LIVE TEACHING WITH AN ADVANCED MULTIMEDIA DISTRIBUTED SYSTEM

Federico Filira, Michele Moro

ILEARN 2007

Paris - 2007 January

Outline

- Introduction
- Requirements and goals
- System architecture
  - Streaming
  - Direction
  - Control
- Future work
- Conclusions

Introduction

Some figures

4 sites

12 multimedia classrooms

2 Mbps per lesson

History

1996 Distance e-Learning 1° project

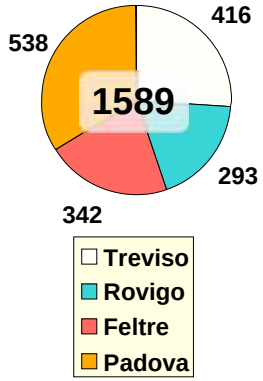
1999 Live D.L. (satellite)

2001 Live D.L. (private radio link 34 Mbps)

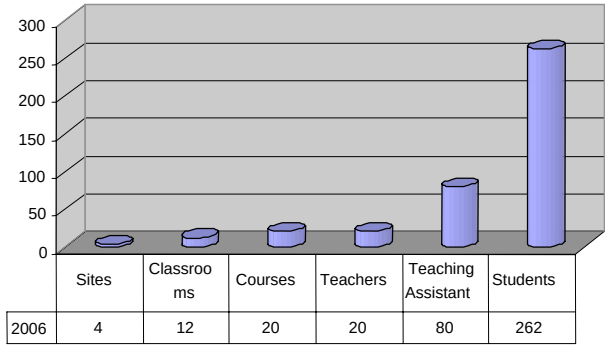
2005 Live D.L. (commercial intranet 6Mbps)

Teleteaching Statistics

2001-2006 enrolled students



2006 figures



Requirements

1. Wired line Intranet connection (2Mbps per lesson)
2. Excellent audio and video quality
3. Synchronization between streams and low communication delays
4. Full modular software solution
5. Absence of a main control center
6. Dynamically built lesson (no scheduling needed)
7. “Stateless” behaviour of system components
8. Friendly GUI
9. Fully open-source software

Virtual Classroom

A virtual classroom is a set of geographically distributed physical classrooms in which students at different places are attending the same lesson delivered at the same time by the same teacher.

That is:

- same didactic effectiveness in any physical classroom
- teacher’s activities in any classroom
- possible temporary teacher substitution by a remote assistant

Student view

User’s tools

TEACHER

control GUI

wireless *microphone*

document camera like a blackboard, but can display handwriting printed pages and objects

general *desktop utility* (slides, pdf…)

video camera

STUDENTS

2 displaying devices:

- wall projectors
- wide screen TV set or monitor

hi-fi audio *speakers*

wireless *microphone*

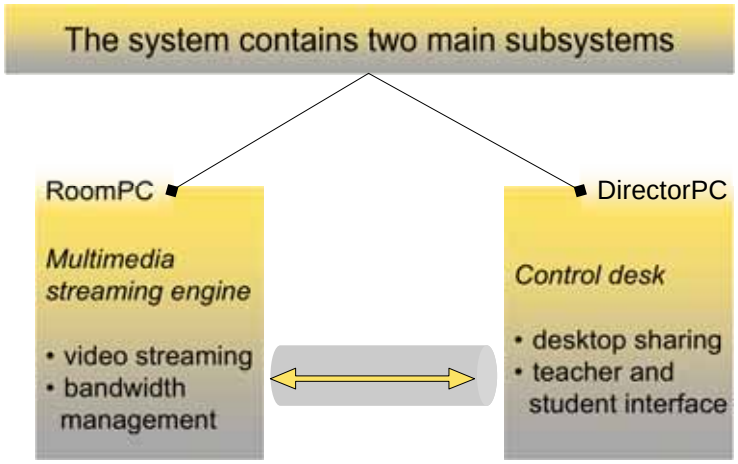
GUI for requesting teacher interaction

video camera

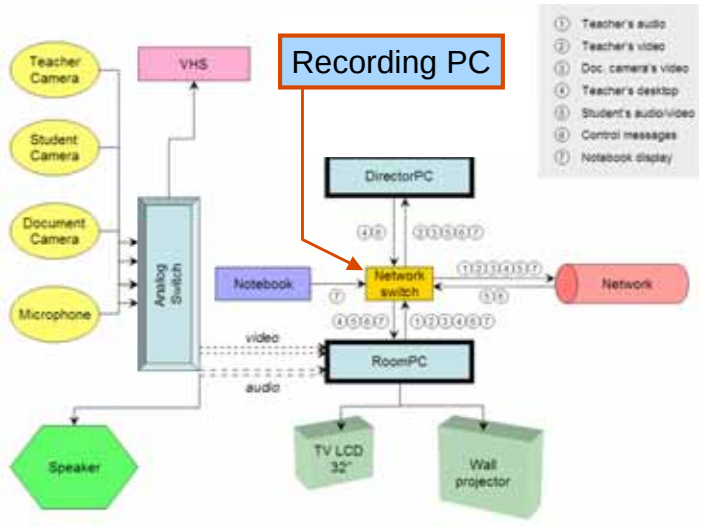
HIDDEN

control software: dynamically built virtual classroom, sync…

System architecture



Architecture: components



Components of the lesson

A lesson consists of many multimedia and data streams, which have to be recorded:

- Video of the teacher
- Audio of the teacher
- Document camera
- Up to 3 audio & video streams from the remote classrooms

Audio / Video

- Teacher's desktop
- Data control flow

Data

Architecture: streaming requirements

1. bandwidth limited to 2Mbps per lesson
2. perfect A/V synchronization
3. specific need of each stream (variable bandwidth)
4. low latency (<1 s) for stream
5. "true" real-time on local video

We need multicast transmissions:

- Streaming solution uses vlc (VideoLAN client)

Real-time video presentation:

- on TV monitor directly from analog switch
- on wall projector via software duplication of Linux devices

Architecture: bandwidth management

1. bandwidth limitation
2. bandwidth shaping

We use traffic control and routing capabilities of the Linux kernel HTB (Hierarchical Token Bucket):

- dynamic partitioning protocol
- flexible bandwidth allocation scheme
- suitable for a set of different frequency shaped sources

HTB bandwidth division:

- minimum amount for each stream
- incremented on instantaneous demands (within upper limits)
- different upper limits in different circumstances

Architecture: director stage

DirectorPC uses two LCD monitors:

- desktop sharing
- teacher or student interface

Desktop sharing uses Linux VNC-based solution:

- VINO
- Tight-VNC (Compatible with all VNC implementations)

This means the possibility to connect teacher's notebook, very useful if teacher uses:

- another OS (MS Windows, MacOS, *nix…)
- licensed software

This is the only unicast transmission

Architecture: parameters

Teacher Audio:	MPEG ~150 kbps (voice or music)
Teacher Video:	MPEG4 ~800 kbps 320x240 (25fps)
Student A/V:	~600 kbps MPEG4 320x240 (25fps) mixed with MP3 100 kbps
Document Camera:	MPEG4 640x480 (25 fps) ~1000 kbps
Desktop VNC:	100-400 kbps (min-max bandwidth), resolution 1024x768, depth 24 bit

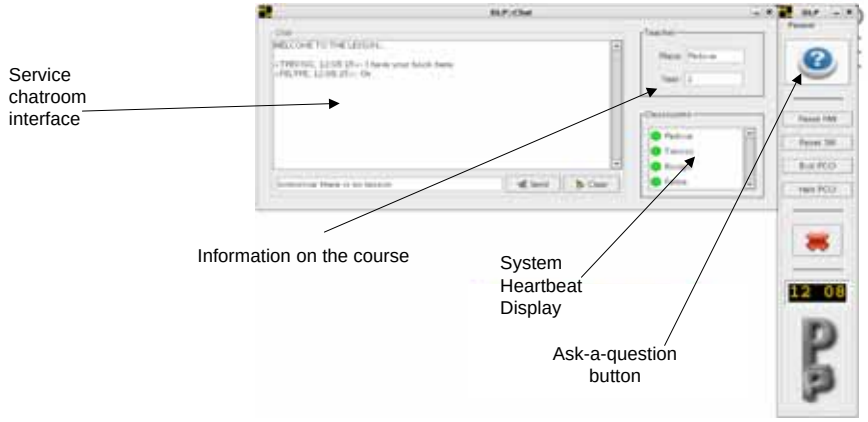
average occupation bandwidth during one lesson

~1500 kbps

Architecture: startup GUI

Architecture: teacher GUI

Architecture: student GUI



Architecture: control

Used for operating mode changes, remote classrooms status and request to put questions

Control channel uses multicast communication…

… so the teacher software never needs to know the IP addresses of remote classrooms

Remote classrooms need to know teacher's IP address only for VNC use

Control: features

1. No scheduling needed
2. Virtual classroom dynamically built
3. "Stateless": problems arising at connected sites are transparent to the teacher, apart from a possible alert

Conclusions

Requirements satisfied:

- bandwidth limited to 2Mbps per lesson
- perfect A/V synchronization
- specific need of each stream (variable bandwidth)
- low latency (<1 s) for stream
- real-time on local video
- 100% open-source software
- efficient and complete for teacher to students and assistants interaction
- stateless and scalable

Possibility of:

- remote teacher's substitution (by assistants)
- remote direction

Future works

1. Replacement of VHS recording with a digital one:
   a) simulation of direction commands issued by the teacher during lessons (lesson-on-demand)
   b) off-line direction
   c) automatic indexing of lesson (for specific topic search by students)
2. Teacher's tracking camera
3. Availability of (a stripped down version of) the system for students at home through an ADSL line (university@home)