LOLA
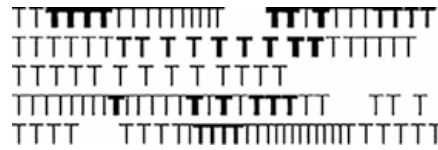
(LOw LAtency audio visual streaming system)

The new frontier of musical education

Nicola Buso

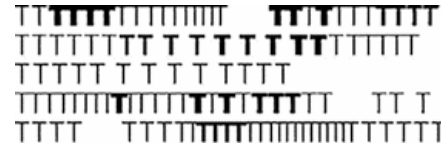**Conservatorio G. Tartini**

Consortium GARR

1.0
A Dream to turn into Reality

The Dream... at the GARR Conference 2005, in Pisa...

"To perform together, from distant locations...
as if distance has vanished
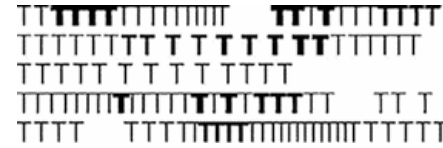*in a click of a computer mouse"*

1.1
Target of the LOLA project

• **A system** suitable for musical performances and education **relying on both audio and video communication**

• **A** Transparent and Natural end-user interaction

• **Providing lowest possible delay using available technology**

• **Low cost and portable equipment**

• **Oriented to dedicated high performance networks (LightNet Project, GARR, GÈANT, Internet2,...)**

- interactive musical tasks
    - Network musical performances
    - Network music education and training
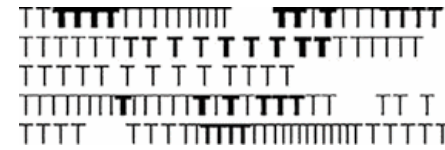
- interactive on stage performances
    - Network Dance performances
    - Network Drama performances
    - Network performing arts education and training

- ... and beyond:

    - remote real time surgery
    - virtual space immersion

- Let the user invent new possibilities...

2.0
Musical e-learning before LOLA

Conservatorio di musica Giuseppe Tartini — Trieste

H.323/SIP

- High Video Compression
- Low Quality Audio Codecs
- Video over Audio Priority
- Significant roundtrip latency
- Optimised for Low Bandiwidth
- Propietary Polycom "Music Mode"

DVTS (Digital Video Transport System)

- No Video Compression
- DV Audio Codecs
- Audio/Video in DV frames
- High roundtrip latency due to IEEE1394
- High Bandiwidth (30Mbps)
- Good Quality
- OK for music lessons/masterclasses

Musical e-learning before LOLA
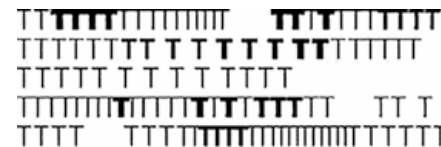

CXP (Conference XP)

- Indipendent Audio and Video Handling (compression, codecs)
- Low to High Quality Audio/Video Codecs
- Multiple Audio/Video streams
- High roundtrip latency
- Variable Bandiwidth (2Mbps to ... inifinity)

Skype

- easy, simple
- Low quality audio
- video... yes you can see
- Umpredictable latency
- if... there is nothing else!
- mostly used for private paying lessons

Conservatorio di musica Giuseppe Tartini
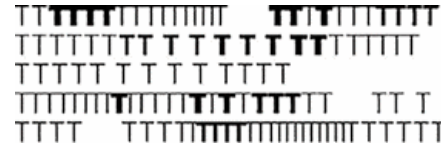Trieste

Requirements to Play Together
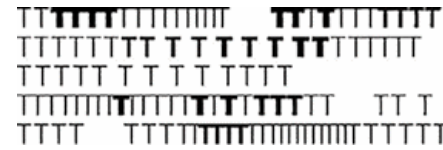
What you can do with previous tools:
- Lessons/Masterclasses, but you cannot play together
- Serious echo handling problems, innatural interaction
- You need EchoDamp (Brian Shepart, USC), but again, you feel "Far Away"!

-Audio Latency below ~75ms (depends on music gender)

- Eyes Contact to synchronize
- Spatial Sound immersion for expression
- Room Reverbering
- Continuous Presence of all musicians
- Non distracting environment

4.1
LOLA Trials, and improvements

First test with music: 21.09.2009

Two Pianos, in two studio rooms at Tartini, linked over the loop with LOLA
 Round Trip Latency ~90ms

PC monitor aside the music score, "as if the other pianist was in his canonical 'duo position', e.g. in front"

Tests performed:

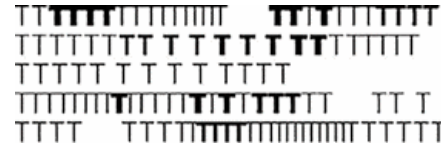One piano plays alone, with the return audio channel open; sound was coming back, but no echo cancelling needed;
Two pianos play together some scales and easy execises;
Two pianos play together some canone by J.S. Bach;
The latency is artificially increased to test interaction limits;

There is NO ECHO!

We can try with a full setup and a real Piano Duo to get feedback

4.2
Second Test

Bach Brandeburgh Concerts - Trevisan-Zaccaria Piano Duo: 05.11.2009

- **Two Pianos, in two Concert Hall at Tartini, linked over the loop with LOLA**
- **Round Trip Latency ~80ms, mostly due to CODECs**

- **Sound Rendering, Room Environment, musician interaction with LOLA environment.**
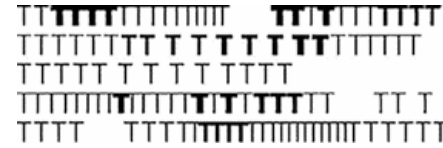
- Tests performed:

  - **Play Bach Branderburgh Concerts**
  - **Roundtrip Latency tests**
  - **Remote sound in (insulating) earphone vs audio monitors**
  - **Adaptation techniques to delay**

- **They can play together, but too much attention is required to handle the delay. No comfortable environment for artistic performance.**
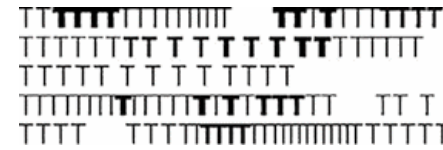- **We need to go further down with CODECs delays**

Bach Brandeburgh Concerts - Trevisan-Zaccaria Piano Duo: 04.02.2010

- **Two Pianos, in two Concert Hall at Tartini, linked over the loop with LOLA**
- **Round Trip Latency 20ms (artificaly up to 70ms)**

- **Tests performed:**

- **Play Bach Branderburgh Concerts**

- **They started to play... and played them all!**
- **Natural interaction**

- **Many tests to refine the Sound Rendering of the remote piano.**
- **The focus is totally on music, sound, interpretation.**

- **IT WORKS!**

4.5
Time to go Public and explore!

Network Performing Arts Production Workshop: 23.11.2010
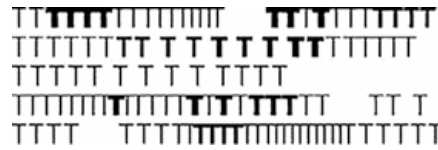**Tartini (Trieste) – IRCAM (Parigi) 1300Km.**

Bach: Brandeburgh Concerts/Reger: Piano Suites
Trevisan-Zaccaria Piano Duo

Network Performing Arts Production Workshop: 15.06.2011
Tartini (Trieste) – Gran Teatre del Liceu (Barcelona) 2700Km.

Bartok: violin suites
Agostinelli-Frattini Violin Duo

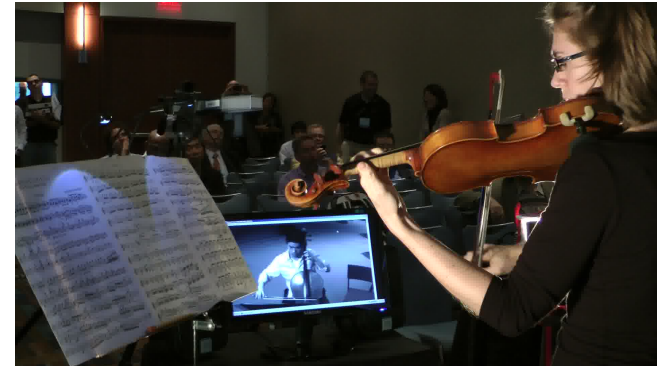## IT WORKS also with students, and at LONG distance

4.6
The Proof of Concept

Internet2 Fall Members Meeting: 04.10.2011
NIU (Chicago, IL) – Congress Center (Raleigh, NC) 1200 MILES (1850km)

Haendel: Passacaglia for Violin and Cello
Marjorie Bagley (violin) – Cheng-Hou Lee (cello)

- A very complex concert piece
- Two musicians who never met before make a standard rehearsal (at 1200 miles)
- And then perform a perfect public concert, and even play a "bis" !

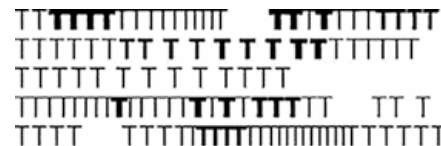## Mission Accomplished! The dream is Reality!
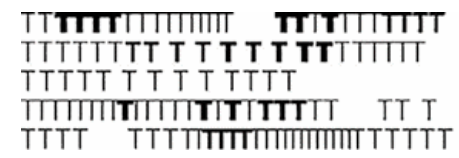
Conservatorio
di musica
Giuseppe
Tartini

Trieste
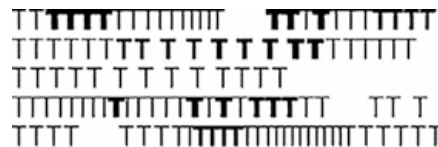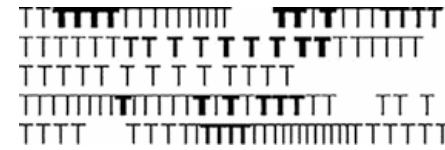
Movie Clip here

- **Management of synchronous audio video streams over packet networks**

- **Minimal delay requirements for interactive task and music performances**

- **Optimal balance between AV presentation delay and quality**

- **The speed of light...**
- **... and of electronic equipment...**
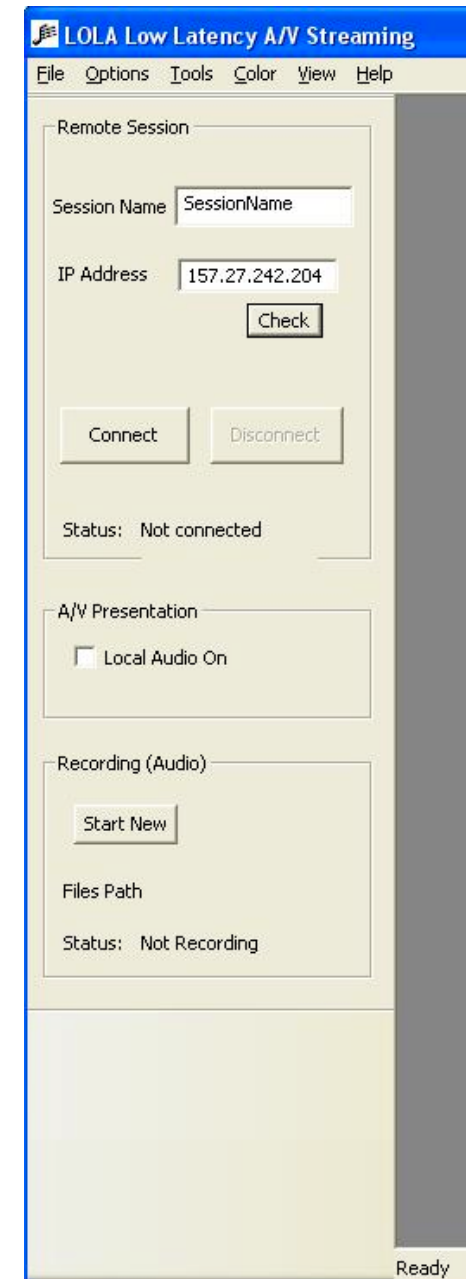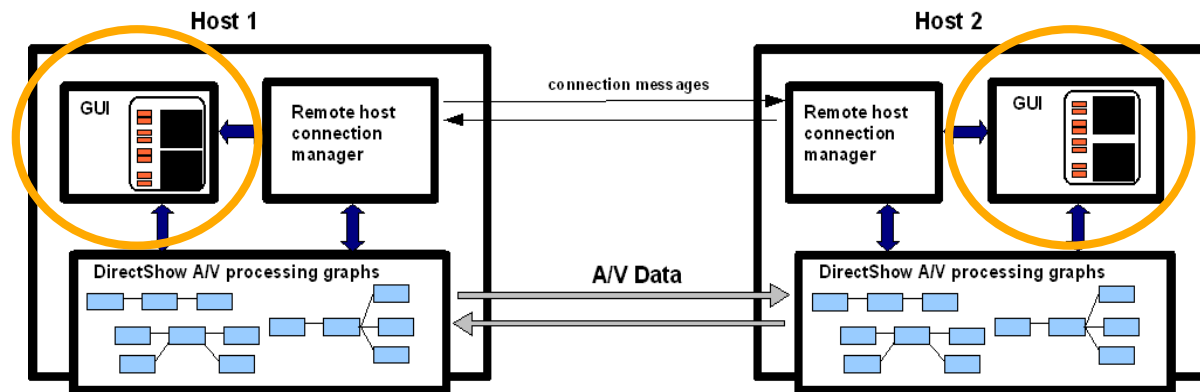
**Research &
Education
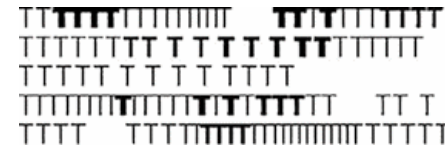Networks**

5.2
LOLA: a very simple GUI

- **number to call**
- **CHECK**
- **CONNECT**
- **DISCONNECT**

- **Audio/Video buffering controls**
- **Visualization options, audio mixer, etc**
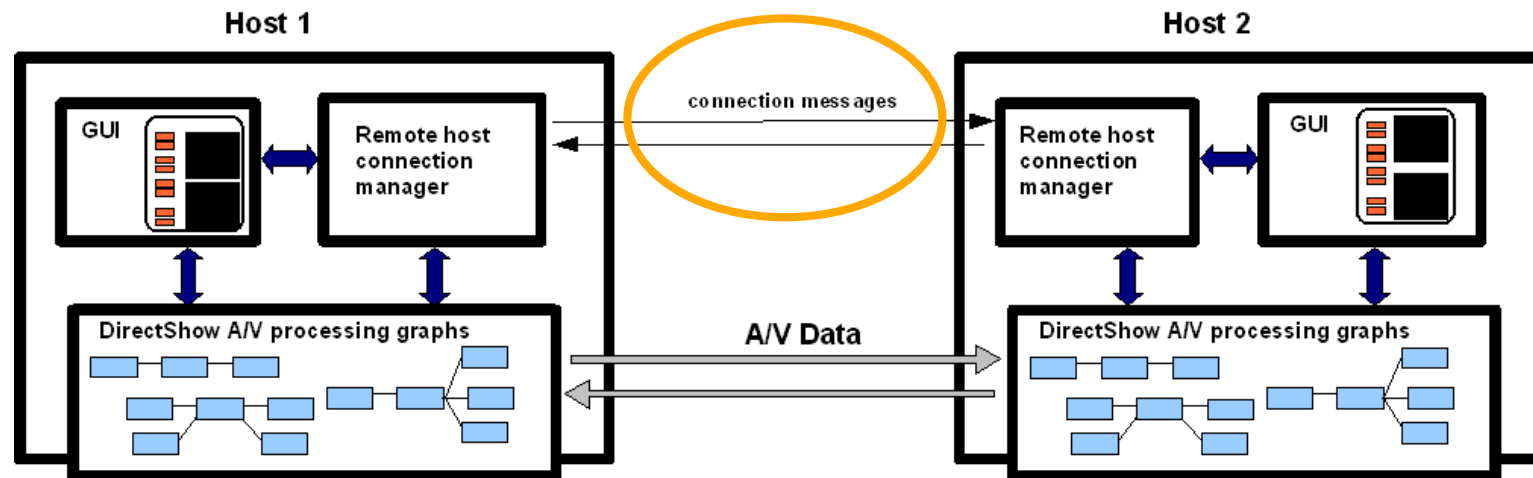- **Directory of remote partners**
- **Recording**
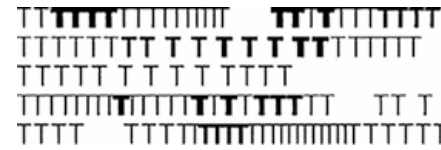
5.3
Functions and networking

Connection negotiation and management

- Send/receive and manage connection requests
- Negotiation of audio/video formats and compatibility check
  - Video: 640*480, 30-60 fps, BW/Color
  - Audio: 44100, 16/24 bit, mono/stereo, etc
- Transmission of raw audio and video streams, monitoring
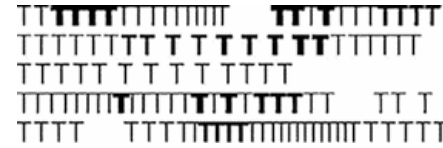
5.4
Functions and networking

Audio/Video data grabbing and transmission

- Grabbing and Tx with low latency devices
    - Video: Grabber BitFlow, BW progressive scan camera
    - Audio: RME HDSP9632
    - Network: 1GBps Ethernet Card
- Presentation delays (no Tx): < 5 msec (audio and video)
- Delays due to Network: from 1 msec (LAN/WAN) to >10-20 msec, depending on the distance
- On actual networks, jitter buffers are required (delay vs quality balance)
- At present, tests are ongoing on dedicated GARR network setups

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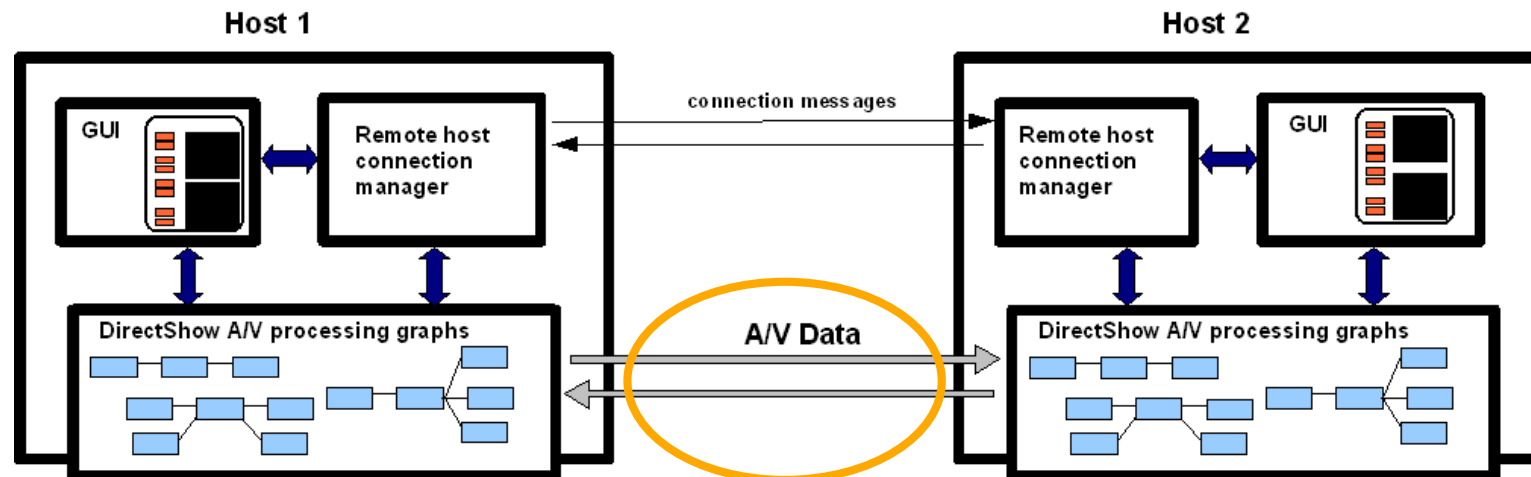
LOLA makes distance disappear, also for music education

- **A true "live" interaction** between teacher and student:

    - You can talk, listen, make examples BUT ALSO
    - You can PLAY TOGETHER
    - You can give in real-time suggestion on "gesture" for the student DURING execution;
   - You concentrate on your music goals, not on technology;

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di musica
Giuseppe
Tartini
Trieste
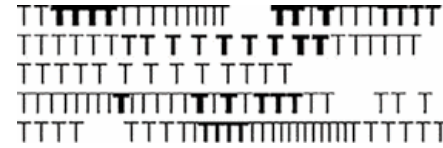
LOLA makes distance disappear, also for music education

- **You can teach much more efficiently** to students, even when they are not close to you;

  - You change your horizon from a City to a Continent
  - Students can benefit more lessons, and more open environment

Conservatorio
di musica
Giuseppe
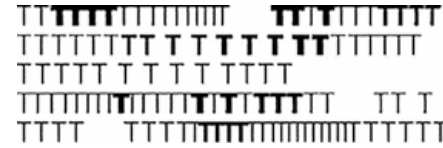Tartini
Trieste
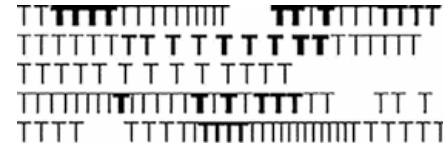
LOLA makes distance disappear, also for music education

- And you have more time for all other activities:

    - You can also ease your "performer" activity,
    - more time to teach,
   - more occasions to rehearse from remote,
   - less "idle time" because of travel.

- **Use gained musical information**

- **develop and test tools**

- **optimize the performer/audience sound environment, i.e.:**
  - **easy customer interface tools for configuring the**
  - **amplification/equalization/spatial distribution/balance of the local and remote signals;**
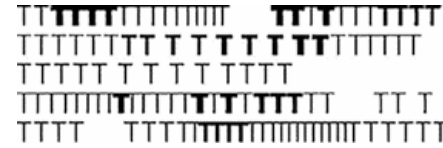 - **equivalent facilities for optimizing the audience listening.**
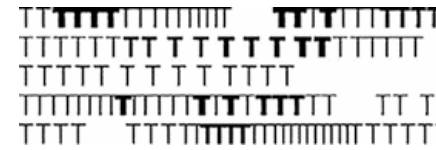
- **Partnership with High Level Music Education Institutions in Europe**
- **Develop pilot projects**
- **Test different families, formations and combination of instruments**
- **Test network reliability in different areas.**

- Klagenfurth (AT)
- Lubiana (SI)
- Belgrado (RS)
- Copenaghen (DK)
- Oslo (NO)
- Helsinki (FI)
- Parigi (FR)
- Stoccarda (DE)
- Ghent (BE)
- Londra (UK)
- Lugano (CH)
- Izmir (TR)

Conservatorio di musica Giuseppe Tartini Trieste
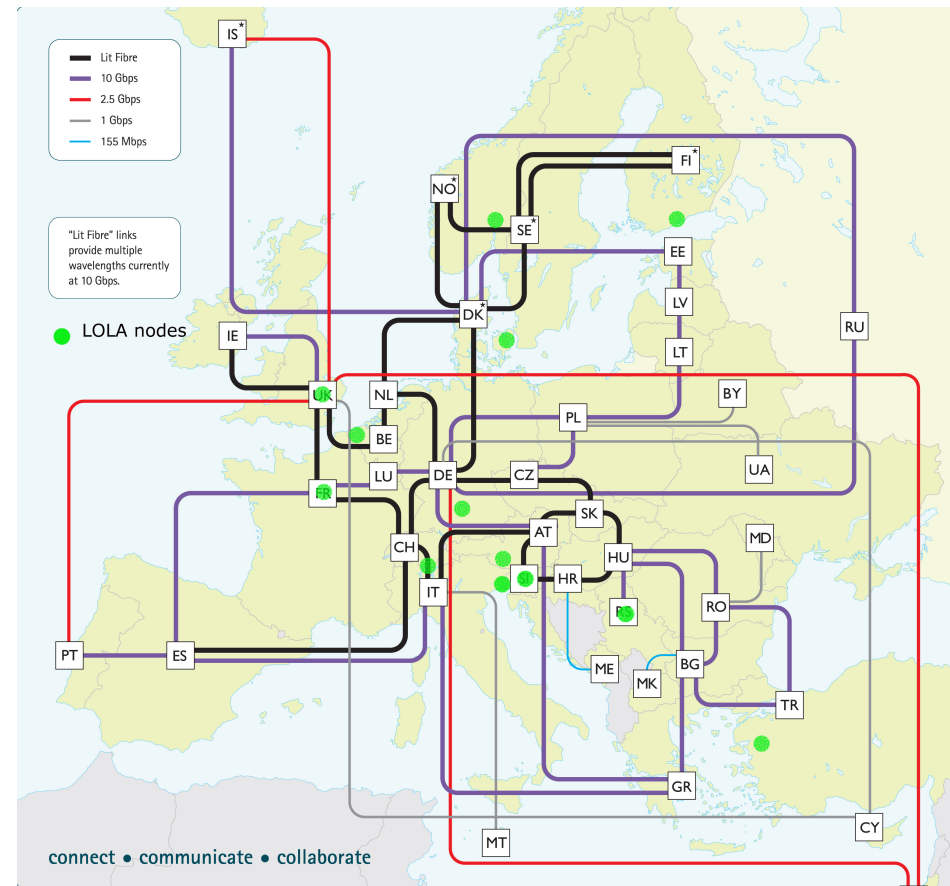
8.1
LOLA: the team

Paolo Pachini: general coordination

Carlo Drioli: programming

Nicola Buso: testing and musical advice

Claudio Allocchio (GARR): testing and networking advice

Massimo Parovel: conception and supervision

Nicola.Buso@conts.it
Claudio.Allocchio@garr.it