RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

Collaborative VideoWalls

Laboratory for Computer Science Research

Presented by Richard Martin

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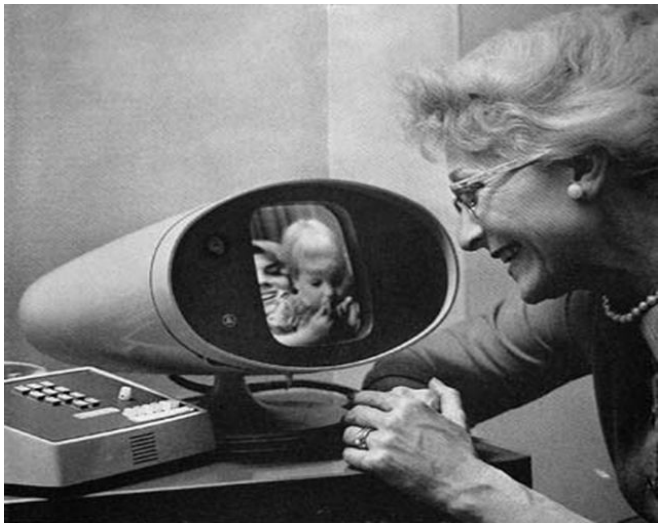
Vision: incorporating interactive video

Metropolis (1927)

Bell Labs, 1964 World's Fair



Total Recall (1990)

2015: Vision Realized

Skype

Facetime

But current tech is still limited

How to enable natural group interactivity at a distance?

Workgroup (<10)

Seminar (~25)

Banquet (~150)

Lecture (>300)

Existing models are limited approximations

Limited spatial perspectives (e.g., 3 cameras)

Manual control of perspective

Small viewing areas

Approach and Principles

Goal: Enable group interactivity with existing models

- Core value of the educational processes

Principles:

- Emulate spatial experience with technology
- Users should not change – tech should accommodate
- Approximate spatial paradigms when necessary

Approach:

- Video: Array of cameras and monitors to emulate visual experience
- Audio: Array of microphones and speakers to emulate audio sensation

Videowalls: Enabling Natural Human Interaction

Outline

Introduction

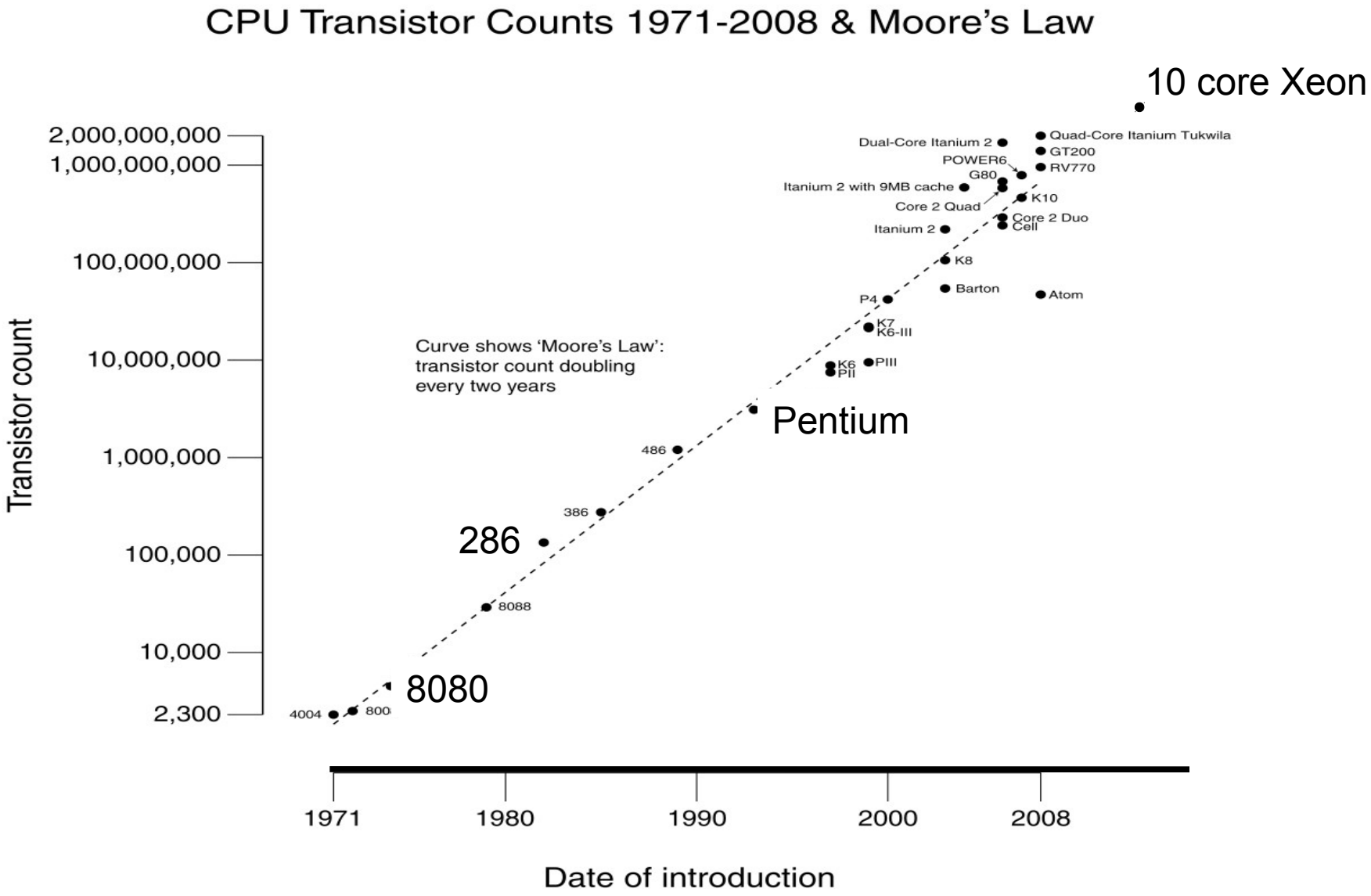
Opportunity

Building video walls

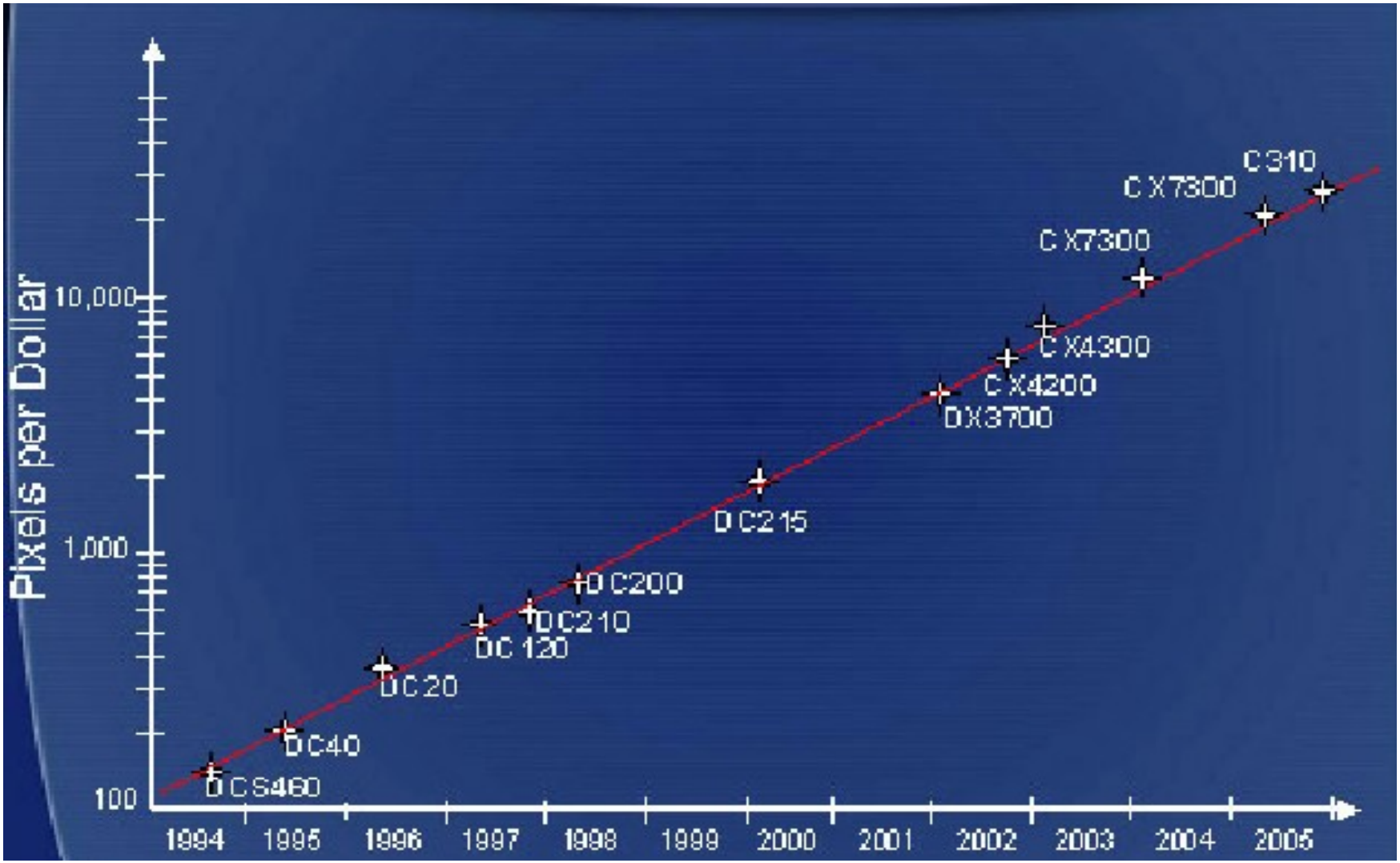
Experiences and use cases

Future work and conclusions

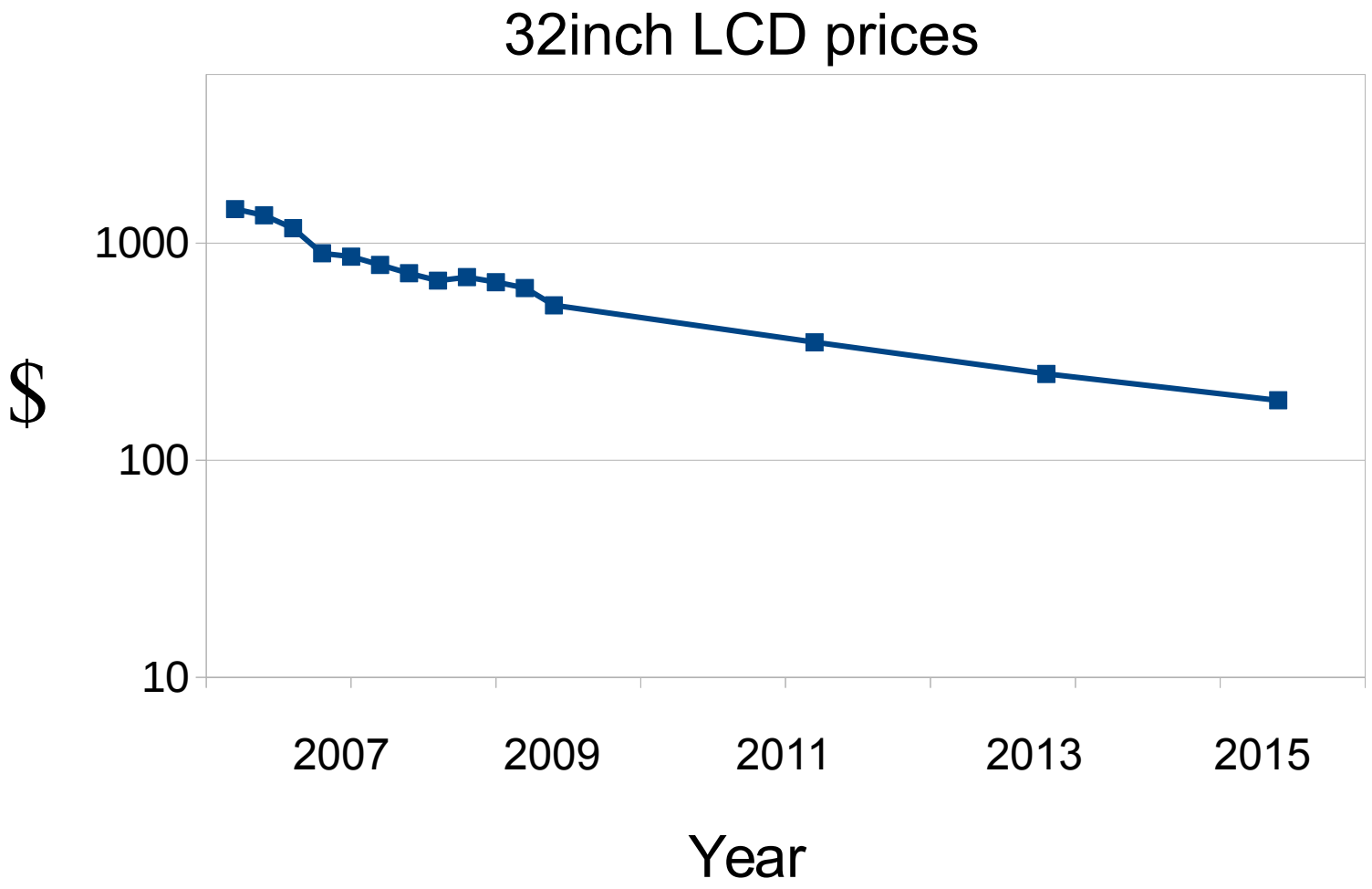
Enabling Trend: Transistors per Chip



Enabling Trend: Camera Pixels/$



Enabling Trend: Display Pixels/$



Enabling Technology: Systems on a Chip

BCM2835 SoC: Full Linux OS
- Networking
- Security
- Monitoring/reporting

512 MB DRAM

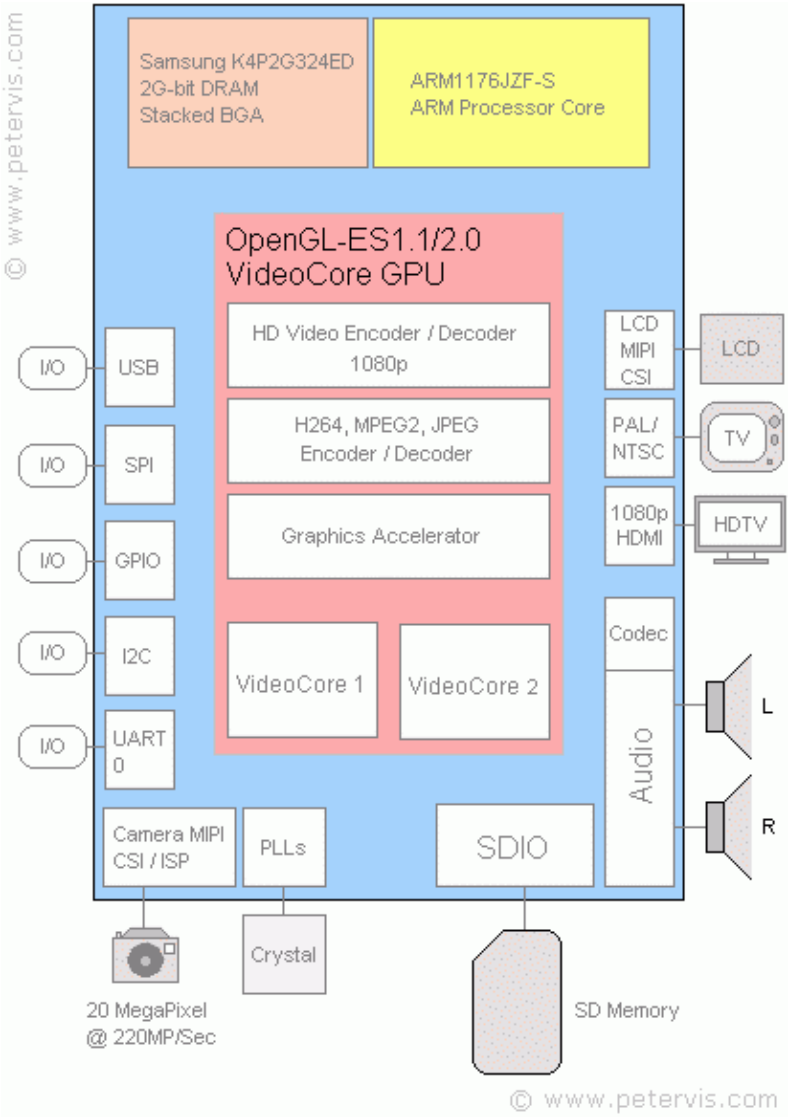
Hardware Video Stream Encode/Decoders

Graphics/Rendering

Camera Encoders

HDMI output

Stereo audio out



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Building a Wall: Architectural Approach

Use a collection of screens, cameras and microphones

- Similar to RAID storage, striped networks

Compressed Internet streams of video and audio are the unit of abstraction

Software combines streams into a single logical device

Building a Wall: Display Architecture

Tiled set of screens instead of 1 large screen:

- Increased resolution maintaining commodity pricing (pixels/$)
- Flexibility in sizing using different screen sizes and number of screens

Challenge:

- Introduces seam artifacts (bezels … more later)

Building a Wall: Camera Architecture

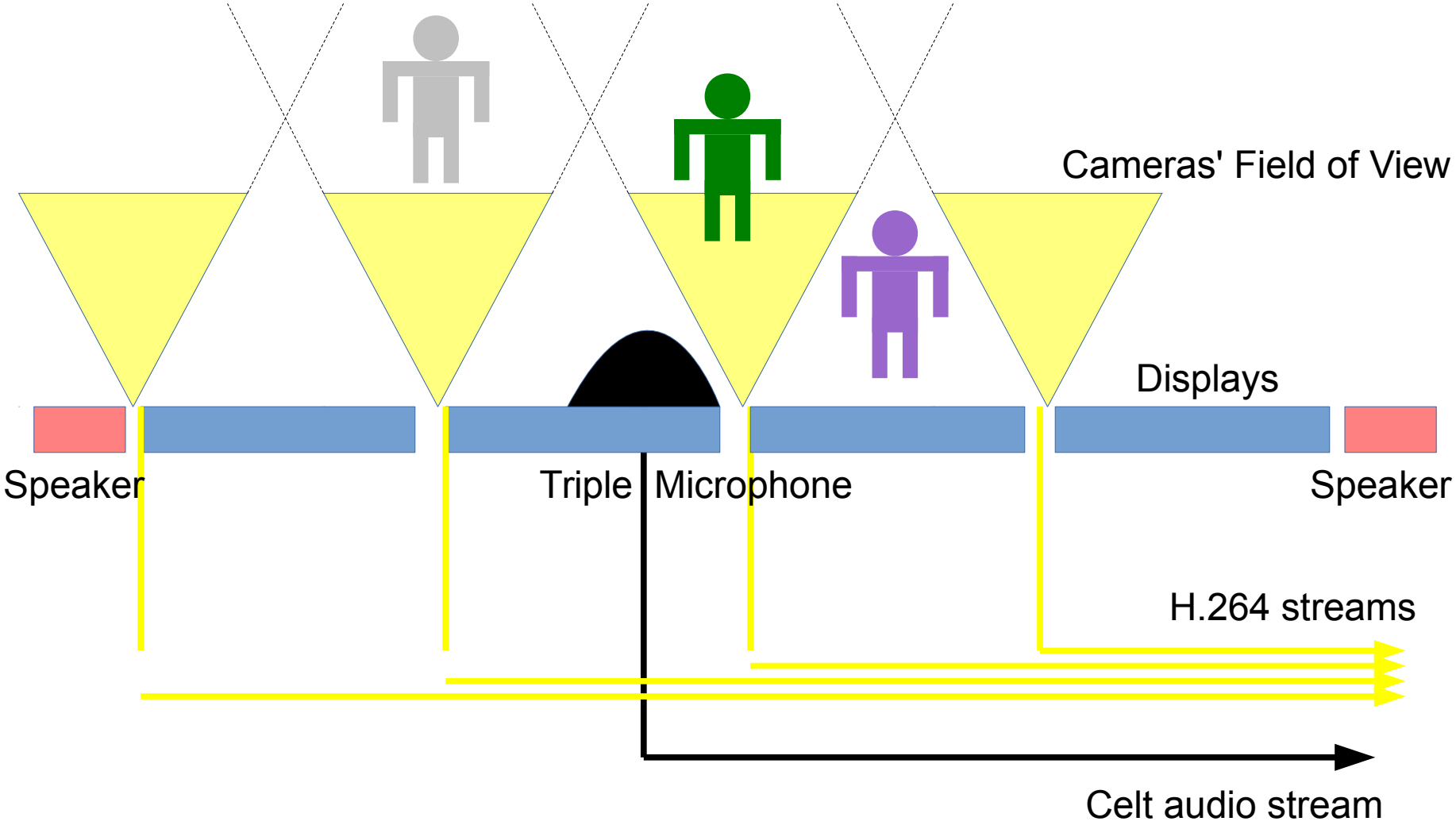
Tiled set of adjustable cameras

- Increased resolution with commodity pricing (pixels/$)
- Allows multiple viewpoints for realistic perspectives
- Camera adjustment enables many room layouts.

Challenges:

- Holes in view
- Overlaps in view
- Sweet spot is 5'-15' away

Videowall Architecture



Logical Object Discretization for Tiled Displays

Additional Technical Challenges

Network Bandwidth

- H.264 hardware encoders @ 1080p → 3.4 Mbps/stream
- Sensitive to loss → Use TCP

Latency for Interactivity

- Challenge: keep one-way latency < ½ second for all streams
- H.264 encoder
  - Frame rate
  - Buffer sizes
- Audio processing
  - What layer to put echo cancellation?
  - Reduced a lot of processing to improve latency.

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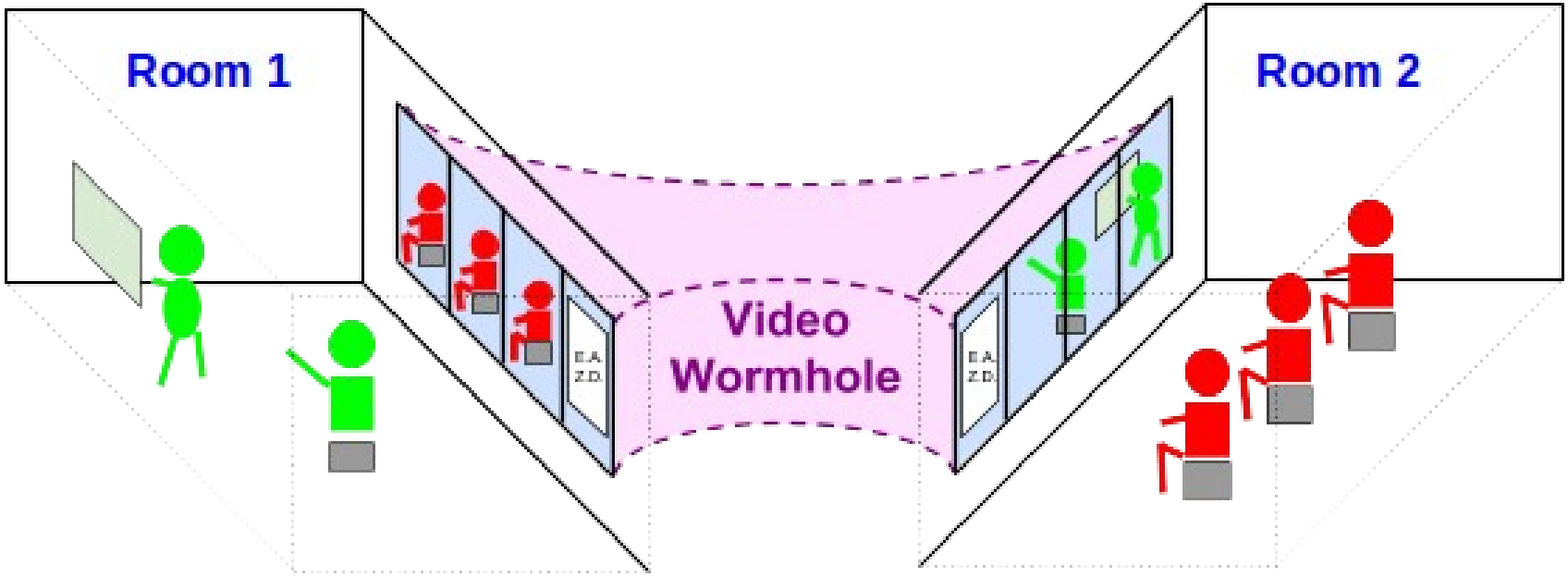
Using Videowalls as Wormholes for workgroups and seminars

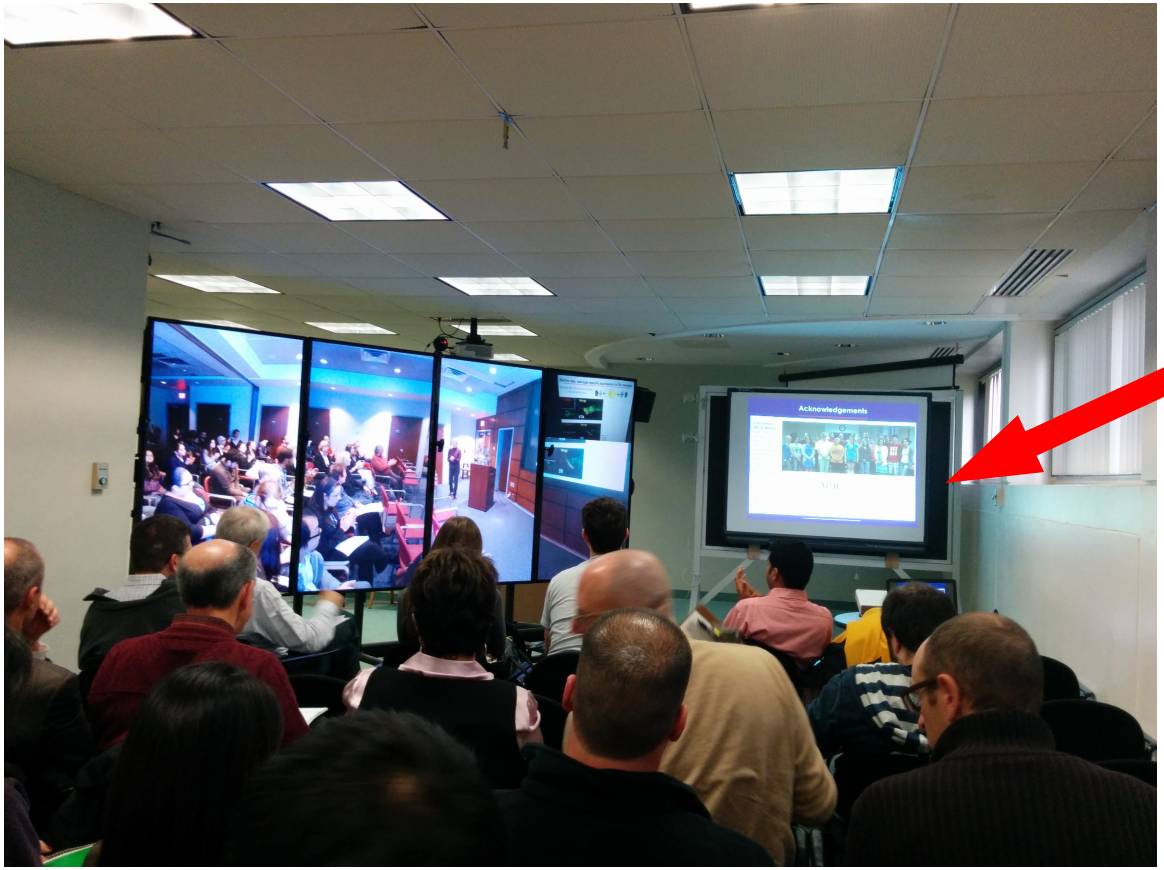


Experiences with a Chinese lecture

Small: 4 and 3, students, 1 instructor

- use of white board OK
- Group results worked well

Experiences with Colloquia



Added a camera focused on the speaker's slides

Display on a local projector

Can view the active participants

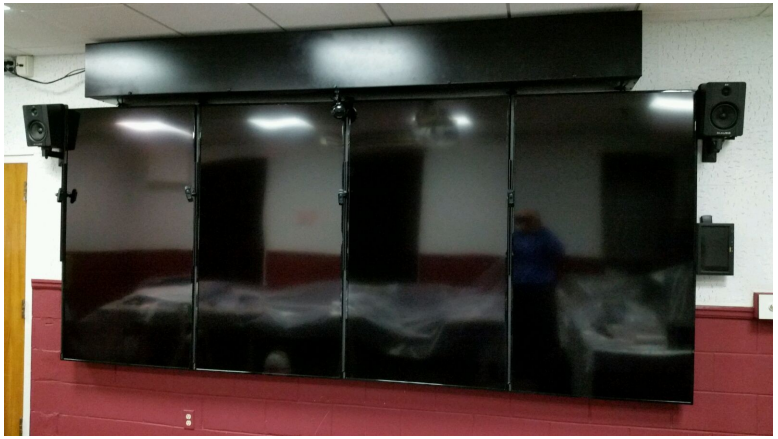
Existing Deployments

Aidekman Seminar Room

Psychology Room 101
Piscataway

Dana Library Newark

Language Laboratory
New Brunswick



Short term next steps

2 language classes between New Brunswick and Newark

- Portuguese for Business
- Brazilian Literature
- Instructors in Newark, students in Newark and New Brunswick

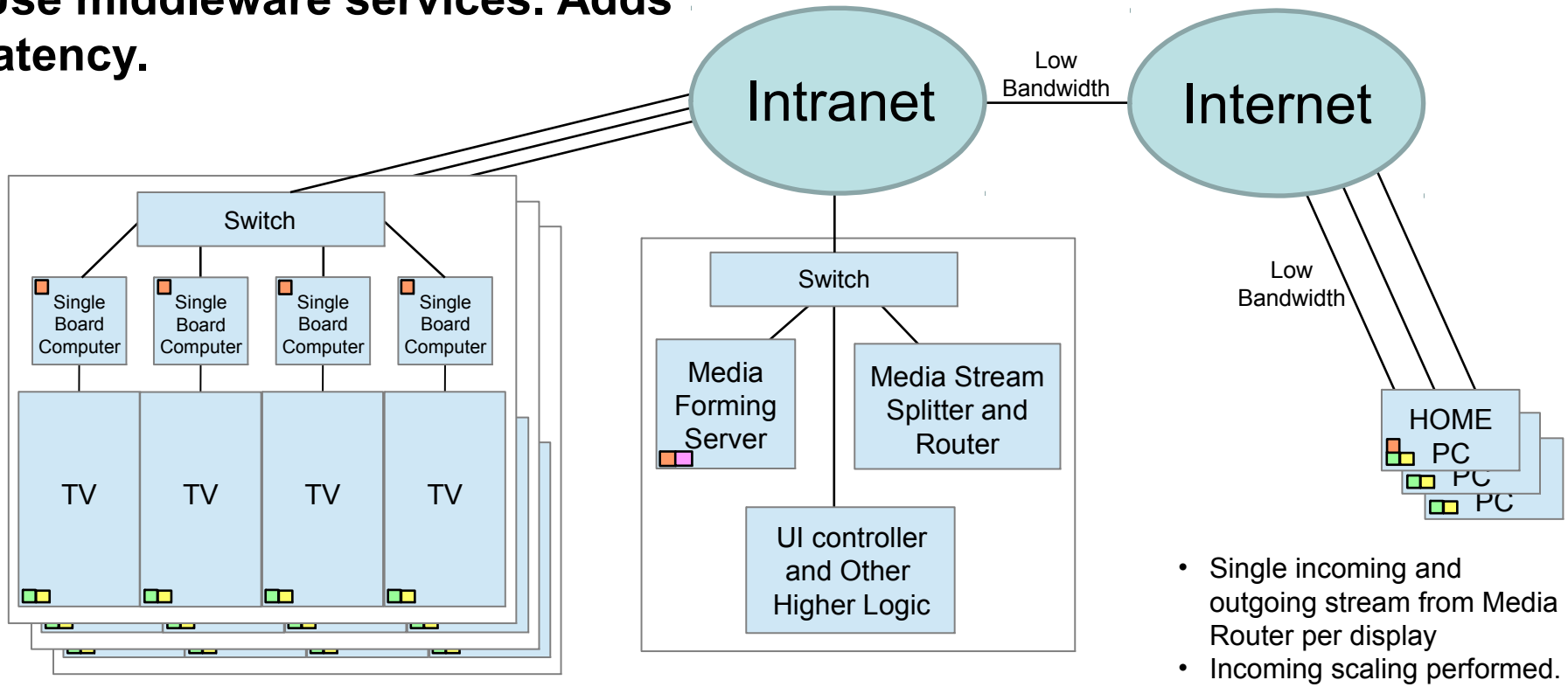
Plan to connect Hickman Hall on Douglass campus to Marymount Manhattan College

- Enable Masters in Political Science with Concentration in United Nations and Global Policy Studies
- Instructors and students in Manhattan and New Brunswick

Future work: Tiled classroom

Future architecture for remote users

Use middleware services. Adds latency.



- Single incoming and outgoing stream from Media Router per display.
- Incoming rotation and scaling performed.

- Incoming streams from all sources split and redistributed.
- Streams combined constructed
- Multiple outgoing scaling/quality performed.

- Single incoming and outgoing stream from Media Router per display
- Incoming scaling performed.

Open Questions

Video encoding

- Perform basic video operations while maintaining computational efficiency in real time?
  - E.g., Crop, scale, overlay, merge

Audio:

- Real time surround sound?

Usage: include remote users with small screens?

- Connectivity with other clients (e.g. Skype)
- How to present videowall at small scales?

Working with seams

- Seamless displays are not necessary if logically discretized. APIs to support?

Does network quality reach continental and international scales?

Conclusions

Videowalls enable natural group interaction

- Goes beyond Skype, Facetime, Hangout, Cisco C90

Titled displays and distributed processing/network architecture

Using embedded SoCs key to reducing cost, power, and heat

More software development and experimentation are needed to enable remote users, better audio (e.g. music lesson), and multi-way walls.

More information

http://videowall.rutgers.edu

Backup slides