

# Bagadus

## Layered Panorama Streaming for a Personal Football Experience

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with slides and figures from Pål Halvorsen,  
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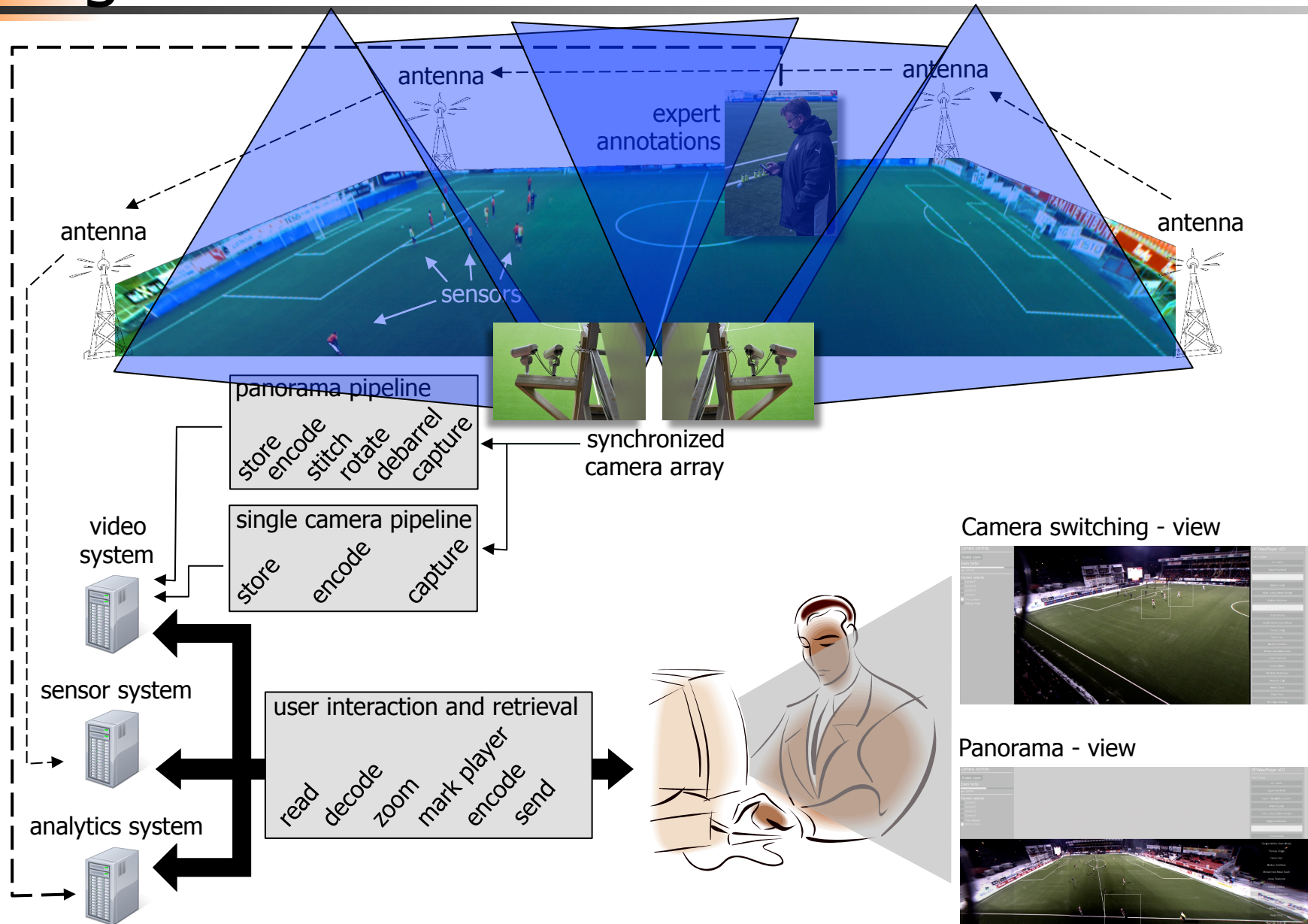
[ **simula** . research laboratory ]  
- *by thinking constantly about it*

# Bagadus, DAVVI and Muithu

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- so far
  - sports video is presented to fans outside the stadium
- viewers desire
  - search
  - personalization
  - summarization
  - long-term tracking
  - ...
- Muithu
  - meta information from trainers
- DAVVI
  - search and summarization
- Bagadus
  - personalized views

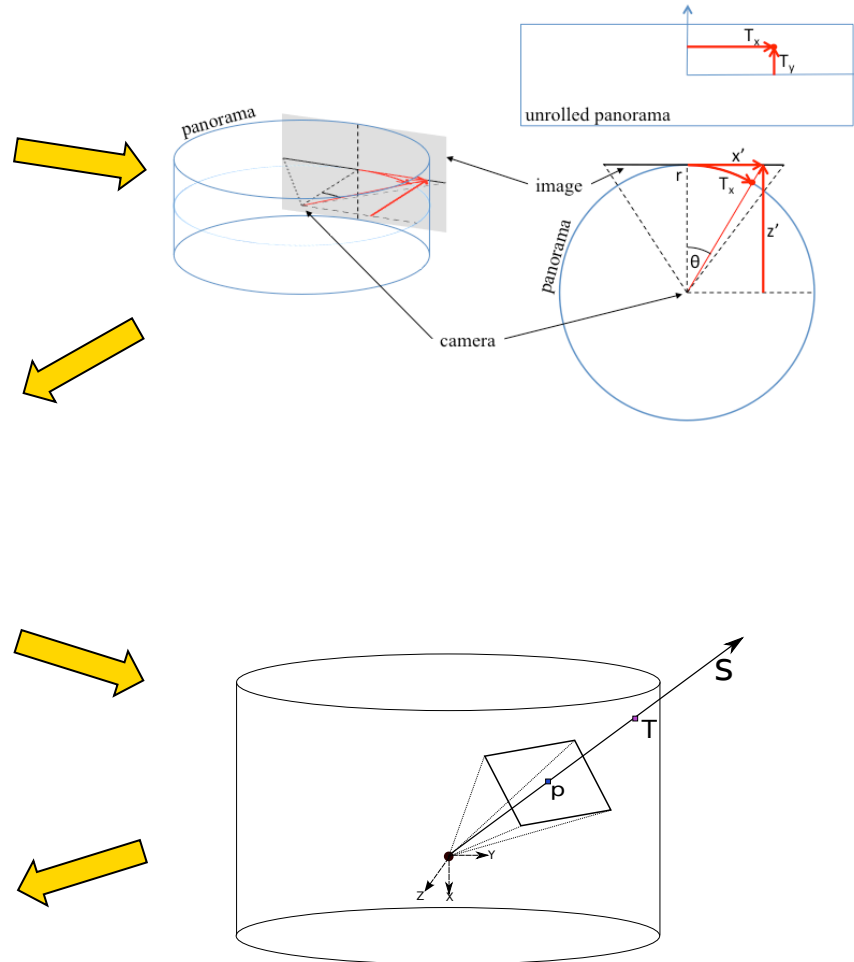
# Bagadus architecture



# Spatial freedom



# Be your own camerawoman



# Spatial freedom

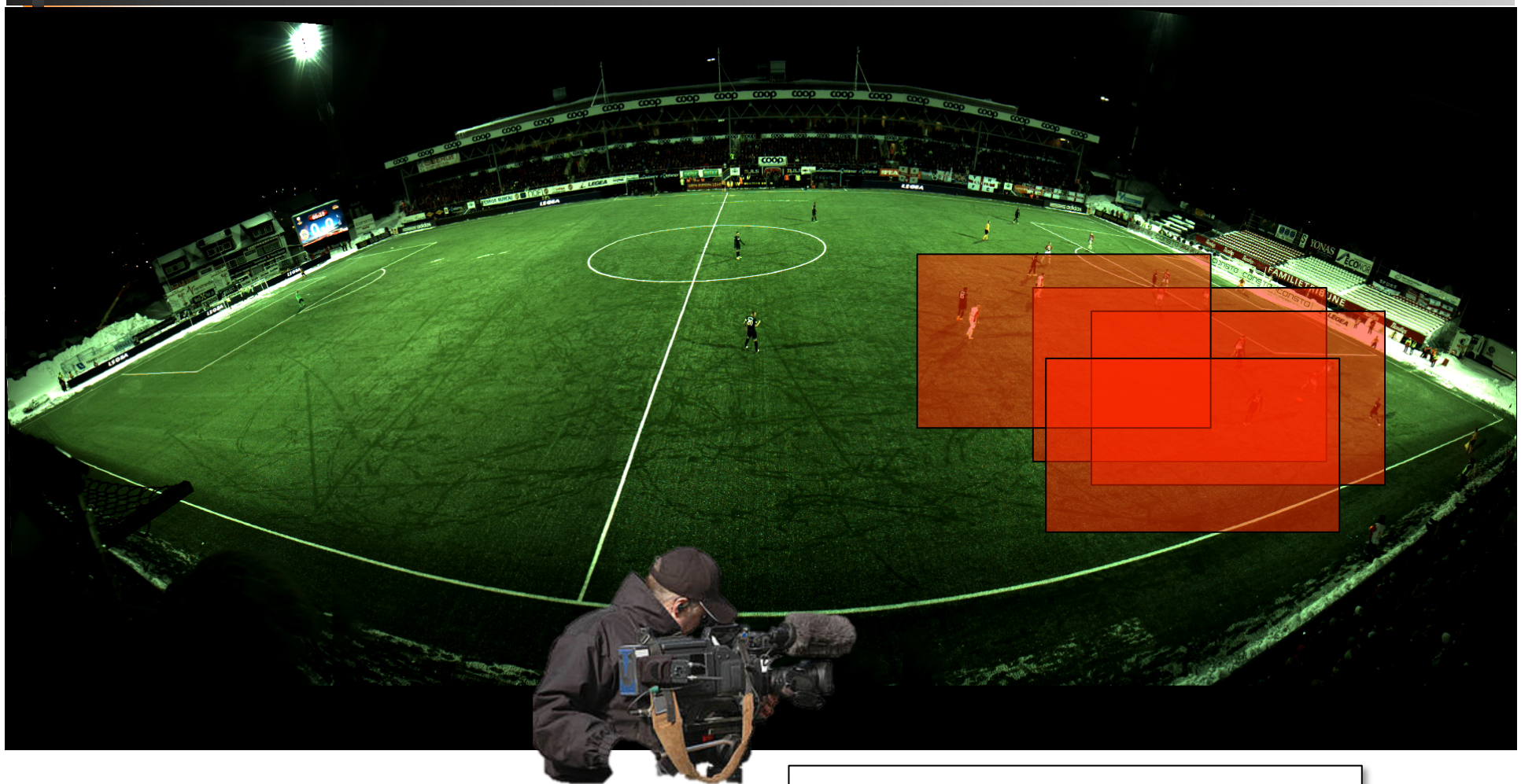


Arbitrary zoom and pan

- from panorama
- to individual players



# Spatial freedom



Each viewer can individually:

- track players
- track the ball
- track groups of players

# Temporal freedom



Each viewer can

- compose topics using search
- correct and improve search results
- create personalized playlists and video summaries
- anytime, everywhere...





# Temporal freedom: DAVVI

The screenshot displays the DAVVI interface. At the top, a search box contains the word "penalty" and a slider is set to "4". A "go" button is to the right. Below the search bar, a row of five search results is shown, each with a small video thumbnail and a text description. A large video player is in the center, showing a goal being scored. To the right of the video player is a "Playlist" section with three items, each with a video thumbnail and a progress bar. At the bottom, there are player controls, a video quality indicator, and a playlist adjustment control.

search box

automatically generate an X-minute playlist

search results – horizontally scrollable

textual description of the event which can be expanded

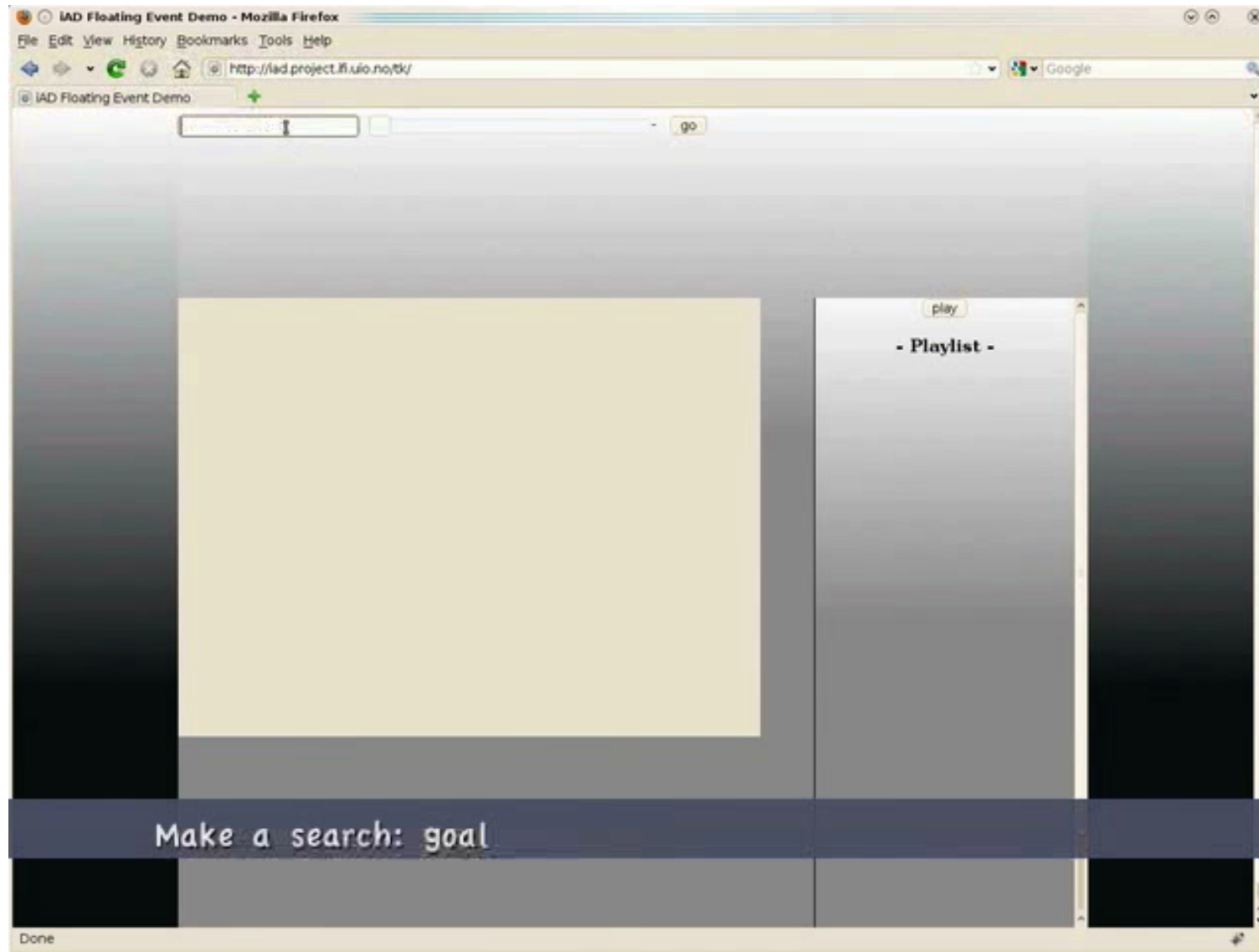
player controls

video quality indicator

each clip can be adjusted

playlist generated by drag-and-drop or automatically generated

# Temporal freedom: DAVVI



# Temporal freedom



Each viewer can

- compose topics using search
- correct and improve search results
- create personalized playlists and video summaries
- anytime, everywhere...



How to create the event database?

- where can we acquire metadata for soccer games?

# Annotation: event identification



How can an event be identified??

- Audio-video analysis is difficult
  - Variation among & within broadcasts
  - Complex video quality, camera angles and on screen graphics
  - Many different events to detect, e.g., in the context of soccer
    - yellow cards / red cards / goals / penalties / free kicks / fouls / corners / throw-ins / tackles / headings / passes / player numbers...
  - Identify the beginning and end of the event
  - Find all the events – recall, but also precision
  - Computationally expensive

# Annotation: sports event analysis

- Event identification figures:

- Huang et al. (U. III)
- Hanjalić
- Sadlić

**Still not good enough!**




- Initial evaluation of visual/aural approach we developed for IAD: **67% - 83%**



# Annotation: live text commentaries (for sports)

- Many online TV-stations and newspapers provide **live text commentaries**
- Use a semi-automatic live-text crawler and parser to improve the automatic annotations

[uk.eurosport.yahoo.com](http://uk.eurosport.yahoo.com):

89'		<b>GOAL FOR LIVERPOOL!! TORRES WITH THE HEADER!!</b> Gerrard exchanged passes with Kuyt and fed Aurelio on the left; his ball was superb to the near post, where the striker headed past Cech brilliantly. It is his first goal at Anfield this season. So much for a goalless draw!!
88'		This match is heading for a goalless draw. Beforehand you said to your mates it would end all-square, but when the whistle went to start it off you wanted it to be more interesting than that; unfortunately it seems not to be.
85'		Chelsea change: Miroslav Stoch on for Kalou.
83'		'Pool sub: Ryan Babel on for Mascherano. An attacking move from Rafa for once...
83'		Israel Benayoun watches the ball drop and unleashes a dipping volley just over the bar. He is a man in form.
81'		Cole with a great challenge to dispossess Kuyt as Liverpool attacked space on the right. It has not been pretty from Chelsea, but they have fought for a draw.
80'		Benayoun comes inside and strikes towards the far corner, parried away by Cech - who has been infinitely busier than Reina.
78'		Torres flies through the air as a cross comes in, but he cannot get anything on the ball. Strange acrobatic effort.

[news.bbc.co.uk](http://news.bbc.co.uk):

**31:01 GOAL - Fernando Torres**  
**Liverpool 1 - Tottenham 0**

Dirk Kuyt crosses the ball, Fernando Torres grabs a headed goal from deep inside the penalty box. Liverpool 1-0 Tottenham. Assist by Dirk Kuyt.

**29:49**

Foul by Didier Zokora on Steven Gerrard, free kick awarded. Free kick taken by Daniel Agger.

**28:27**

Free kick awarded for a foul by Steven Gerrard on Luka Modric. Gareth Bale crosses the ball in from the free kick, clearance by Jamie Carragher.

**26:33**

Drilled right-footed shot by Fernando Torres. Aurelio Gomes makes a save.

**25:52**

Shot by Jermaine Jenas from 30 yards. Jose Reina makes a save.

**21:52**

Benoit Assou-Ekotto has an effort at goal from 30 yards. Save made by Jose Reina.

**19:29**

Free kick awarded for an unfair challenge on Fabio Aurelio by Jermain Defoe. Fabio Aurelio takes the free kick.

**14:44**

Shot by Steven Gerrard. Clearance made by Vedran Corluka.

**14:23**

Inswinging corner taken right-footed by Steven Gerrard, Vedran Corluka makes a clearance.

**12:31**

Luka Modric fouled by Fabio Aurelio, the ref awards a free kick. Alan Hutton takes the free kick.

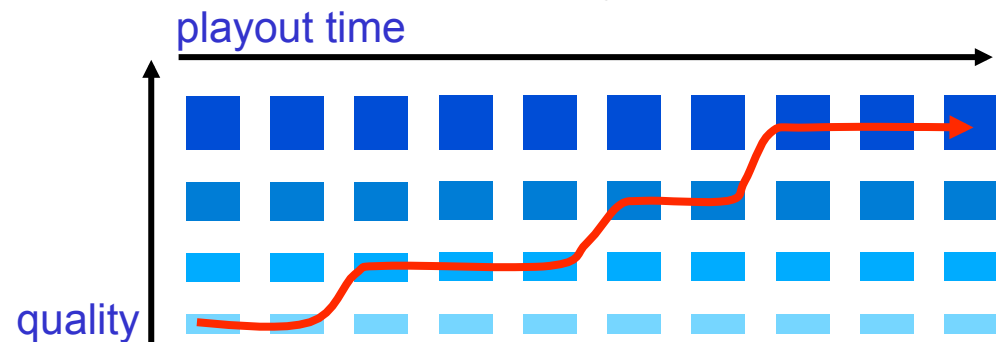
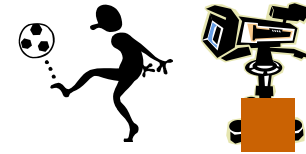
**10:43**

Jamie Carragher challenges Gareth Bale unfairly and gives away a free kick. Didier Zokora restarts play with the free kick.



# Delivery to a large audience

- Segmented adaptive HTTP streaming
- Based on experiments, use 2-second segments (2-hour movie → 3600++ small, indexed videos)
- To support adaptation to available resources, each segment is coded in *several quality levels*
- Can deliver entire cylindrical panoramas
- Allows client-sided zoom and pan
- Is time-coded for summarization etc.





**New challenge: stadium delivery**

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# Audiences get connected

" norge - G... Cisco Connected Stadium - Ind... to Become First League in the... Trådløs ligaløsning i Tippeliga... first in the world to

Nyheter

## Norwegian Professional Football League to Become First League in the World to Implement Wi-Fi and Mobile Video as a League Solution

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**Norwegian Professional Football League to Become First League in the World to Implement Wi-Fi and Mobile Video as a League Solution**

Viking, Rosenborg, Ullevaal stadium and Haugesund to be first teams/venues to implement solutions and enhance fan experience

**Norway - 21 January 2014** - The Norwegian Professional Football League (NPFL), through a framework agreement with Datamatrix, will become the first league in the world to implement Cisco Connected Stadium Wi-Fi and Cisco StadiumVision Mobile as a league solution, to give their fans the most connected experience possible and place them at the center of the action. Viking, Rosenborg, Vålerenga (Ullevaal stadium) and Haugesund will be the first teams and venues that will implement the solutions.

The need for these solutions was apparent as various surveys indicate that Norway is one of the world's leading countries in use of smartphones and Internet, 94 % of Norwegian football fans bring their smartphone to matches, and internationally 73 % of fans bring their mobile devices to the stadium and 49 % share experiences there.

"With the framework agreement that is now signed between Datamatrix and NPFL, the clubs in the Tippeligaen have a great foundation to build reliable Wi-Fi solutions in-stadium," said CEO of Norwegian Professional Football League, Leif Øverland.

"We have had a very thorough review of various solutions in the market and it was clear that Cisco Connected Stadium Wi-Fi and Cisco Stadium Vision Mobile are the foremost solutions, used by teams and venues around the world, which will provide an optimal wireless network and mobile video delivery for our fans. Along with Datamatrix, who made a solid impression with its wireless expertise in the development of wireless venues like Holmenkollen and Telener Arena we are convinced that this will be a robust, well-

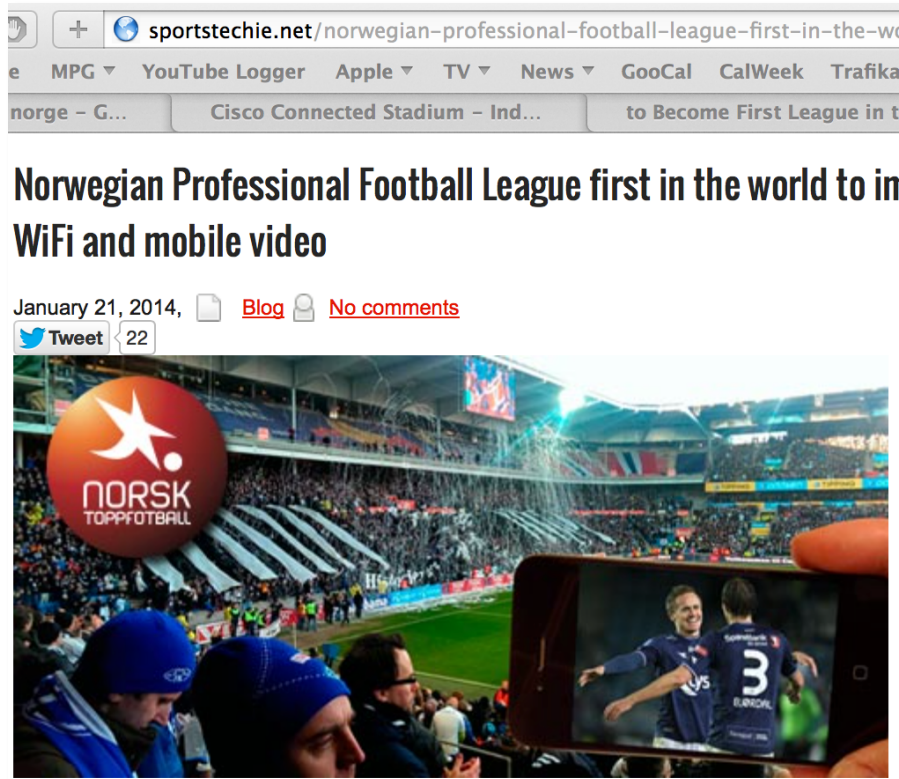
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# Audiences get connected



## Audience will watch scenes of local and remote matches

- rewind arbitrary number of seconds to replay local events with individual zoom/pan
- see remote reports

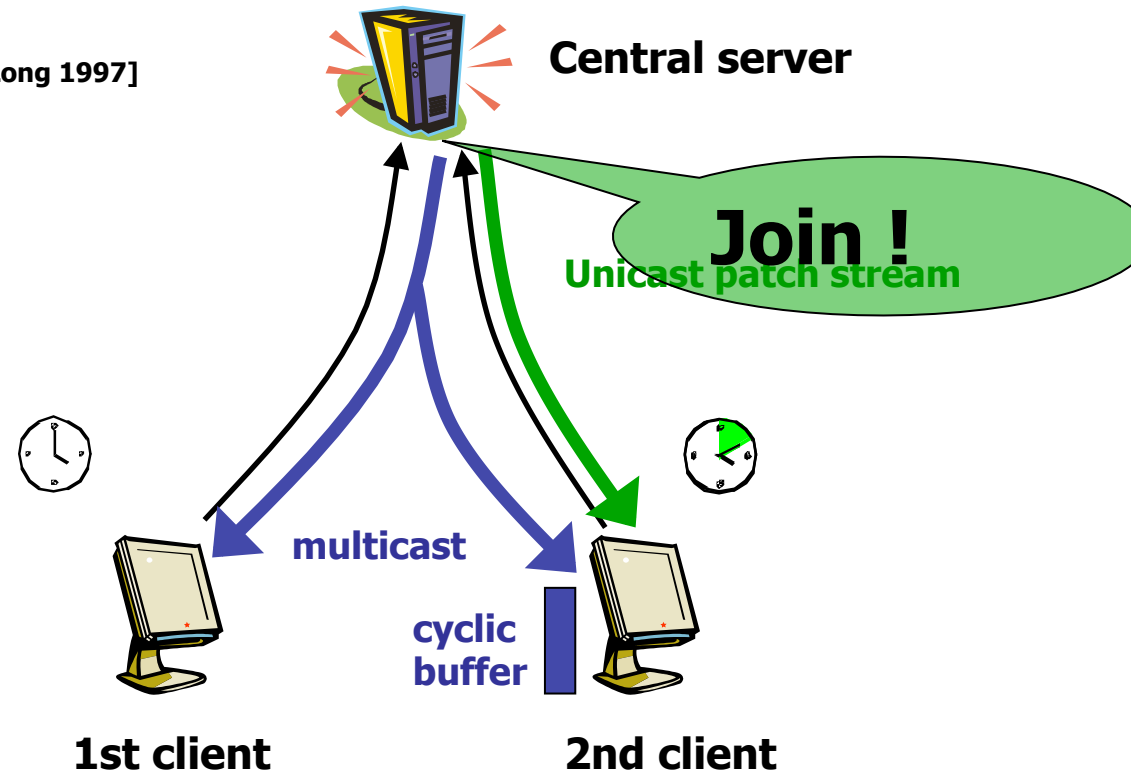
## Challenges

- which content is of interest?
- when is this content interesting?
- how to provide interaction?
- how to scale?
- how to support current mobile platforms?
- what is legally/contractually possible?

# Optimized delivery scheduling

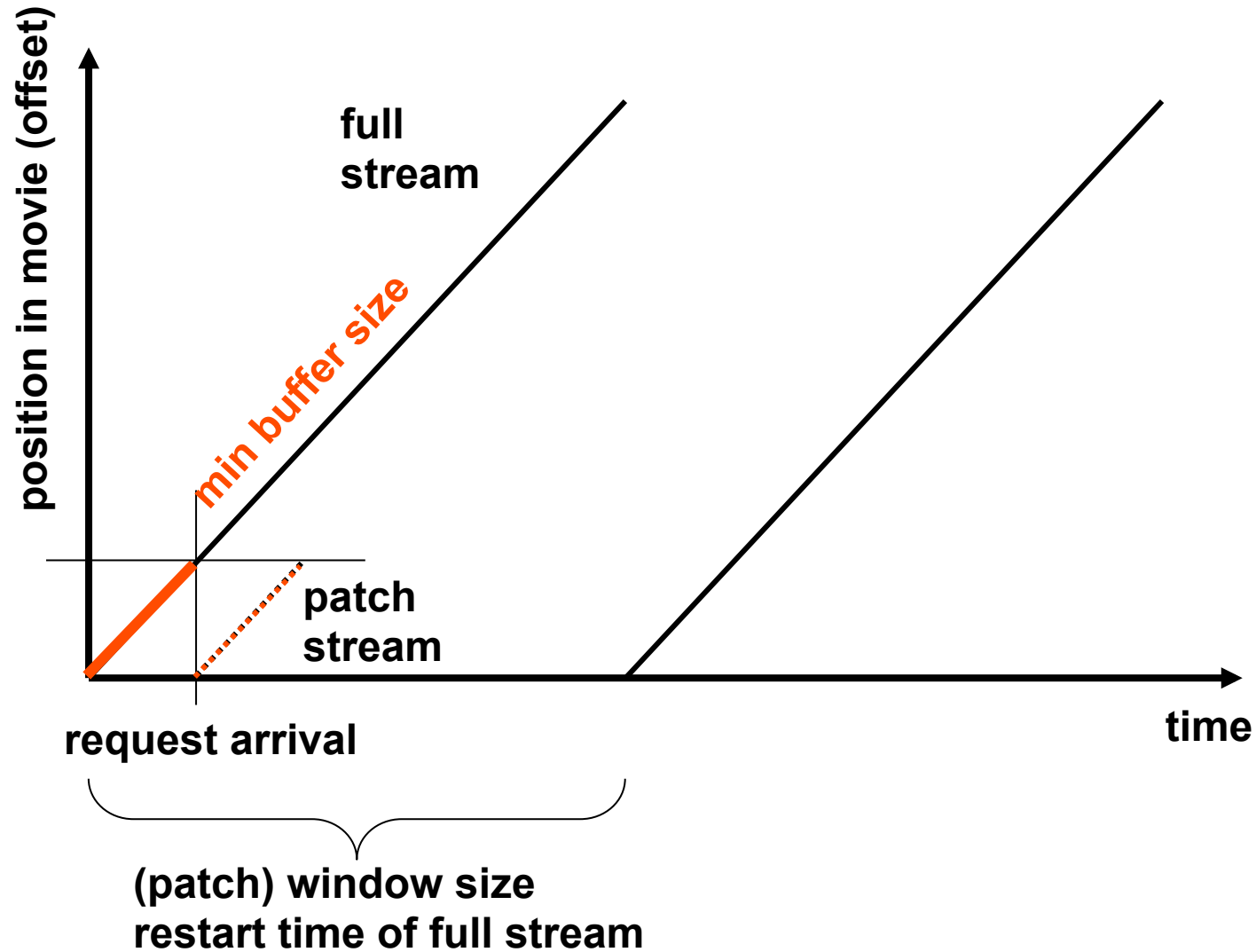
- Patching

[Hua, Cai, Sheu 1998,  
also as Stream Tapping Carter, Long 1997]



- Resource optimization is possible

# Optimized delivery scheduling



# Optimized delivery scheduling

- Optimal patching window size
  - For identical multicast and unicast setup costs
- Servers can estimate  $\Delta_U$ 
  - And achieve massive saving

$$\Delta_M = \sqrt{2 \cdot F \cdot \Delta_U}$$

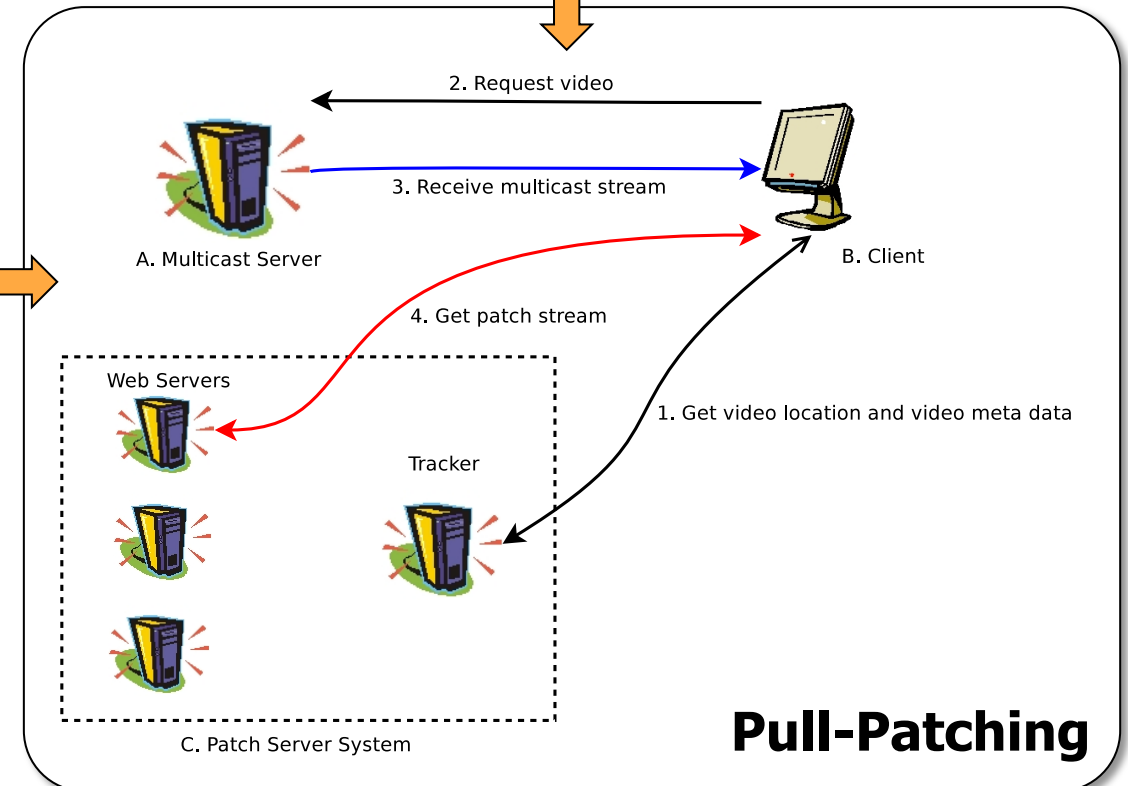
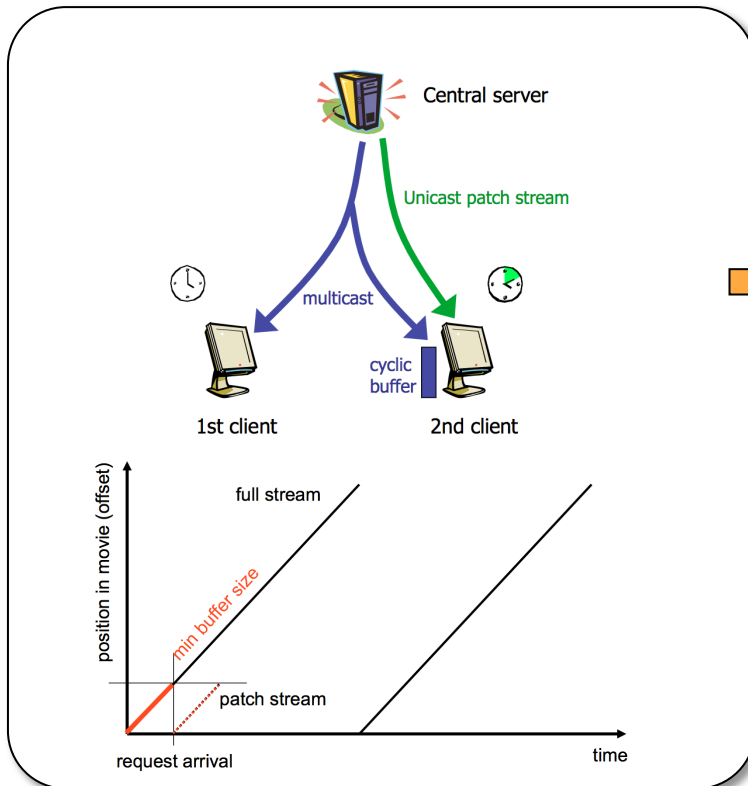
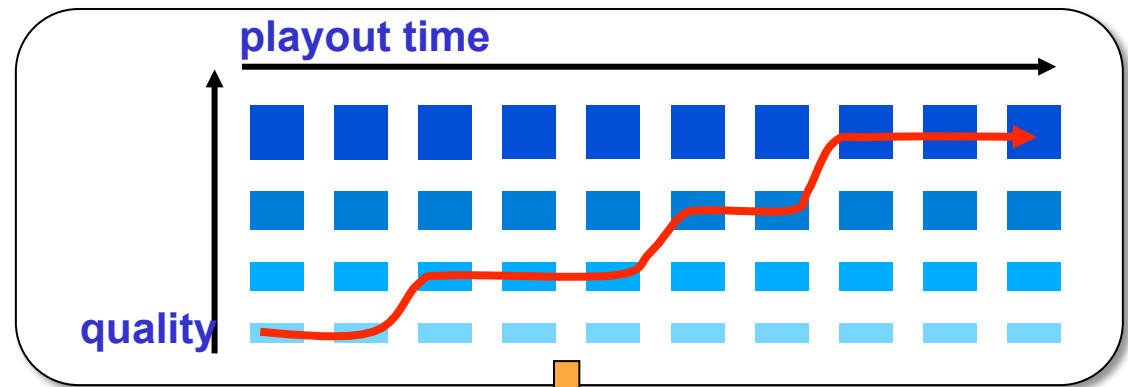
The diagram illustrates the equation  $\Delta_M = \sqrt{2 \cdot F \cdot \Delta_U}$ . Three callout boxes are connected to the equation by lines:

- A box labeled "Patching window size" is connected to the  $\Delta_M$  term.
- A box labeled "Chunk length" is connected to the  $F$  term.
- A box labeled "Interarrival time" is connected to the  $\Delta_U$  term.

# Pull-Patching

## Combination

- adaptive segmented HTTP streaming
- patching

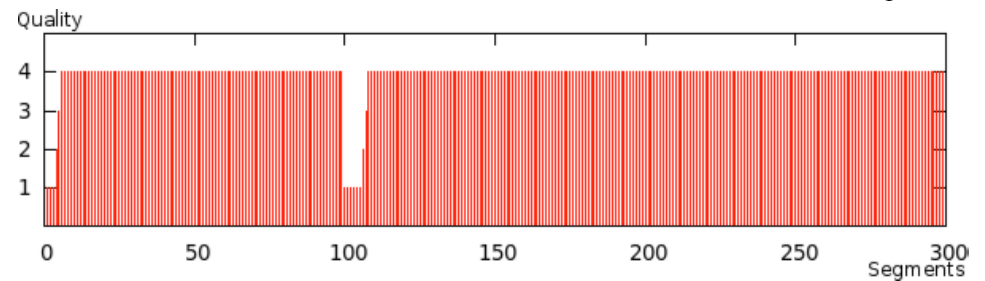
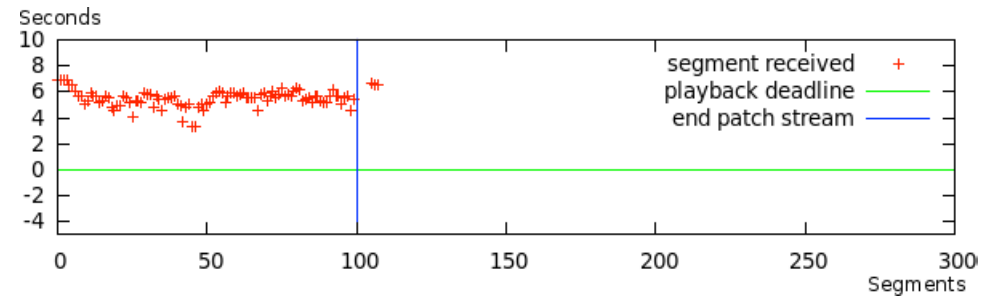
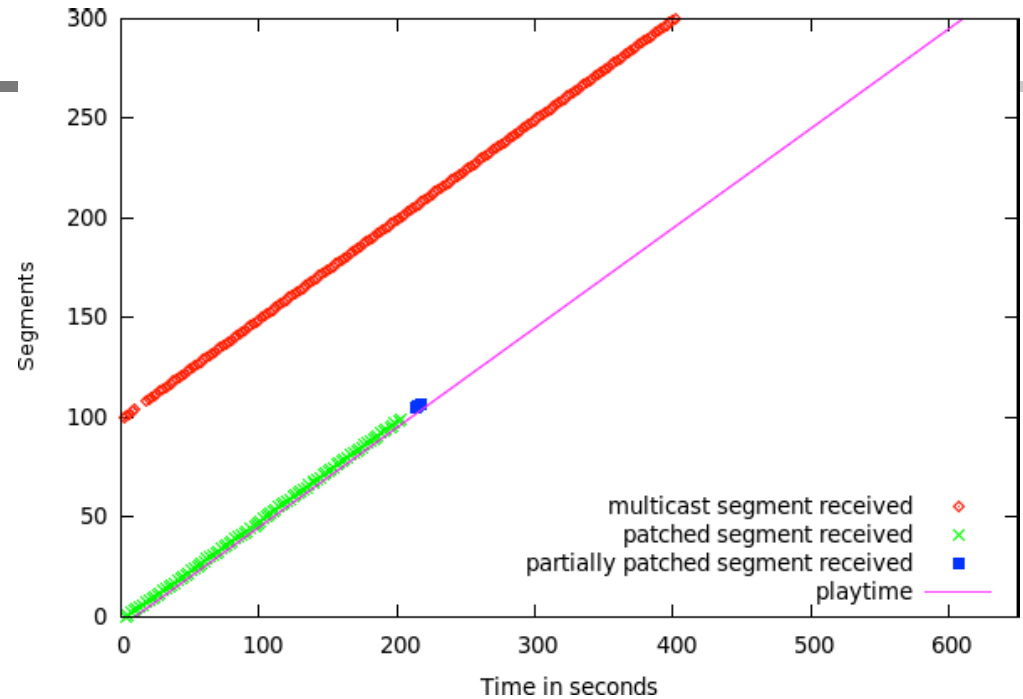
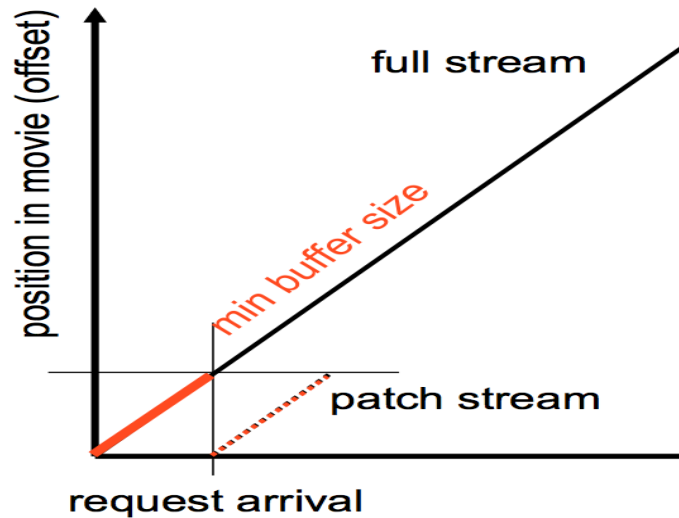


**Pull-Patching**



# Pull-Patching

- **Experiment**
  - client joins 100 segments into the stream
  - 4 video layers
  
- **Results if ...**
  - ... enough resources (8 Mbps)

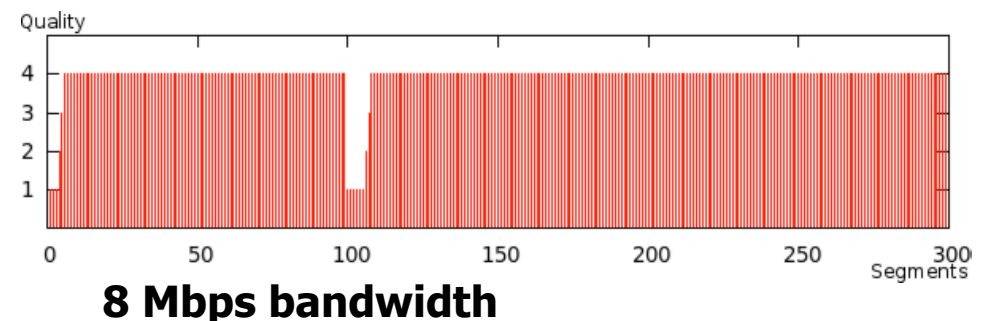
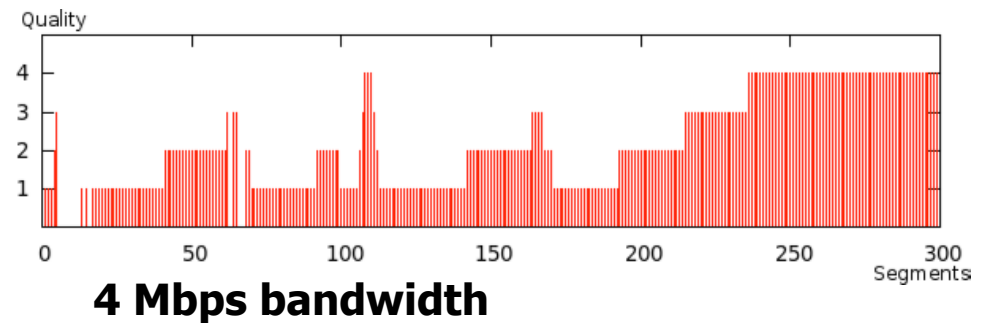
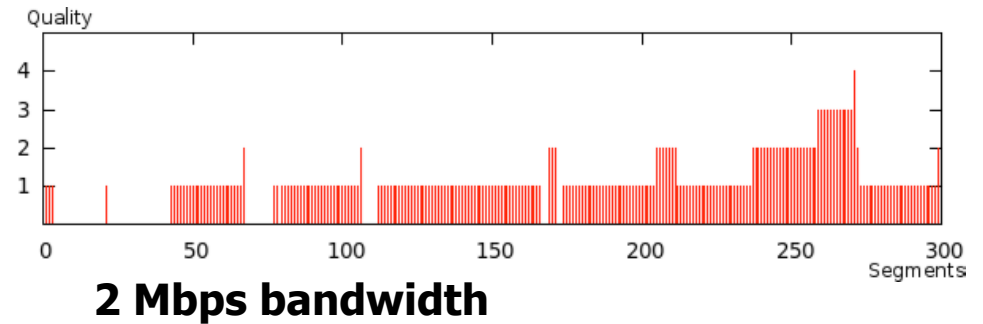


**8 Mbps bandwidth**



# Pull-Patching

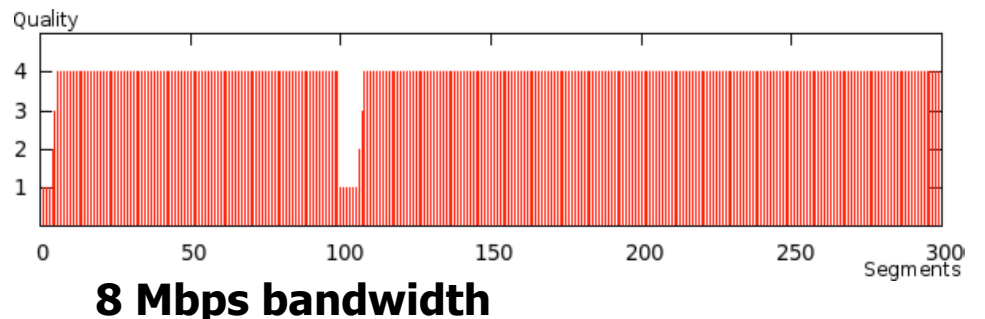
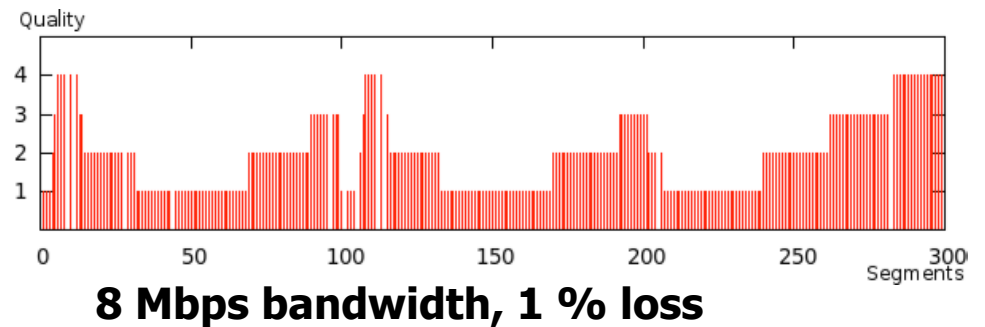
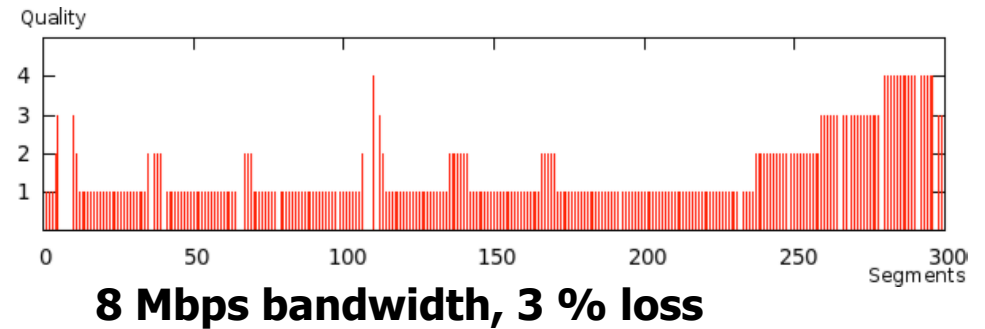
- **Experiment**
  - client joins 100 segments into the stream
  - 4 video layers
- **Results if ...**
  - ... enough resources
  - ... bandwidth limitations



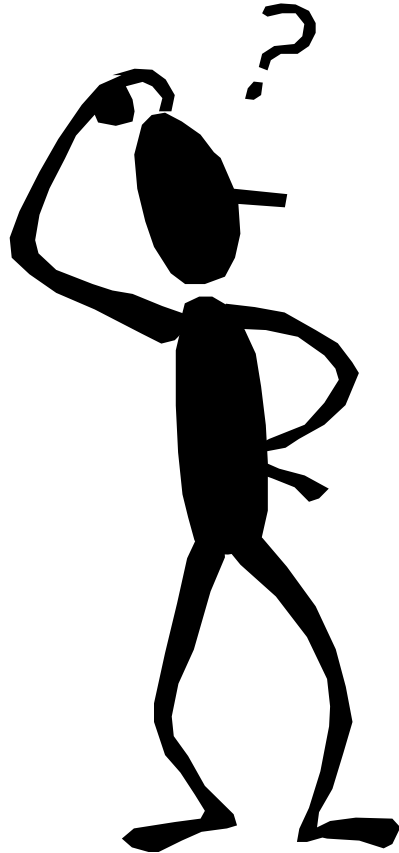


# Pull-Patching

- **Experiment**
  - client joins 100 segments into the stream
  - 4 video layers
- **Results if ...**
  - ... enough resources
  - ... bandwidth limitations
  - ... loss
  - (... delay and jitter)
- ⇒ **Pull-Patching works**
  - client side decisions
  - overcomes traditional patching limitations
  - dynamic adaption
  - loss and delay handling
  - patch server scalability



# Questions? Contact?



Contact information:

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[ **simula** . research laboratory ]  
*- by thinking constantly about it*

