ITU-T Workshop on

"From Speech to Audio: bandwidth extension, binaural perception"

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3D Telephony

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Motivation

- Limitations of today's telephone system, especially in multiuser scenarios.
- Recent studies [1] figure out that in teleconference often:
  - Some people could not be heard (33.9%)
  - Difficulty to identify who is speaking (29.1%)
  - Poor audio quality (23.8%)
  - Too much extraneous noise (20.2%)
- Location of the talker can not be identified.

[1] Yankelovich, N.; Kaplan, J.; Provino, J.; Wessler, M. & DiMicco, J. M. Improving audio conferencing: are two ears better than one? CSCW '06: Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work, ACM, 2006.

Idea

- Human perception abilities are naturally binaural.
  - Has this been exploited by the telecommunication industry yet?
- Is it possible to place each participant of the telephone call at unique position?

Concept

- This research aims to extend telephony into the third dimension.
  - 3D Telephone system that generate a virtual 3D environment.
  - Participants can:
    - Identify the talker by locating the sound source.
    - Hear non verbal signs such as head or the body movements due to changes in the acoustic delays and echoes.

Methodology

- Anyone uses 3D telephony?
- No products in the market:
  Ever seen a phone with 3D sound?
- Do we know how 3Dtel will look like?

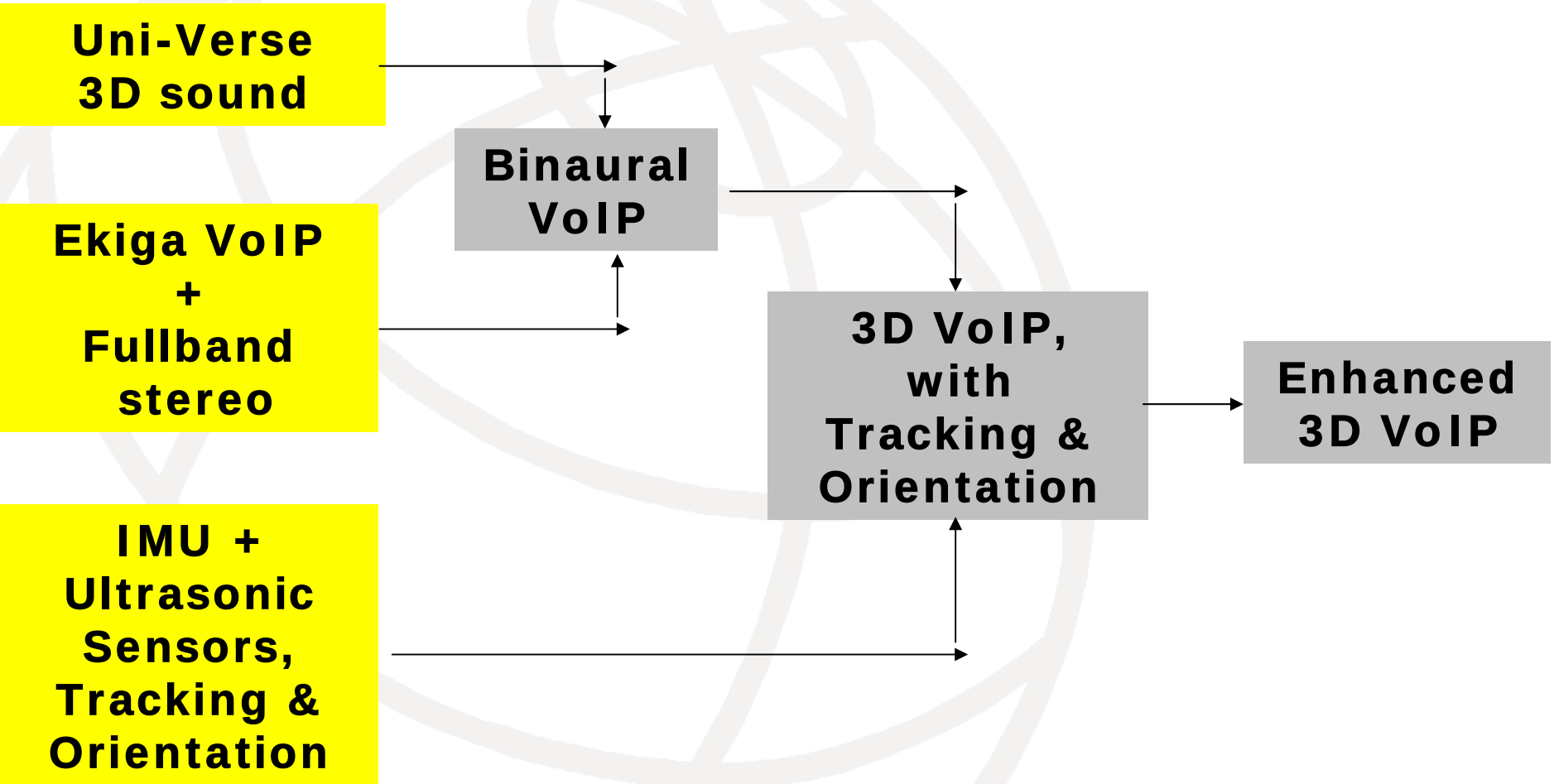
- Our research approach:
  1. Build a 3D telephone system.
  2. Use it and make available for early adopters.
  3. Collect the feedback and ideas.

Components for Open Source 3D Telephone

- 3D sound rendering
  - EU FP6 project Uni-Verse published an open-source 3D sound software
- VoIP phone
  - Using Ekiga with full-band audio
- Head-tracking with Inertial Motion Units
  - MEMS based
  - Ultrasonic sensor for tracking and detecting the room size.

Roadmap

- Current standing (yellow)



3D Telephone
Listening Tests

1. Question: Where to place the participants of a conference call.

2. Question:
   Does the speech quality decreases?

3D sound listening test.

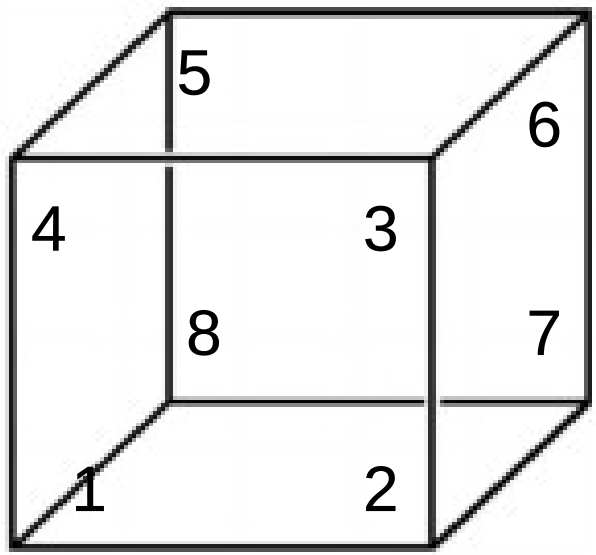
- Aim for conducting test:
  - To locate the sound source in the virtual room.
  - To judge the quality of the 3D sound in virtual room.
    - Test 1: When there is only single sound source.
    - Test 2: When there are two sound sources at a time. (Recommendation to ITU-T to add in the standards)
- Testing environment.
  - As Recommended by ITU-T P.800(Listening Quality Scale)
  - Locating sound source(no standard test)

3D sound listening test.

- How we have made these samples
  - Dimensions of the virtual room.
    - 20m x 30m x 20m (width x height x length)
  - Sound samples
    - 24kHz, female and male speech
  - Position and orientation of the listener and sound sources in test 1 and 2

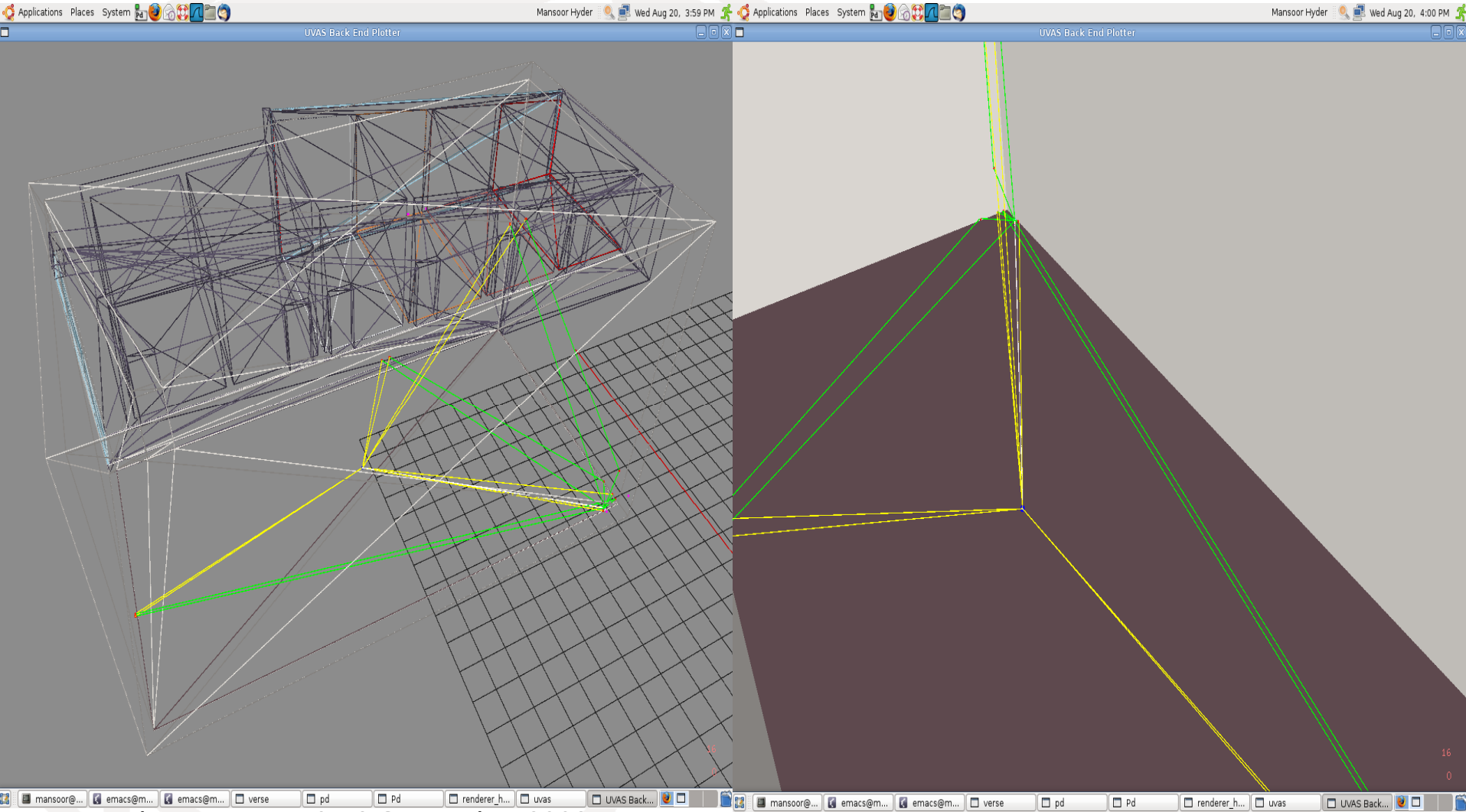
3D sound listening test 1

- Test 1
  - One sound source at a time.
  - Listener, fixed at the center of the room facing 5,6,7 and 8.
  - Source, moving in all corners of the room.
  - Test Goal:
    - To locate the sound
    - To judge the quality of the sound.



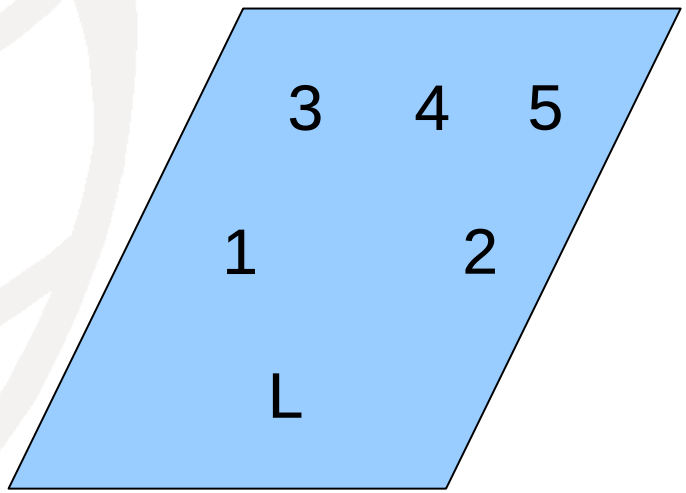
3D sound listening test 1

- Screenshots Virtual room test1



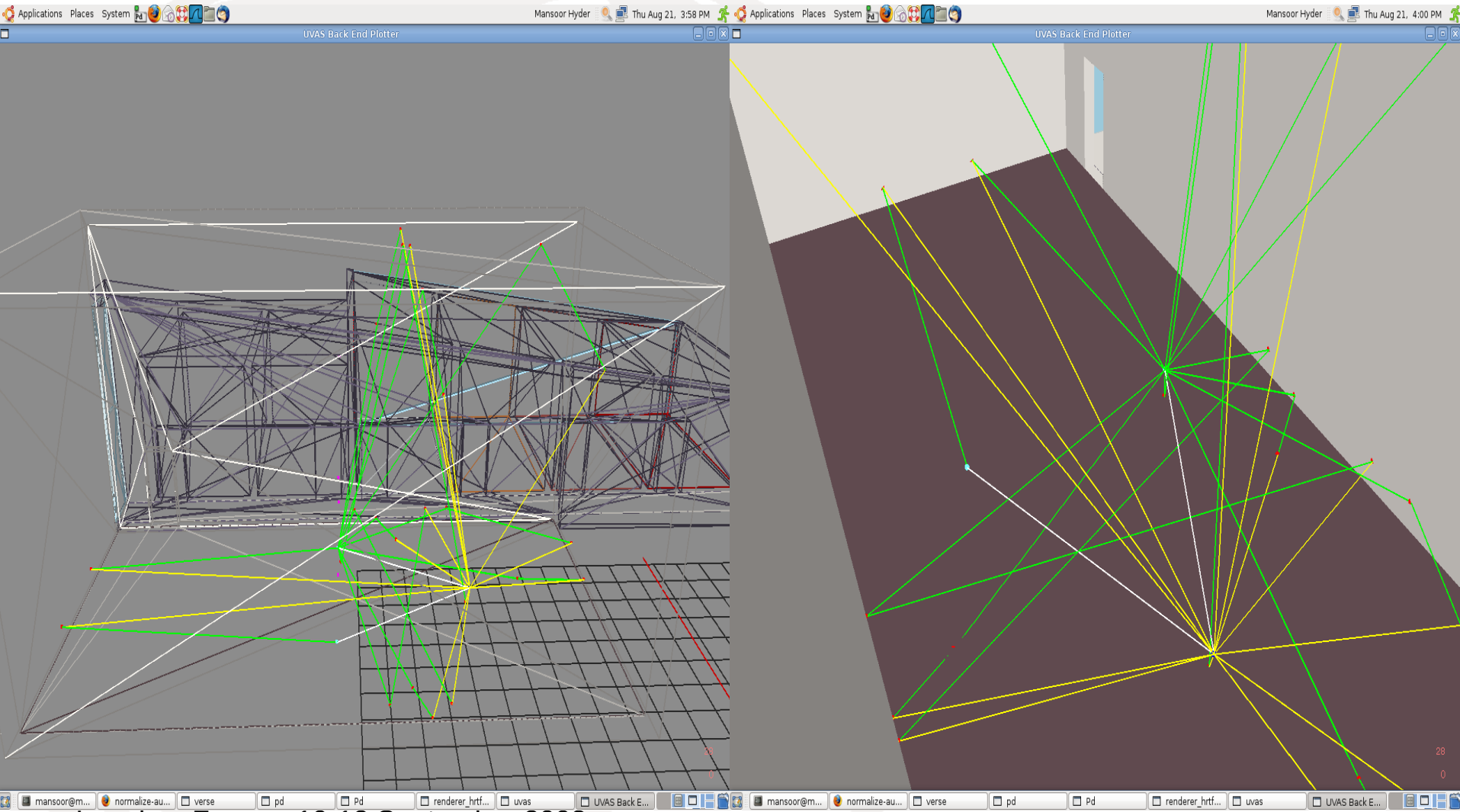
3D sound listening test 2

- Two sound sources at one time
- Listener, facing 5 sound sources infront of him.
- Sources, placed in front of listener like participants sitting on table.
- Test goal:
  - To locate the sound
  - To judge the quality of the sound.

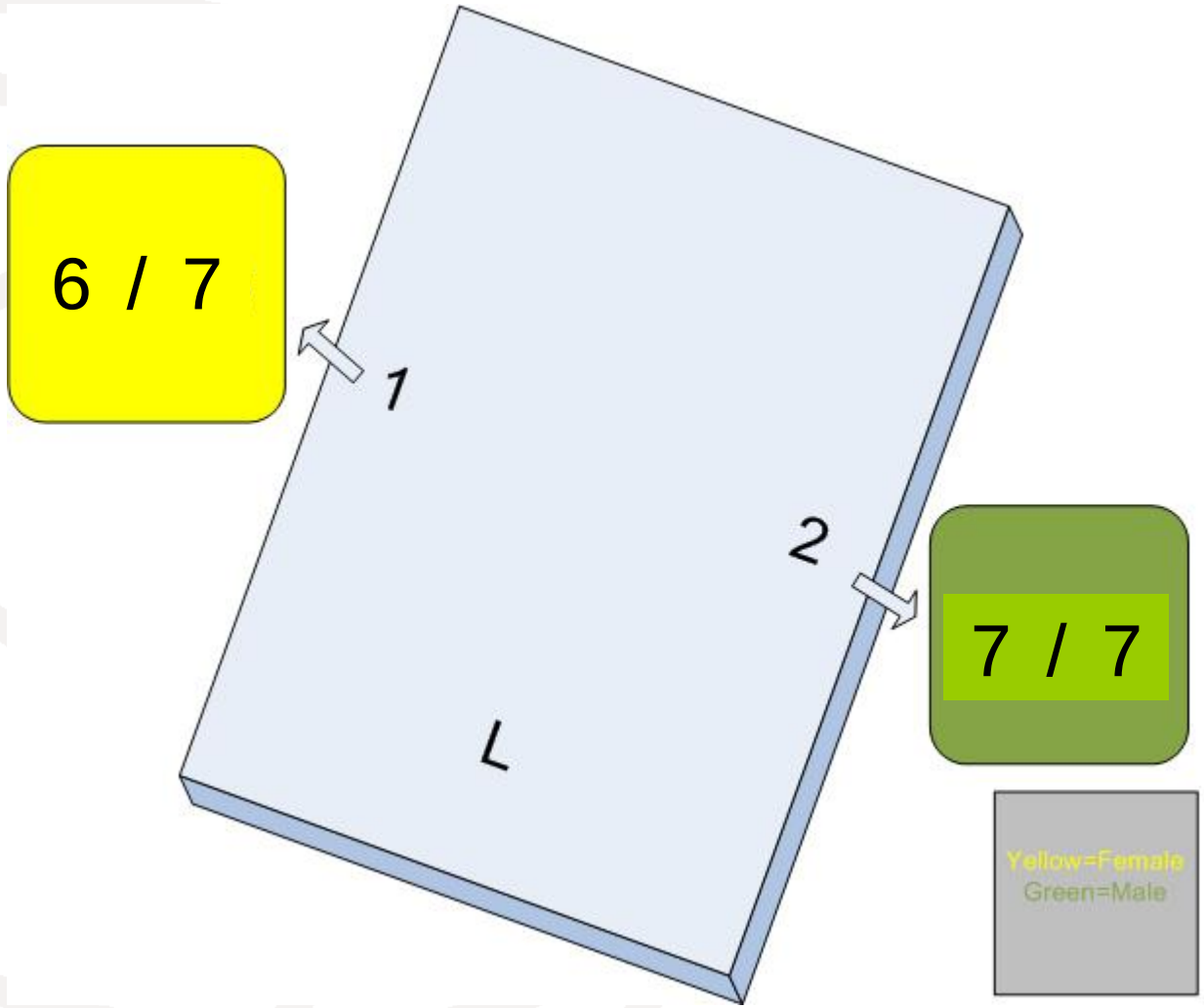


3D sound listening test 2

- Screenshots test 2



Test Results



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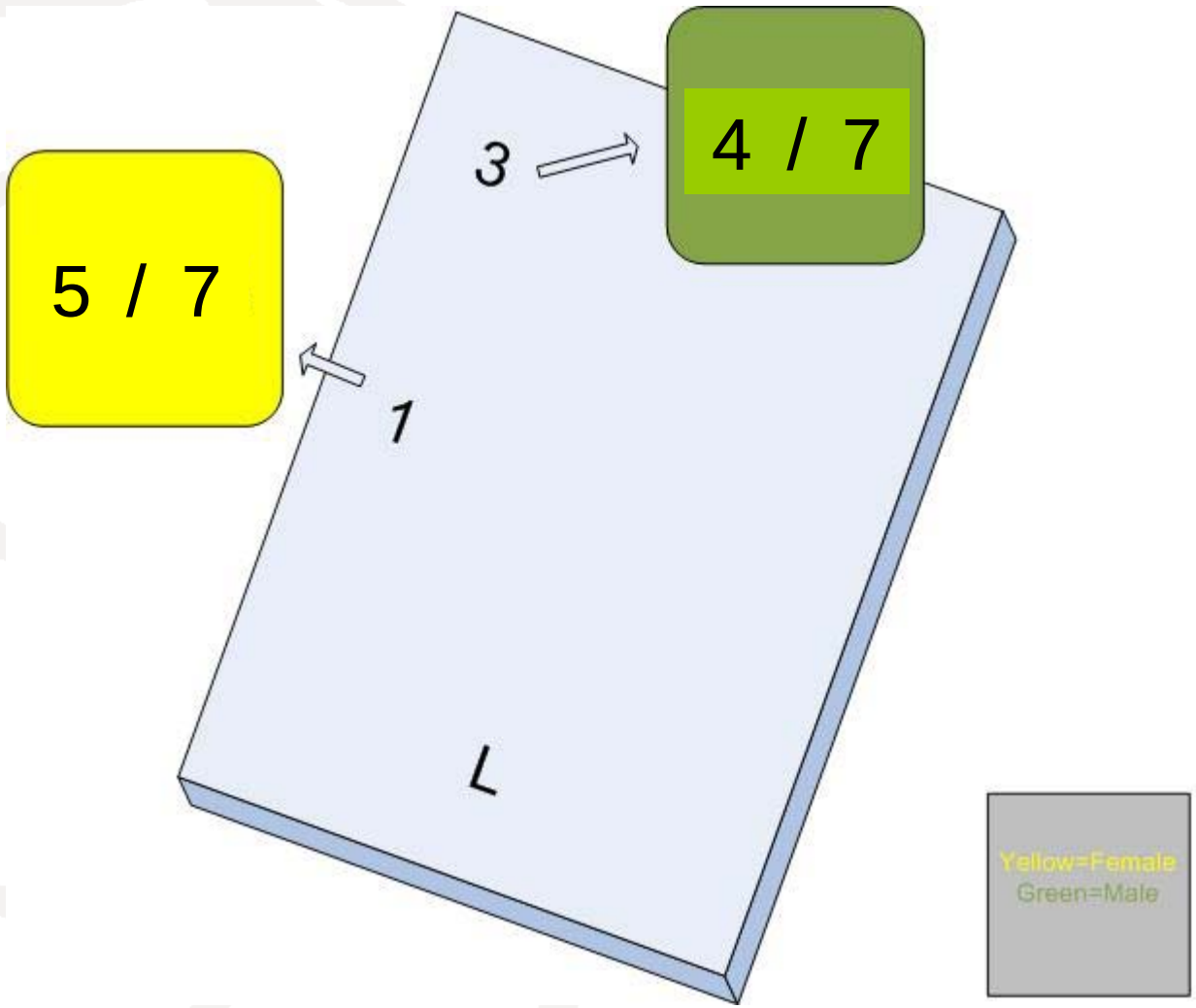

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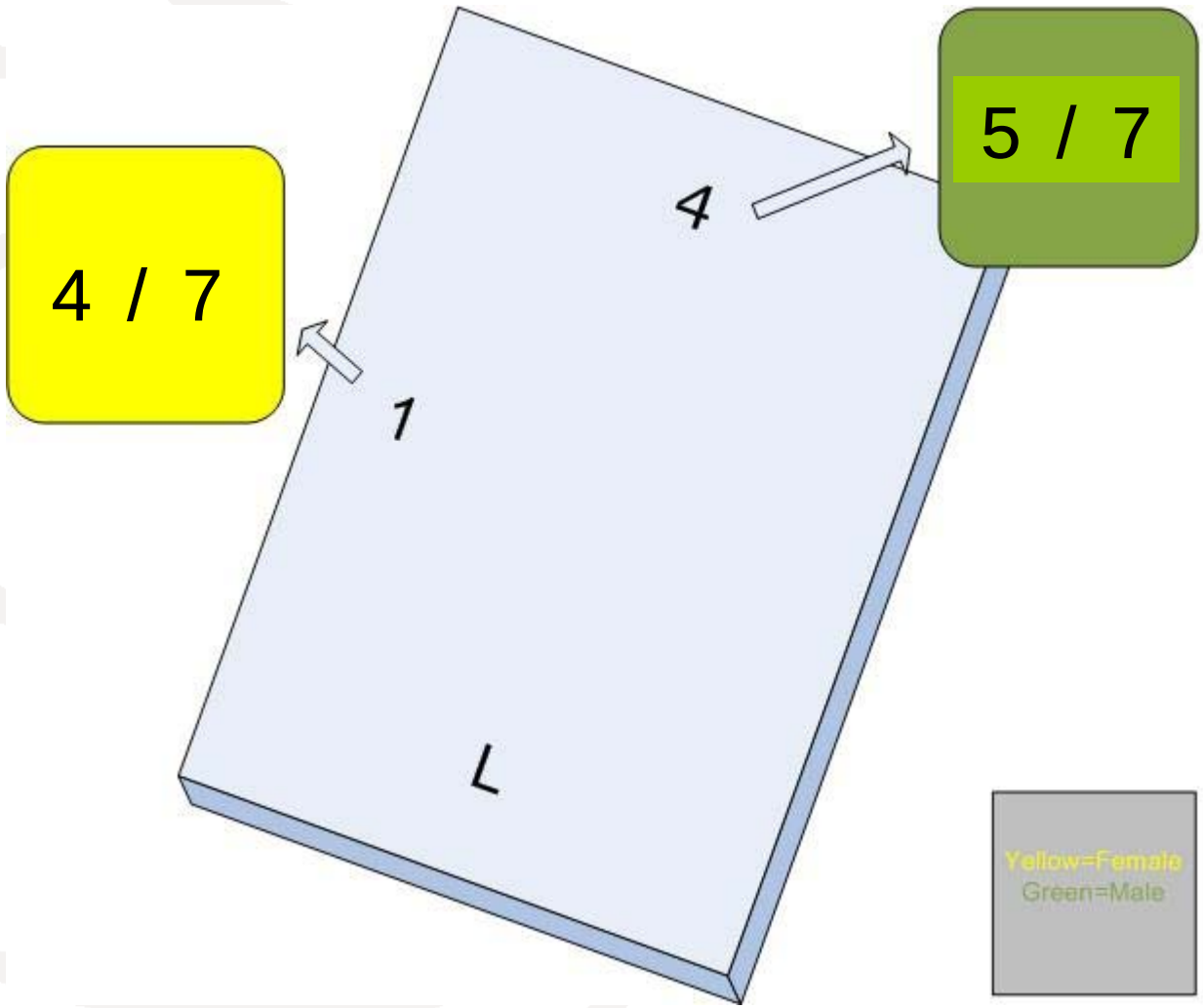

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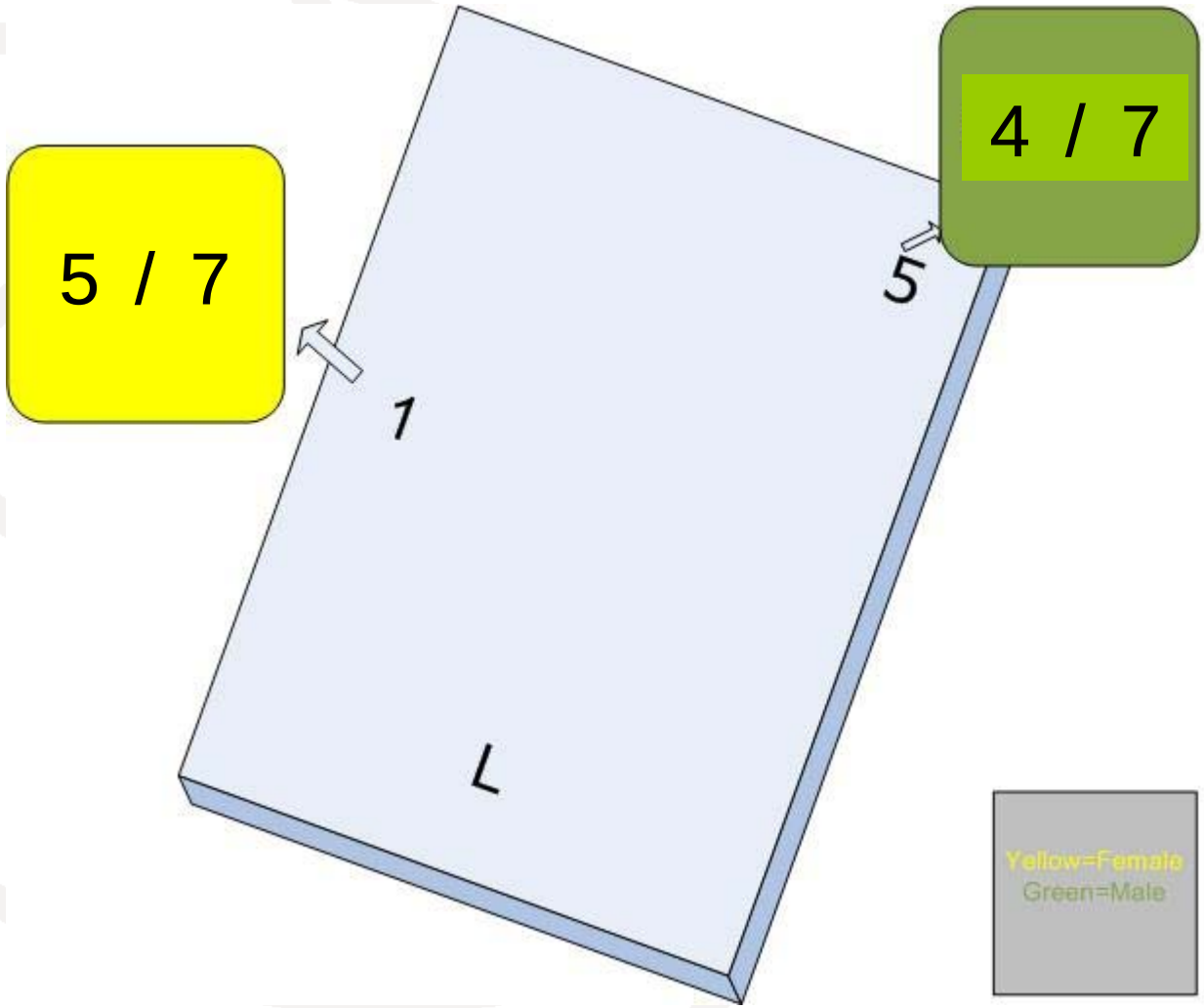

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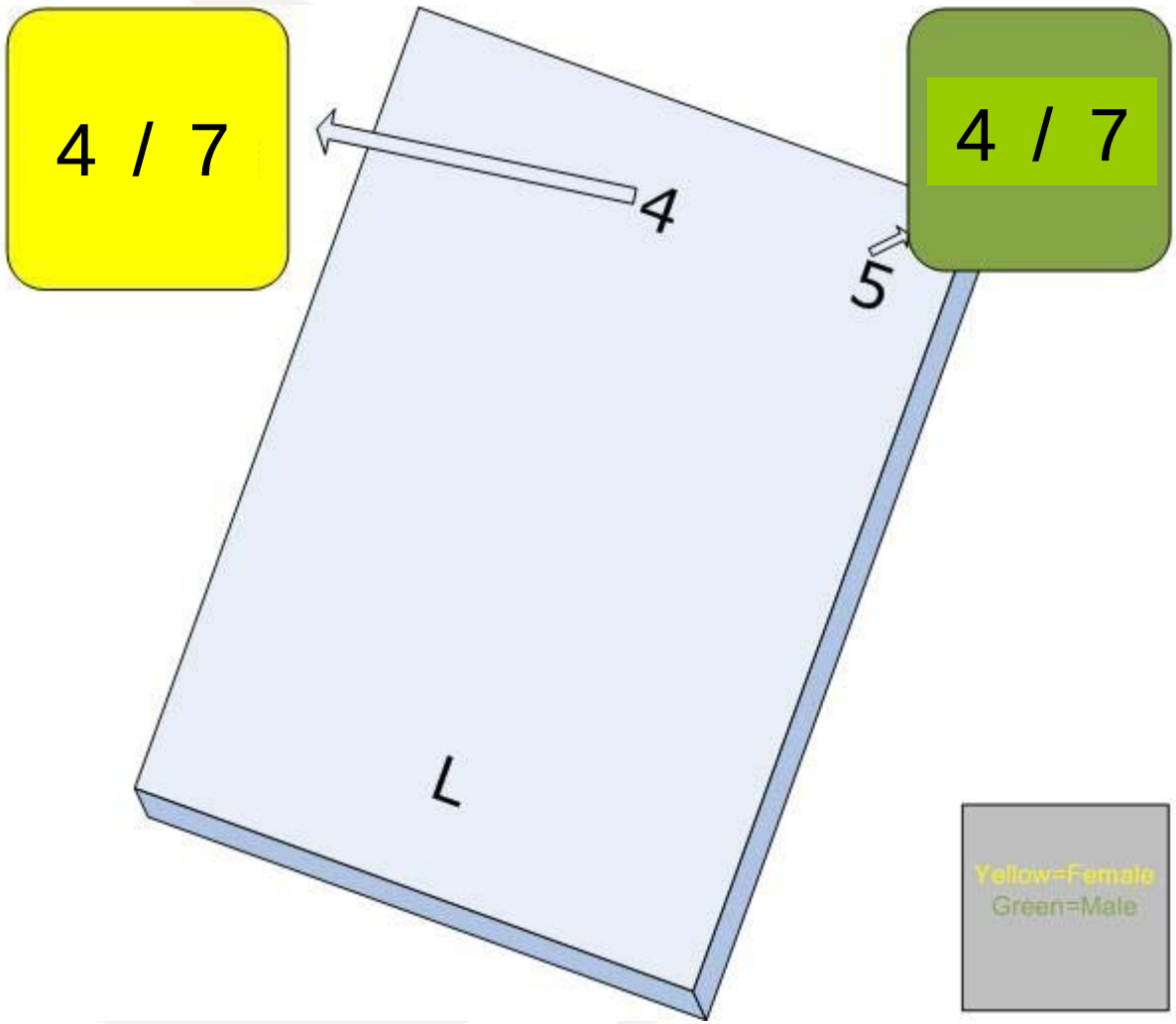

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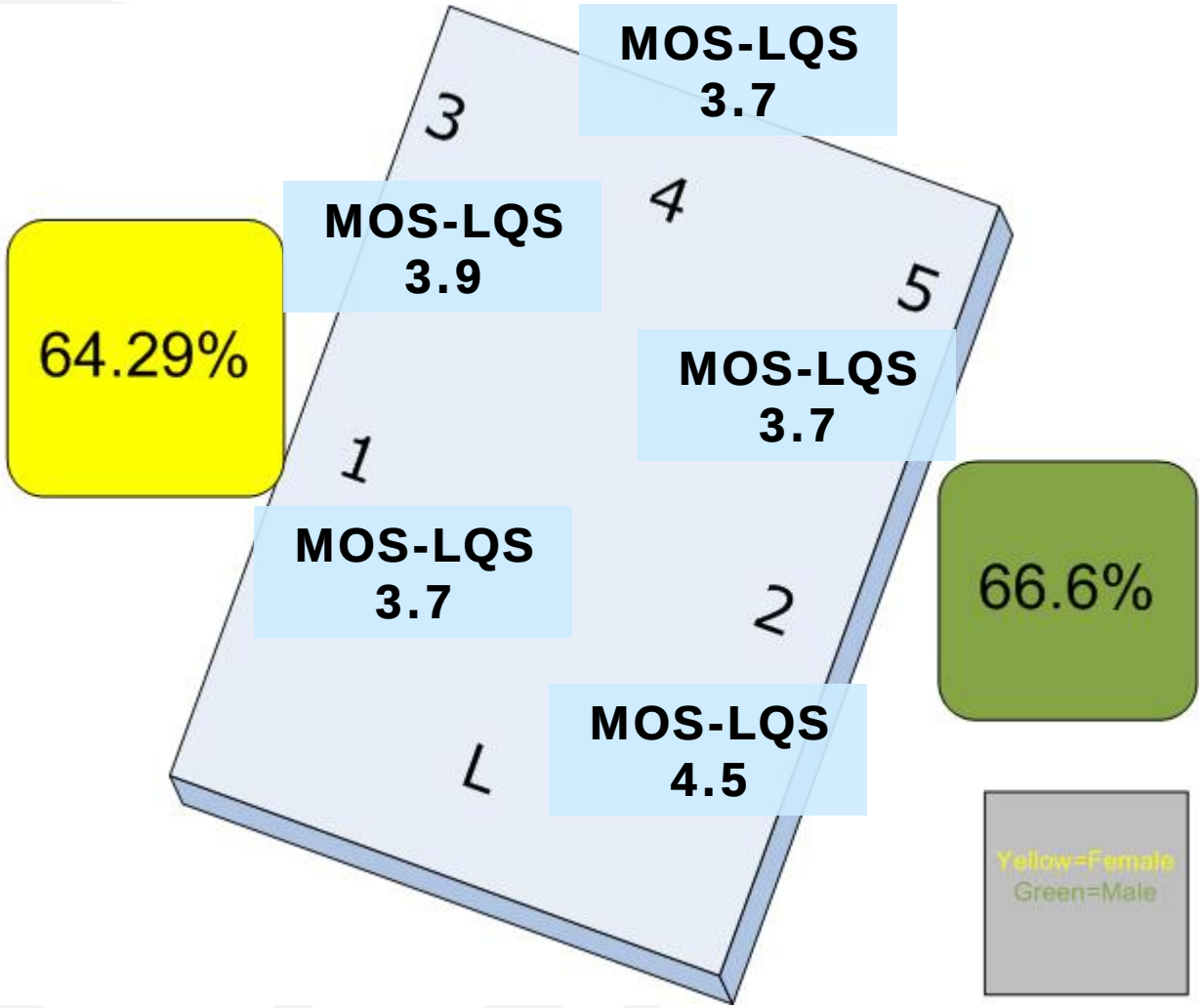

Combined Average

Summary and Outlook

- Test result shows that 3D sound is easy to locate when it is placed at the same height with the listener.
- It is hard to locate when it is placed up in the direction to the listener

- Goal of my PhD: set up and enhancement of an open source 3D telephony system.
- Standards for 3D telephony will benefit from real solutions.