization timescale: every second
- Point-to_multipoint adaptation based on clustering of feedbacks from clients
 - » Definition of C targets for a scalable video stream





SVC Application Controller

- Hypothesis :
 - » A set of K bit-rate, error probability values $\{r_k, P_{ek}\}$, one for each client
 - » A scalable solution with C layers
- At each interval t:
 - » Classify the K users and define C targets of bitrate/resolution
 - » Determine for each layer $c = 1..C$ a target couple $\{r_c, P_{ec}\}$
 - » For $c=1..C$, make the best compromise (repartition of bit-rate between compression and protection) with respect to the established distortion
 - » Check criterions (quality, layers difference ...) and eventually loop back to step 1

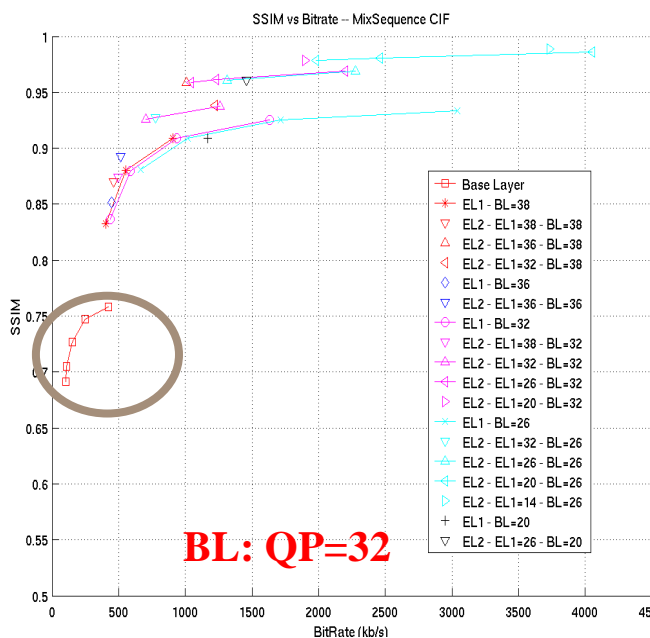




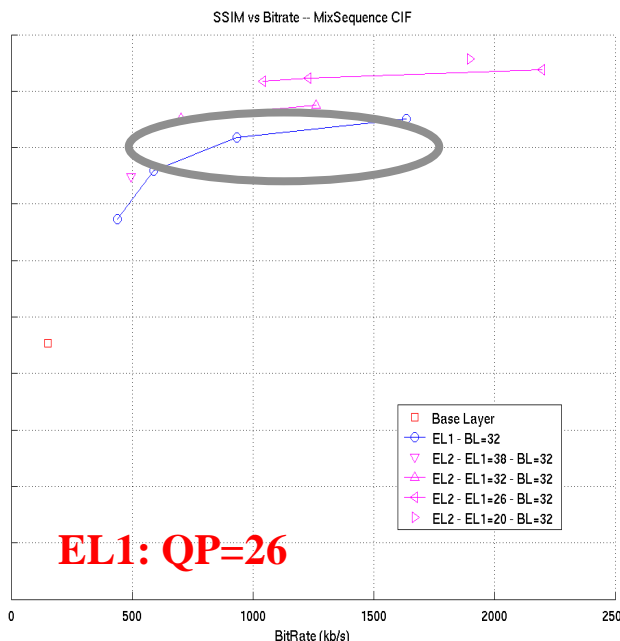
SVC Controller: an example

- C=3 scalability levels
- N=3 users with different conditions: $(r_1, P_{e1}), (r_2, P_{e2}), (r_3, P_{e3})$
 - » Hyp: $r_1 \ll r_2 \ll r_3$ and allow to reach a minimal acceptable distortion

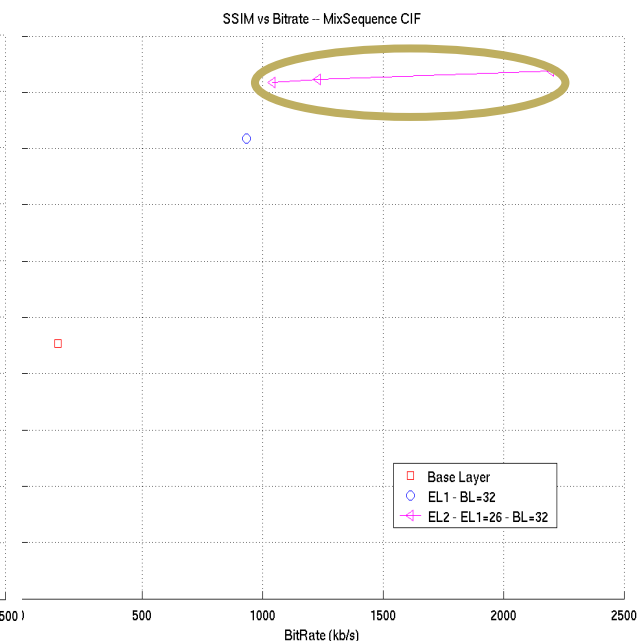
«Bronze»: best compression for BL layer considering constraints (r_1, P_{e1})



« Silver » : obtained considering EL1 possibilities meeting BL choices, and considering (r_2, P_{e2})



« Gold » : obtained with EL2 layer and constraints (r_3, P_{e3})





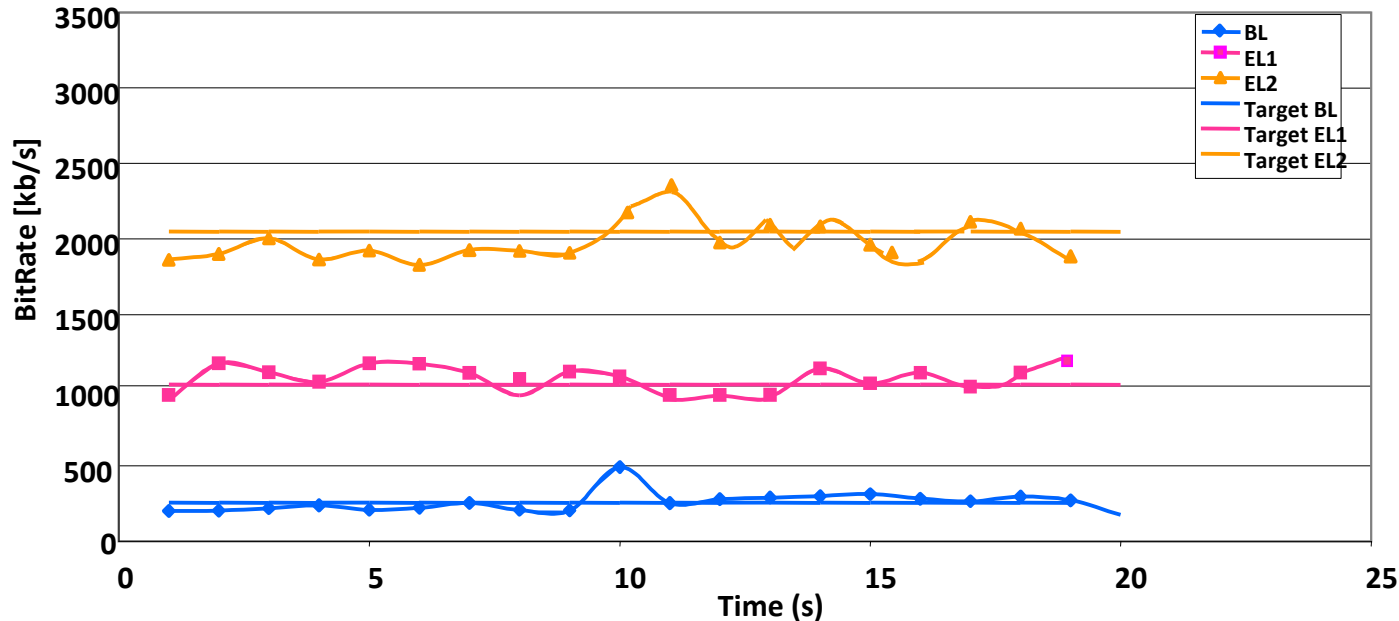
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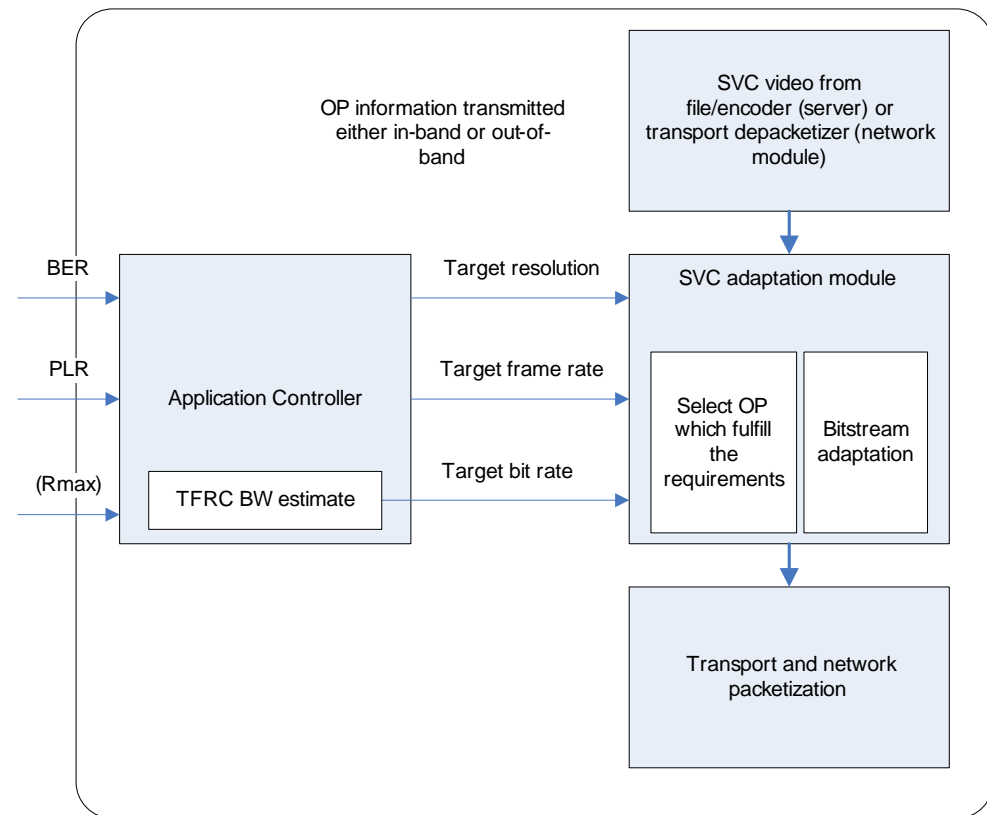
SVC adaptation module: Role

- The main role of the adaptation module is to adapt SVC stream to meet bitrate requirements of the transmission medium
- Location of SVC adaptation module
 - » Streaming server – adaptation is done for SVC stream
 - » In the network – RTP repacketisation is needed
- SVC adaptation module extracts NALUs from a stream and Dependence, Temporal, Quality (DTQ) values for each packet
- The bitstream adaptation process simply compares the target bit rate to the layer bitrate, selects the operation point which fulfil the requirements and drops enhancement layers if needed



Adaptation decision

- The adaptation module performs the adaptation of SVC bitstream according the decision made by the application controller.
- DTQ (Dependence, Temporal, Quality) scalability is supported by utilising operation points (OP) of SVC stream.
- The application controller selects OP fulfilling user requirements (e.g. resolution)
- Selected OP is sent to SVC adaptation module
- An estimate of available bandwidth can be known (e.g. by the base station) or estimated using probing or congestion control based techniques (e.g. TFRC)





SVC adaptation module: Realization

- In the application layer, TCP-Friendly Rate Control based (TFRC) adaptation algorithm can be used to estimate the data rate (T) available for the multimedia source.

$$T = \frac{s}{R\sqrt{\frac{2p}{3}} + t_{RTO} \left(3\sqrt{\frac{3p}{8}} \right) p(1 + 32p^2)}$$

- Packet loss rate p and round-trip time R are reported from the client-side using triggering framework (TRG)
- The accuracy and reliability of the link condition is increased by weighting.

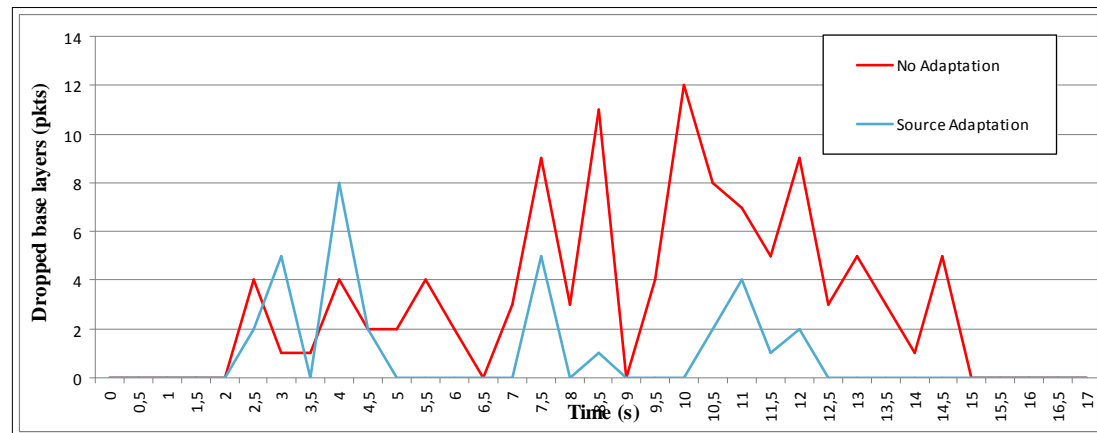
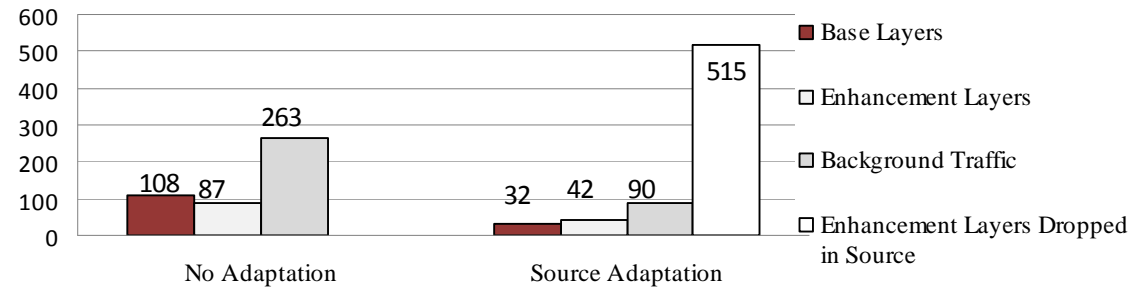
$$\sum_{k=0}^4 E_k \times M_k, M_k \in \{0.45, 0.3, 0.1, 0.1, 0.05\}$$

- The data rate estimate achieved with TFRC can vary quite a lot since TFRC reacts easily to even to small packet ratios.



SVC adaptation module: Results

- Scenario: congested wireless link
- The link capacity is 5.2 Mb/s with small loss (<1%).
- The background traffic starts at 2.0 s (3 Mb/s), progressively increases every 2 s to 3.6 Mb/s and decreases by 500 kb/s per 2 s until 16 s.
- Without adaptation and with source adaptation, the dropped packets at link layer are quite evenly divided between the background and video traffic.
- However, with source adaptation large number of enhancement layers is being dropped already in the source.

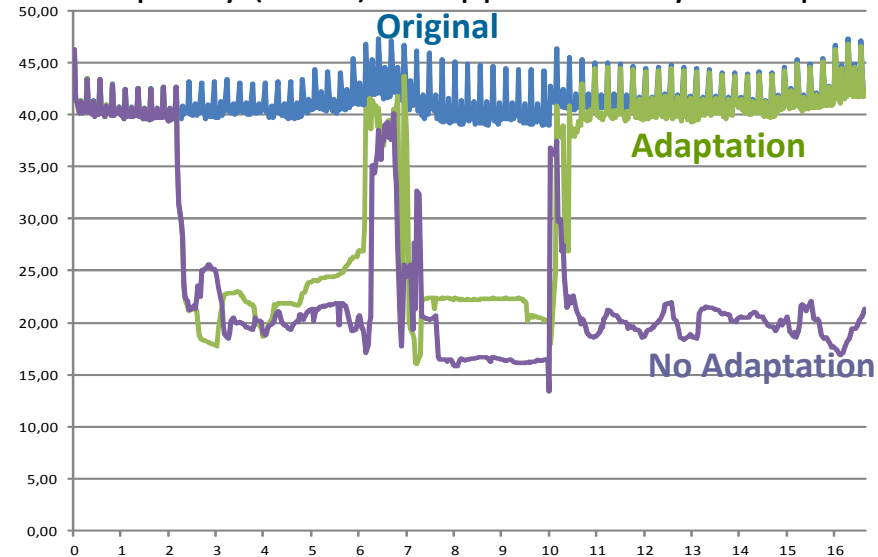




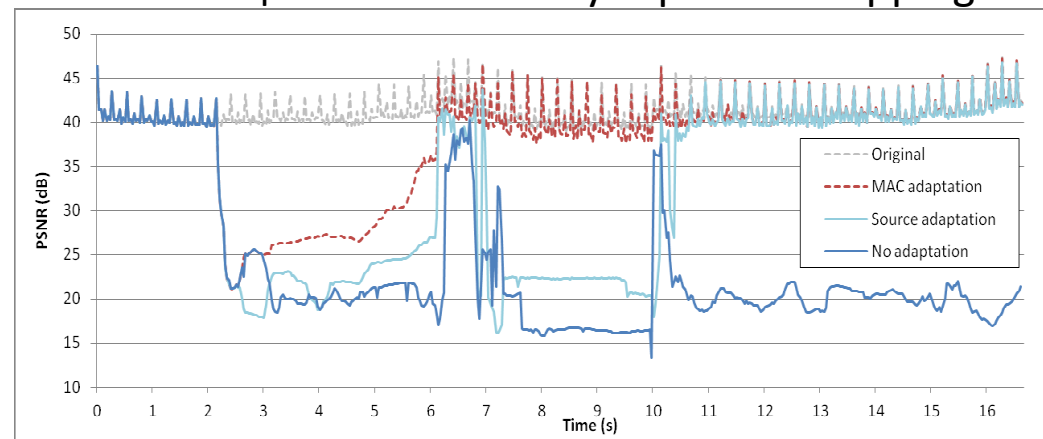
SVC adaptation module: Results

- The importance of correctly received base layer NALUs can be clearly seen from the figure (I-frame refresh rate)
- Feedback messaging overhead with 0.5 s interval is 8.7 kb/s
- With intelligent link layer packet dropping better adaptivity and video quality is achieved.

video quality (PSNR) for application layer adaptation



PSNR with adaptation and link layer packet dropping





Conclusions

- Application layer adaptation performs better when it used for long-term adaptation and different adaptation methods are used when severe signal strength variations caused by wireless channel occur.
- Forward error correction, link layer scheduling and prioritization can be used to better cope with this kind of variations.
- Time interval between feedback triggers should be short enough
 - » too short interval will cause annoying fluctuation in video quality
 - » too short interval will cause more feedback overhead to the network.
- A good candidate for trigger interval needed by TFRC data rate estimation is between 0.5 and 1 second.
- A good estimate for available bandwidth in wireless link is important for adaptation.