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- ….network audio how it works?

„A network music performance is a **bi-directional**, **dis-located** and **multi-modal** set of interactions regardless of its synchronicity or asynchrony between participants.“

Alain Renaud

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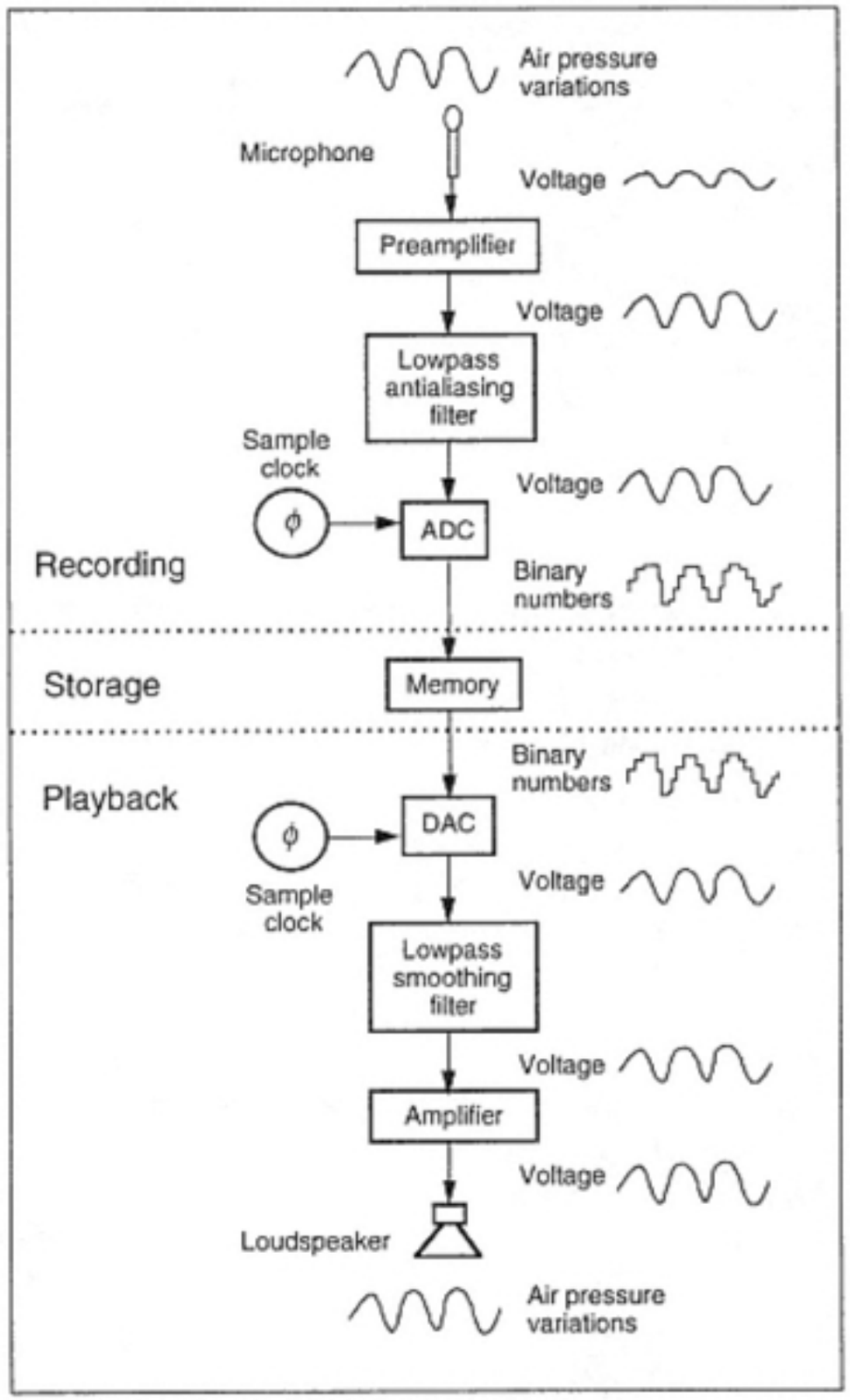

Figure 1.13
Overview of digital recording and playback.

Localhost (loopback)

127.0.0.1

IP Number

192.168.1.110

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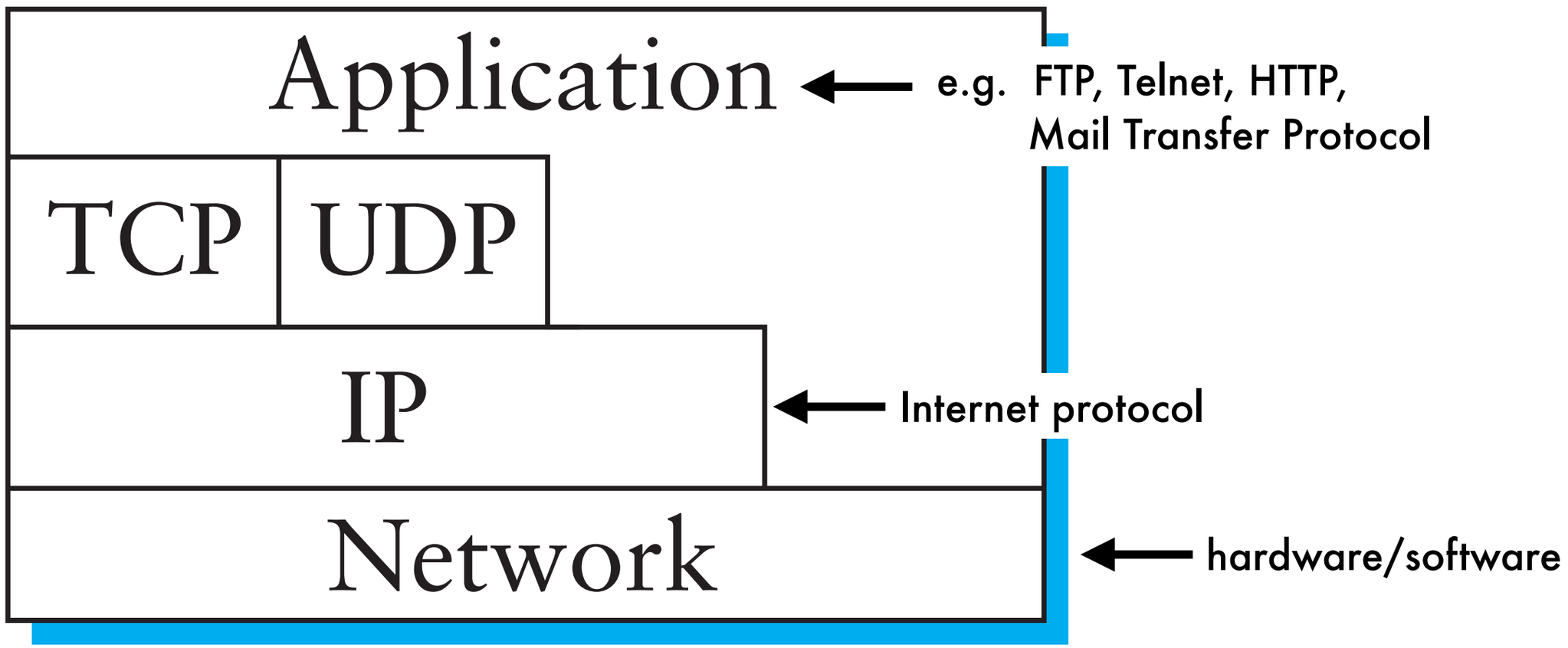
Internet: TCP/IP Architecture



UDP (Comer's definition)

The User Datagram Protocol (UDP) provides an unreliable connectionless delivery service using IP to transport messages between machines. It uses IP to carry messages, but adds the ability to distinguish among multiple destinations within a given host computer.

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TCP vs UDP for Audio and Messages

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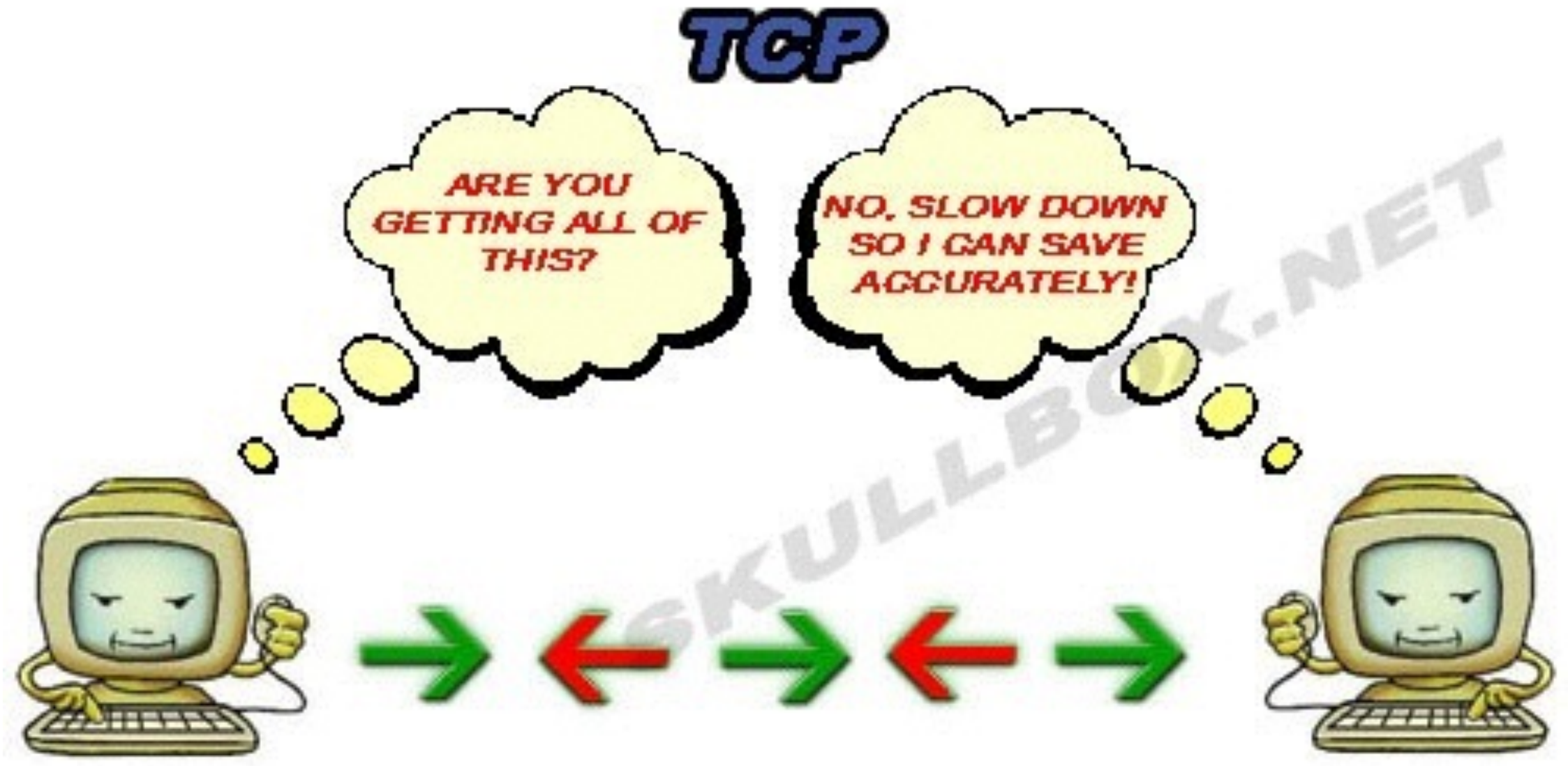

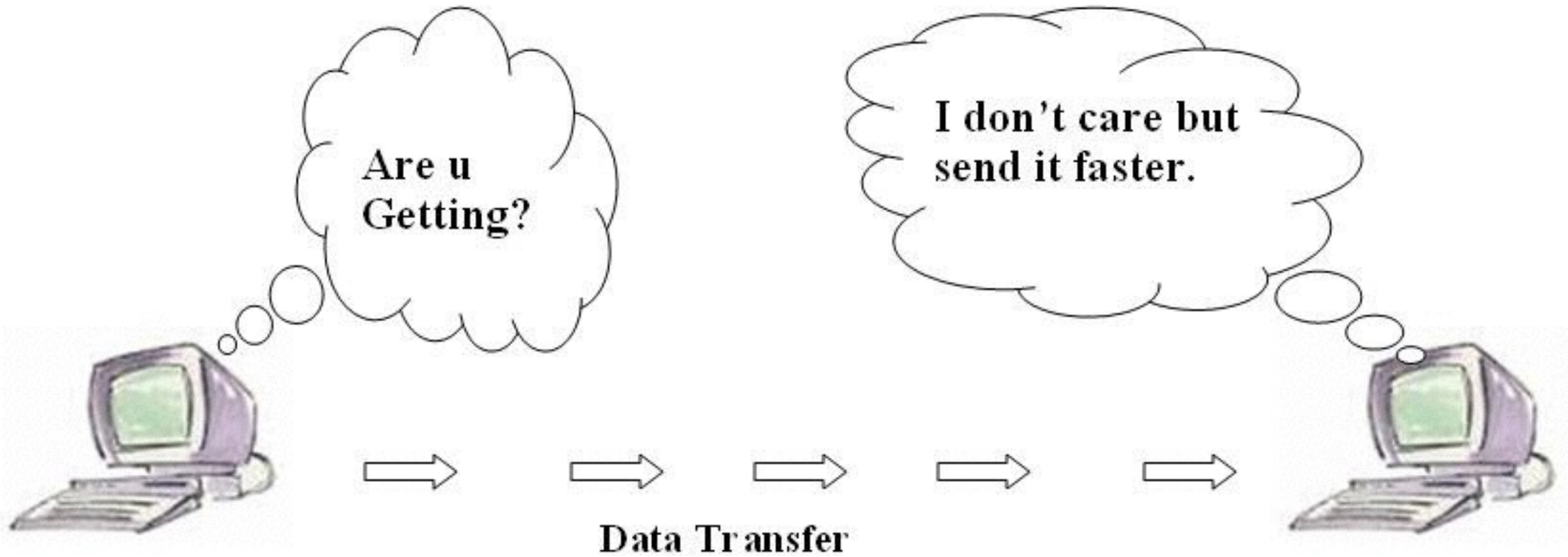

…network audio us UDP

- network music

Year 2000

CCRMA SOUNDWire
Sound Waves on the Internet from Real-time Echoes

http://ccrma.stanford.edu/groups/soundwire/

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CCRMA SOUNDWire
Sound Waves on the Internet from Real-time Echoes

Perform Music On-Line in Real-Time with the Highest Audio Quality Possible

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- **Chris Chafe** is a composer, improvisor and cellist, developing much of his music alongside computer-based research. He is Director of Stanford University's Center for Computer Research in Music and Acoustics (CCRMA)

- **Juan-Pablo Cáceres:** I am a composer and an engineer born in Santiago, Chile. I am currently a PhD candidate in Computer Music at Stanford University, Center for Computer Research in Music and Acoustics (CCRMA).

Goals of High-Quality Audio over Networks

Maximize Audio Quality for available networks conditions

Minimize Latency

But more important, **Minimize Jitter**

Adjustable **Number of Channels**

Audio routing flexibility

Multiple peers

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Early Studies

Hirsch, *"Auditory perception of temporal order"*, 1959

3 ranges of perception:

0-20 ms: phase perception

20-100 ms: auditory patterns

100–up ms: separate auditory events

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Timing and Sync

Rasch, *"Timing and synchronization in ensemble performance"*, 1988.

Tolerances in the performance of small ensembles can be as high as 50 ms on average

Influential Factors: Instrumental timbre, length of articulations, masking, and reverberation

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Human vs. Machine

Variations on synchronization are perceived as “human like”, whereas systematic perfect synchronous performances sound more “machine like”.

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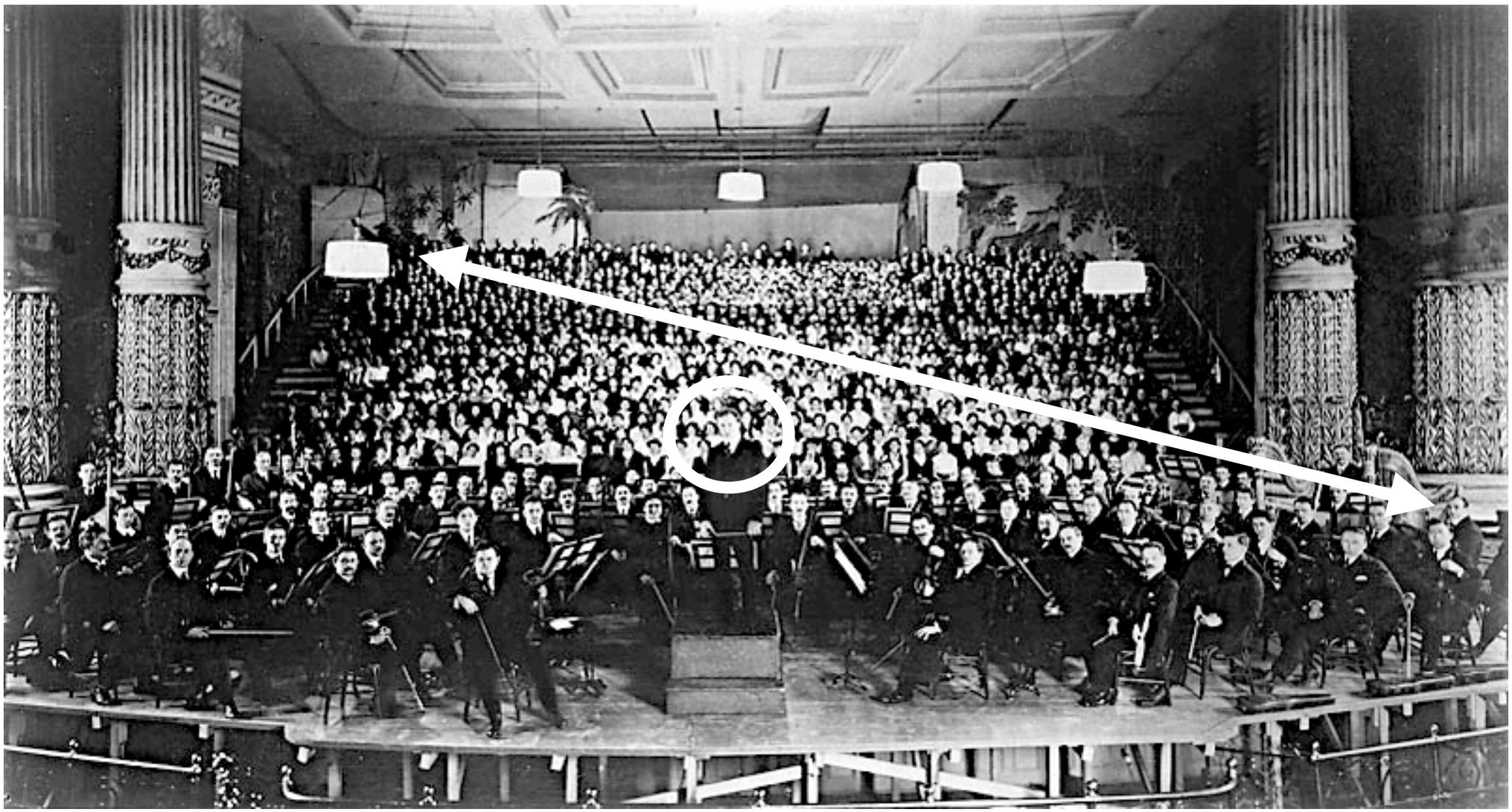
Zürcher Hochschule der Künste
Zurich University of the Arts



+1000 musicians

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The need for a Conductor

As ensembles grow in number and physical size, asynchronization also grows.

At a certain point the presence of a conductor becomes necessary to maintain synchronization for larger ensembles.

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Distant-Dependent Strategies

Echoes

Delay Effects

Distributed Rhythmic Patterns

Synchronization

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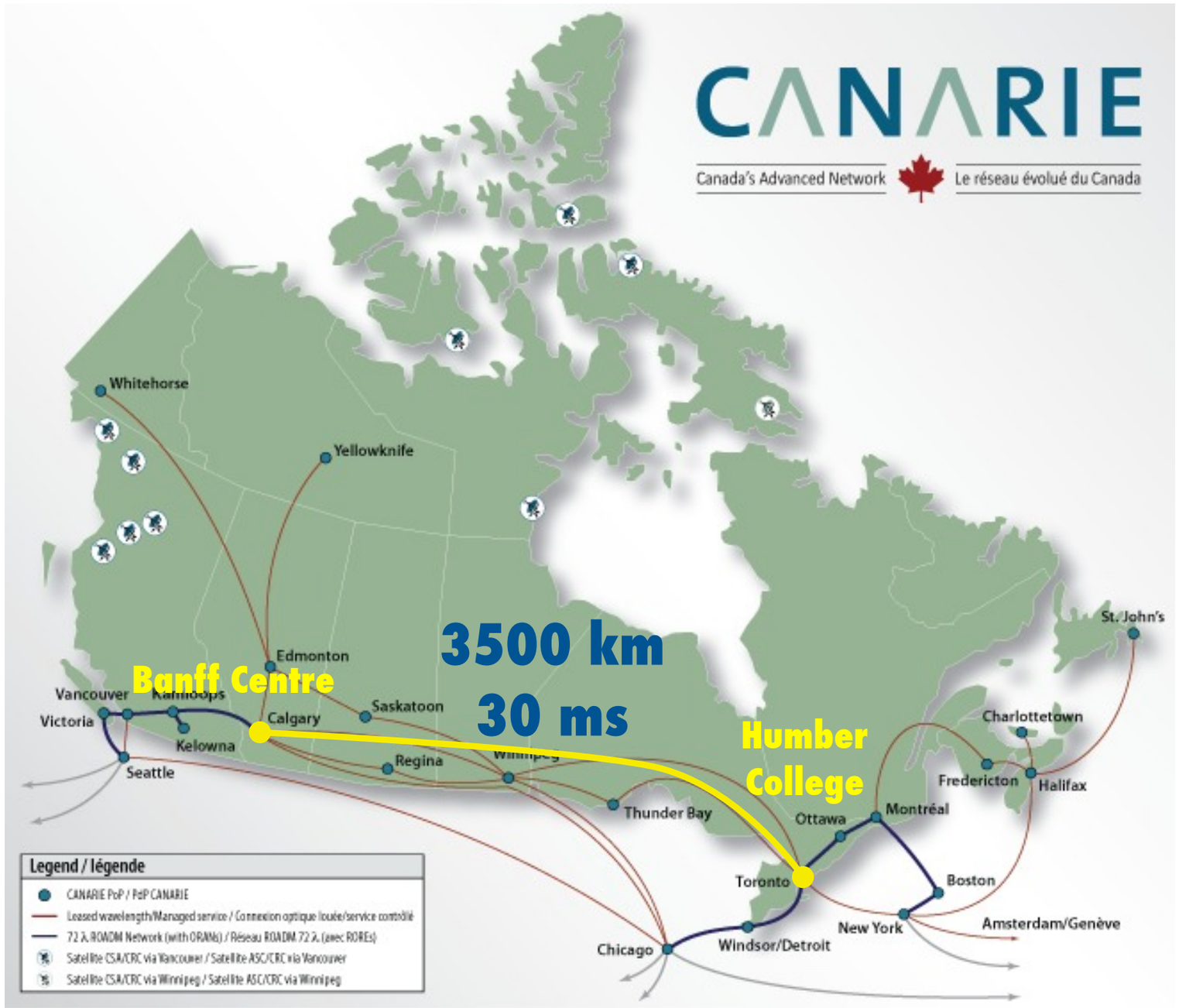
TeleJazz



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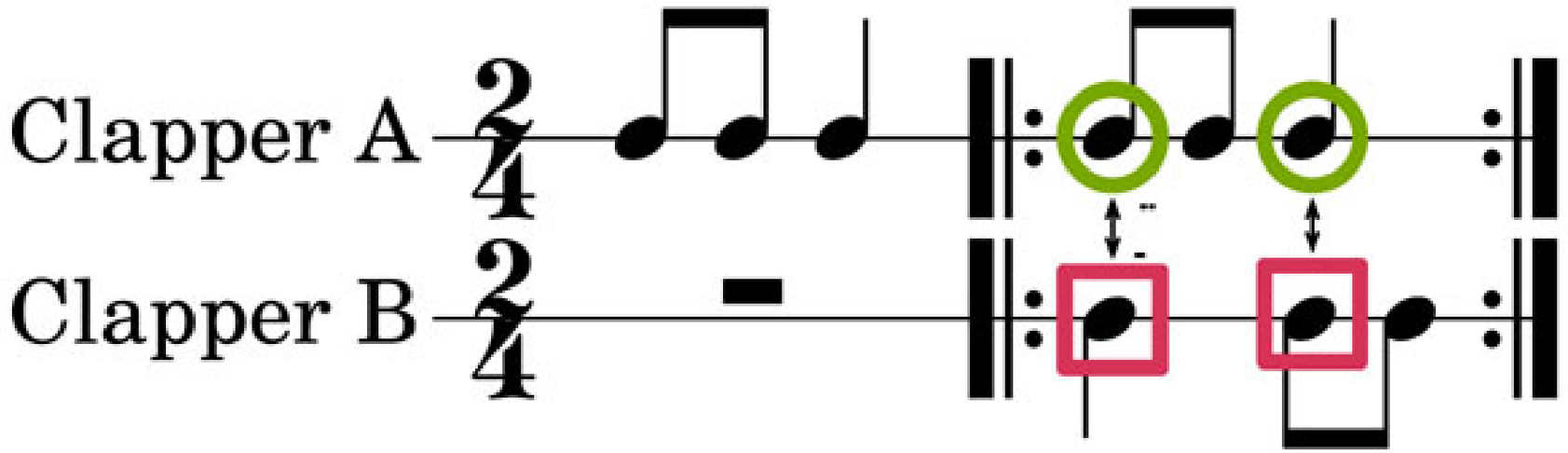
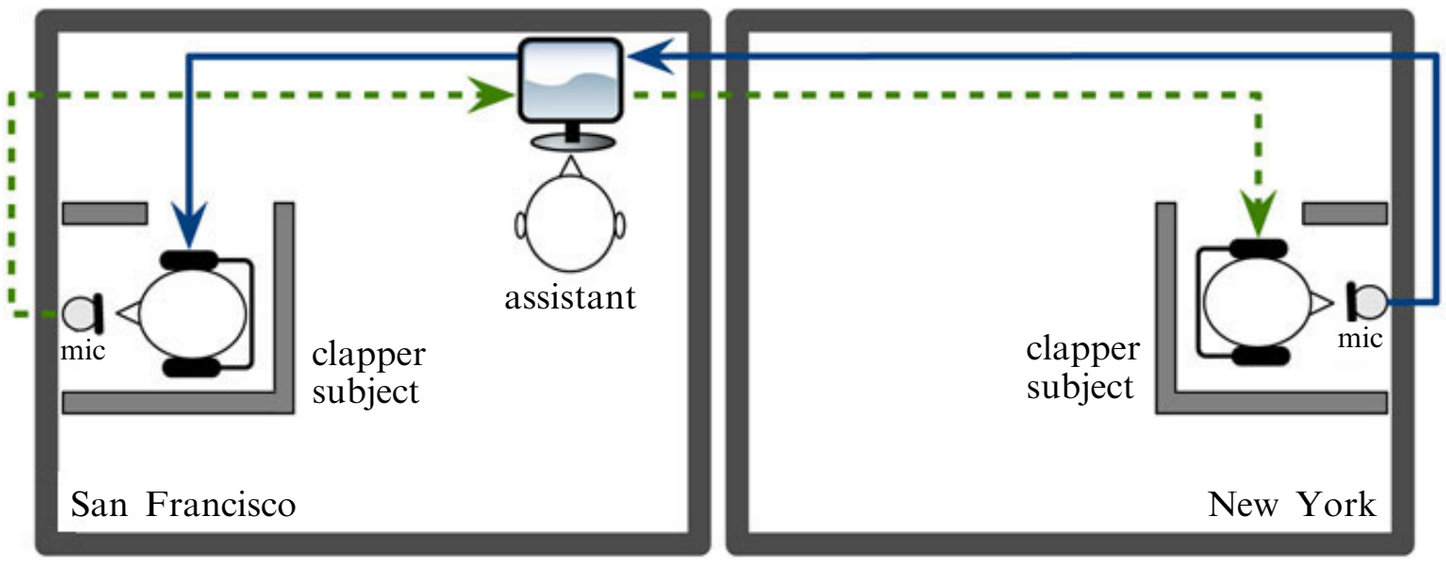
The Clapping Experiment





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NET:DISTURBANCES (ICMC, August 2008)

Concert in Belfast + CCRMA

Juan-Pablo Cáceres | CCRMA | Stanford University | jcaceres@ccrma.stanford.edu

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bis 14:00 wieder hier „En Guetä“