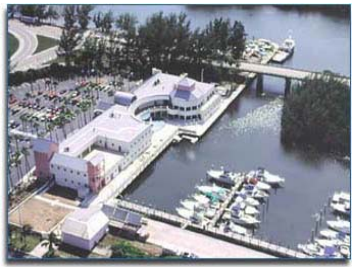
The Magic of Hypercube: From Parallel Computing to Multimedia

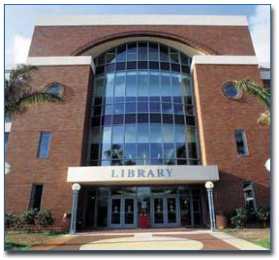
Borko Furht
Chairman and Professor
Director, NSF Industry/University Cooperative Research Center
Florida Atlantic University, Boca Raton, Florida
borko@cse.fau.edu

Institut Eurecom, Sophia Antipolis, July 2009

Florida Atlantic University
7 CAMPUSES



Dania Beach



Davie

Ft. Lauderdale

Boca Raton

Jupiter

Port St. Lucie

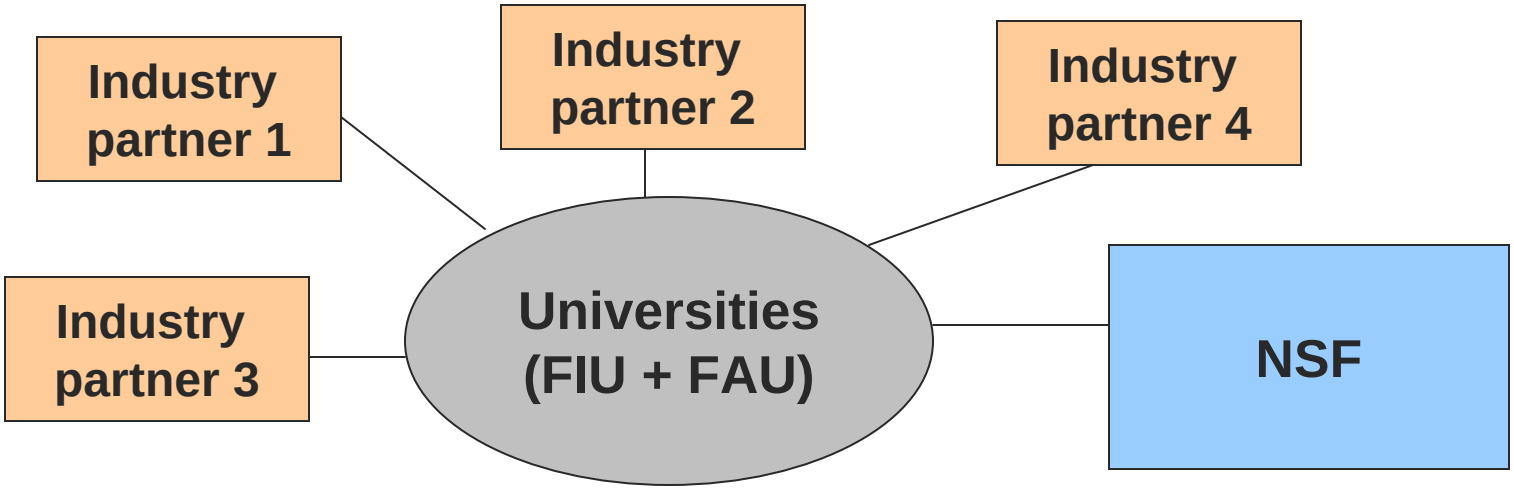
Harbor Branch at Fort Pierce

- 160 buildings valued at over $700 M
- Covers more than 150 miles of Coastline in Southeast Florida
- 27,000 students

Our Strategy in Redesigning Industry/University Collaboration Strategy

- Industry trends: research funding drastically reduced – chances for universities
- NSF-sponsored Industry/University Research Center (FIU+FAU) established in 2008
- Industry R&D Park on FAU Campus
- Embedding industry labs in the Department (joint industry/university labs)

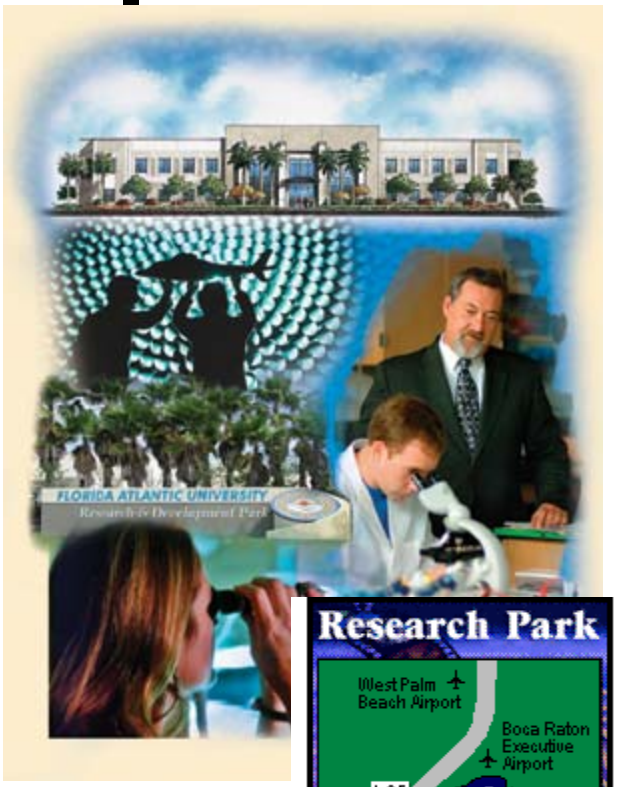
Model of the I/UCRC



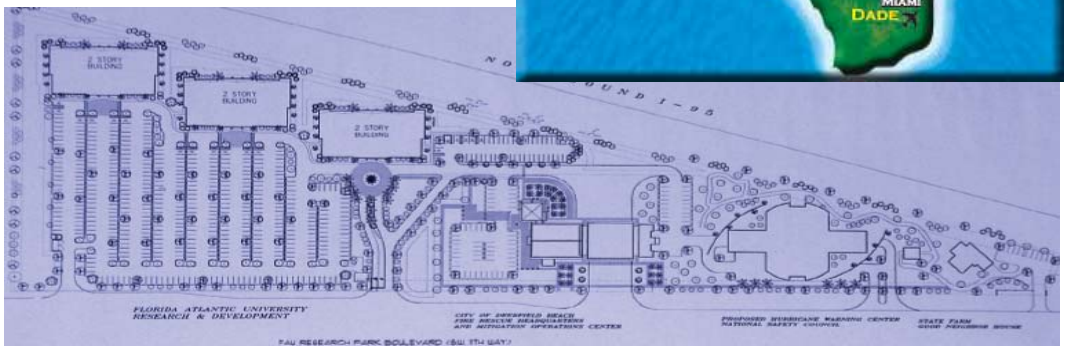
- Industry partners pay the memberships ($5K to $50K per year)
- NSF sponsors the Center ($60K to $200K per university per year)
- Industry Advisory Board selects the research projects
- Industry members select the products for commercialization – no royalties

Industry Advisory Board Meeting 2008

Florida Atlantic Research and Development Parks



Boca Raton and Deerfield Beach

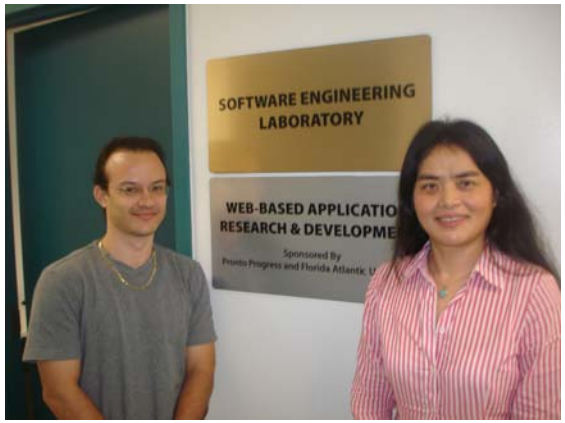


FAU Research Park

- 850 New high tech jobs in 24 companies
- Incubator with 17 start-ups
- Website: www.research-park.org

Joint University/Industry Labs

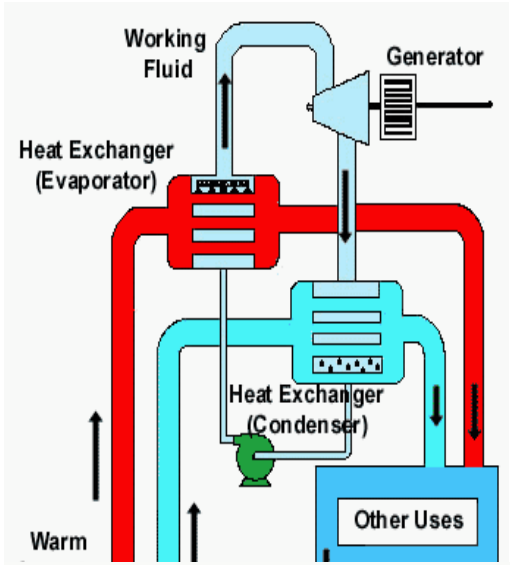
- **Creating joint university-industry labs**
- **“Incubator as part of the Department”**
- **Examples: Pronto Progress –Developing software applications and tools**
- **Motorola: Developing tools and techniques for mobile applications**

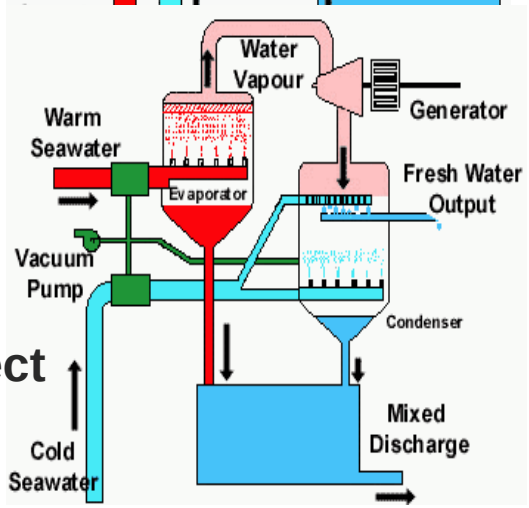


Success Story: Center for Excellence in Renewable Ocean Energy

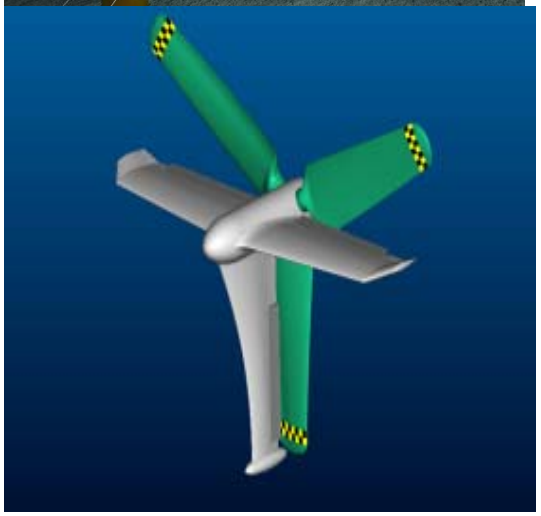
Energy from the Oceans

Thermal



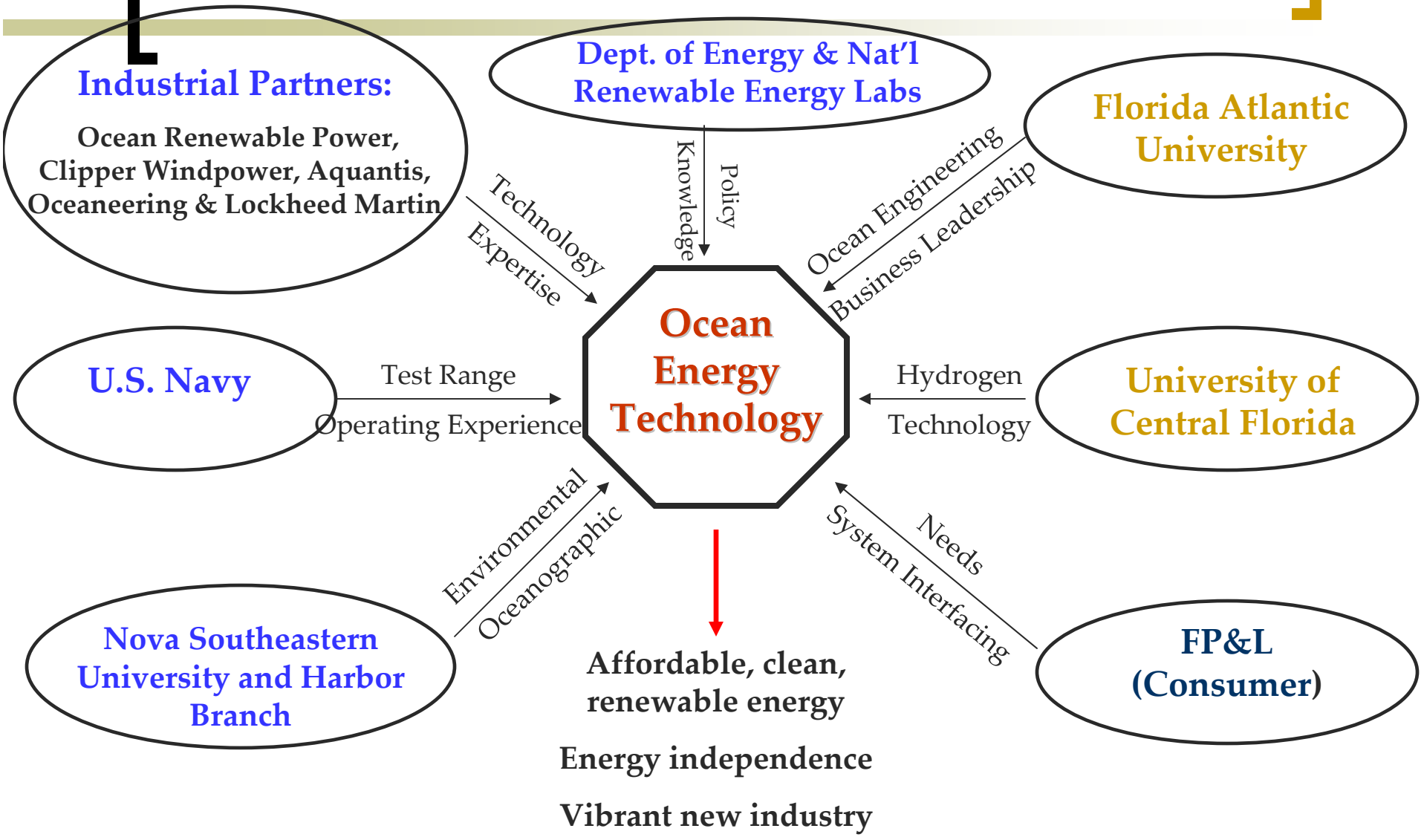


Current

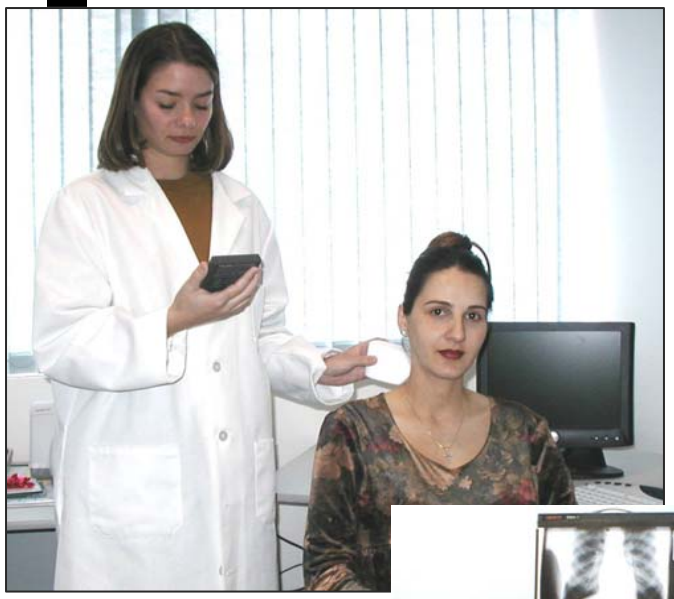


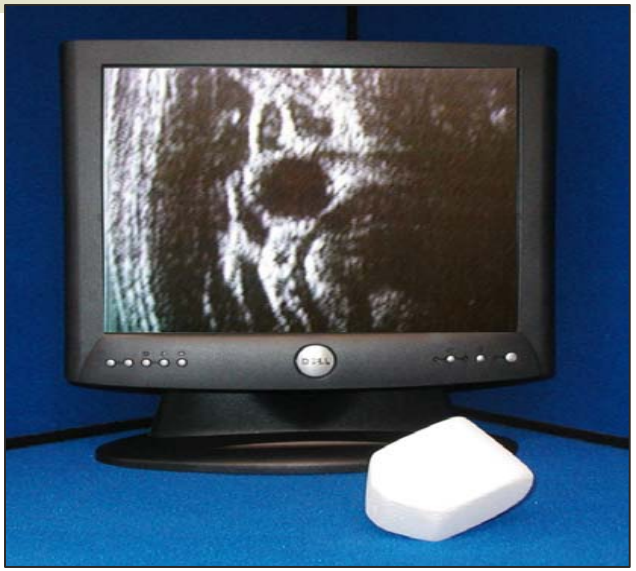
$15 million project

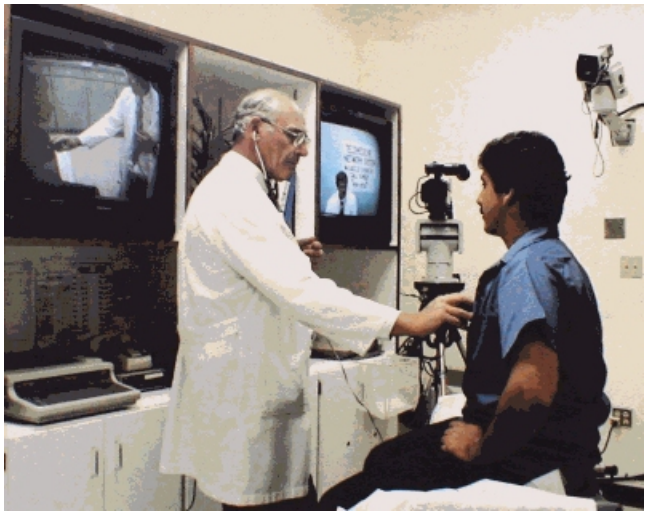
A Strong Partnership for a Unique and Feasible Solution to Florida's Energy Future



High-Definition Telemedicine



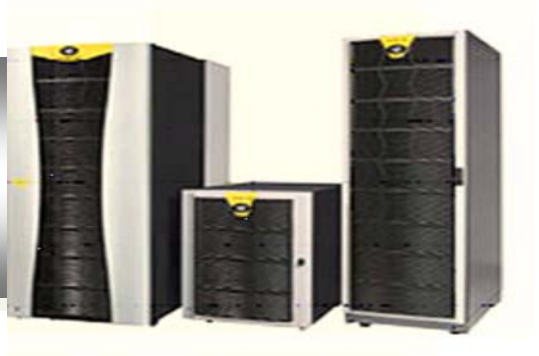




PC-based wireless high resolution Ultrasound

Fiber-optic links

Bioinformatics Research Consortium



- **High Performance Computing in College of Engineering & Computer Science**
  - NSF Funded supercomputer (IBM and SGI equipment)
  - NSF Funded clusters
- **LA Grid**
  - FAU has recently joined LA (Latin American) Grid
  - LA Grid is a consortium of Latin American and US Universities
  - Current membership has 10 institutions
  - LA Grid provides a unique set of supercomputing resources including Barcelona Supercomputer Center for research in various areas including Bioinformatics and hurricane mitigation
- **IBM Bluegene**
  - Strong prospect for having bluegene supercomputer at FAU campus
  - Joint effort of IBM, Scripps, and FAU
  - Primarily for addressing bird flu pandemic, bioinformatics

High Performance Computing Research Projects

Title of the Project	Field
Bioinformatics Research Consortium: Genomics for Quality Healthcare	Bioinformatics
Integrated Computation and Communication	System software
Video Coding and Processing	Multimedia
Biometrics Computing and Face Recognition	Biometrics
Experimental Mathematics	Combinatorics and graph theory
Human Genome	Biomedical science
Computational Physics	Solid state physics
Analysis of Large Test Data Set	Data mining

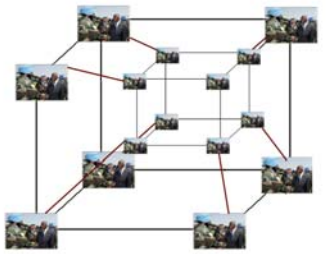
Mobile Technology Consortium

- To bridge the university wisdom with the local entrepreneur spirit for the growth of mobile technology & user experience
- To bring together system companies, small businesses, universities, and government agencies to evolve next generation Mobile Technology platforms, applications and automation
- To provide a quarterly session to present “Hot Technology Topics” and collect needs of the local entrepreneurs and businesses. Initiate 3 projects by year end and spin one company by 2010.

Media Projects Inspired by Hypercube

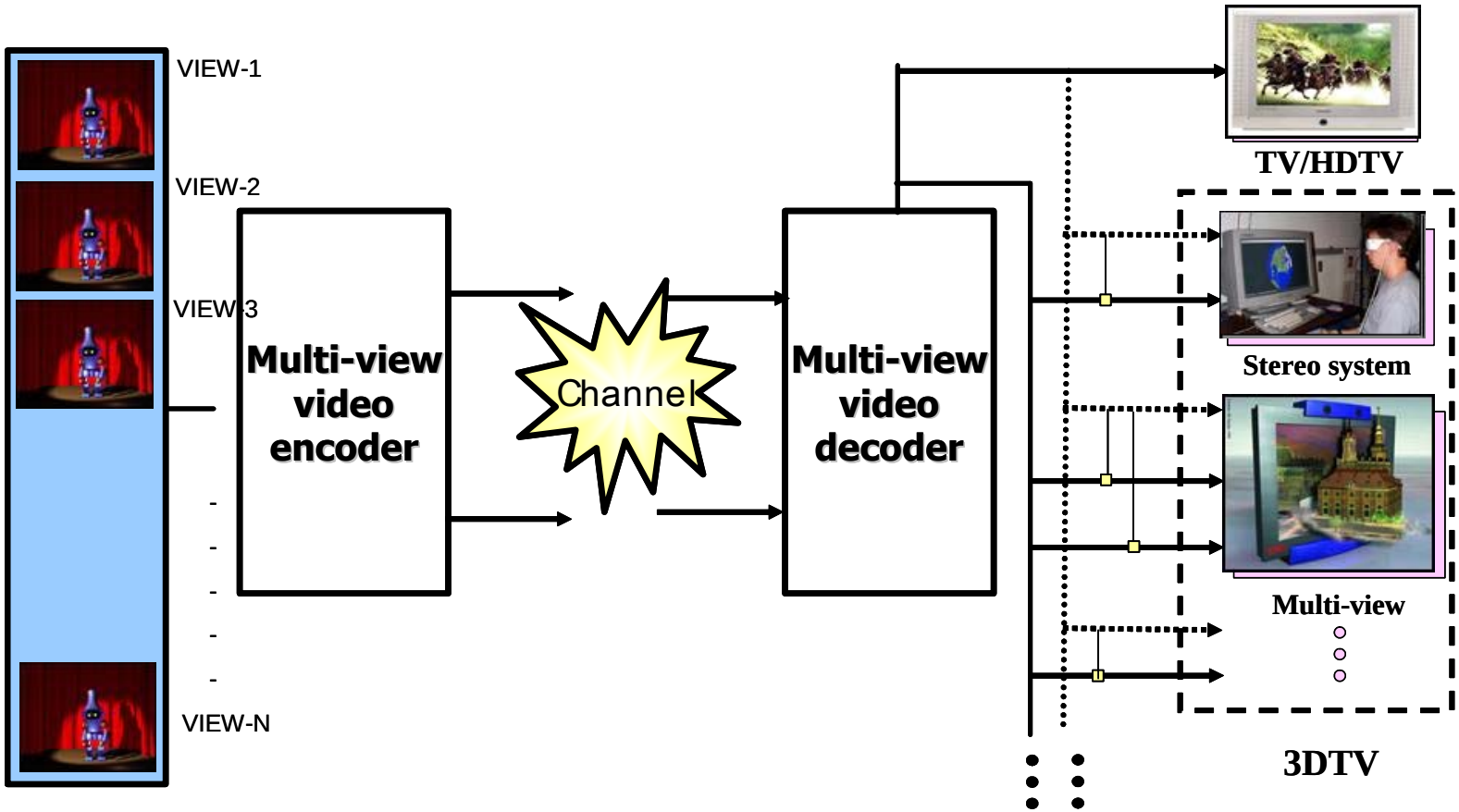
- A Method and Apparatus for Multi-View Video Coding
- Interactive System for Navigation, Visualization, and Retrieval of Video and Image Data
- “Re-birth of Hypercube”

Background



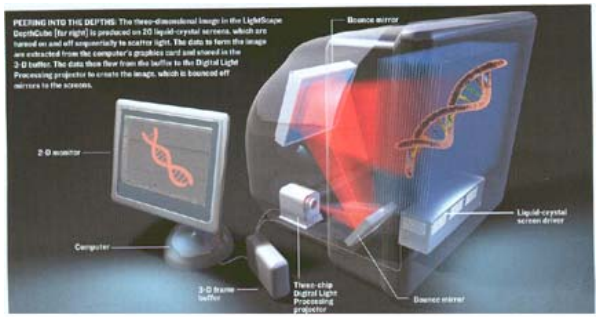
- Article: “Parallel Computing: Glory and Collapse”, IEEE Computer Magazine, November 1994, pp. 74-75.
- Claim in the article: Collapse of parallel computing due to: (1) Cold war is over, (2) New competition from PCs and workstations, (3) Lack of parallel software, languages, and OS
- Received a number of responses:
- Cray Research sales analyst still believes in parallel computers – March 1995 Cray Computer Corporation went to bankruptcy
- Eric Weiss, the Biographies Editor of the IEEE Annals of the History of Computing suggested that I write an obituary on Parallel Computing
- Invited to participate in Rome Lab’s (US Air Force center) Parallel Software Engineering Technology Forecast
- Office of Technology Assessment of US Congress in Washington DC contacted me requesting a variety of information

Multi-View Video Coding System

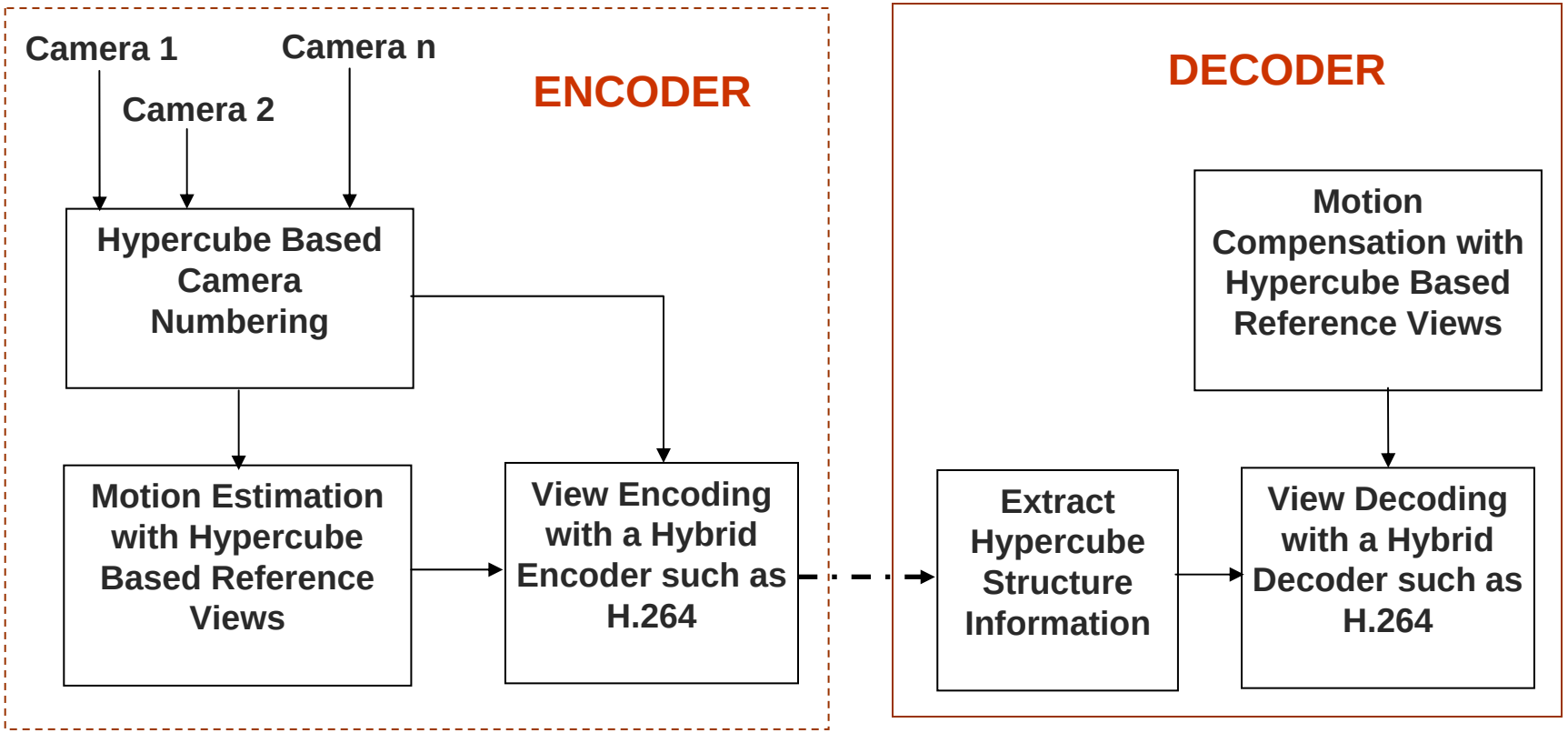


Multi-View Video Coding Systems Benefits

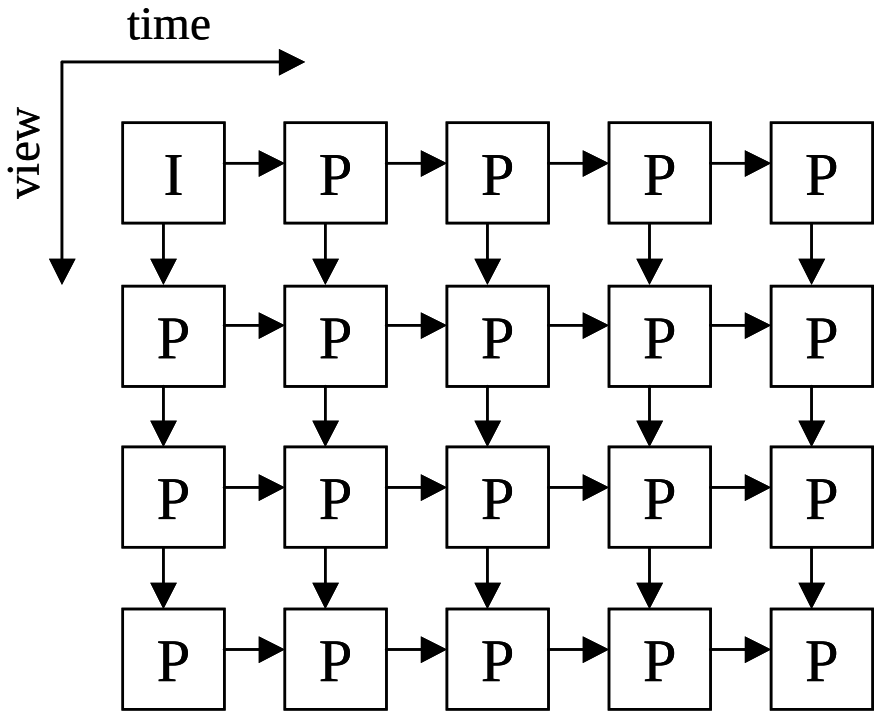
- Allow coding of multiple camera views
- Provide the base for 3D video and 3D imaging
- The compressed 3D video stream is delivered to a receiver (3D TV or multi-view receiver) over the network



The Apparatus (Multi-View Coder) based on Hypercube Structure Of Cameras



Prior Art: Sequential Prediction Structure

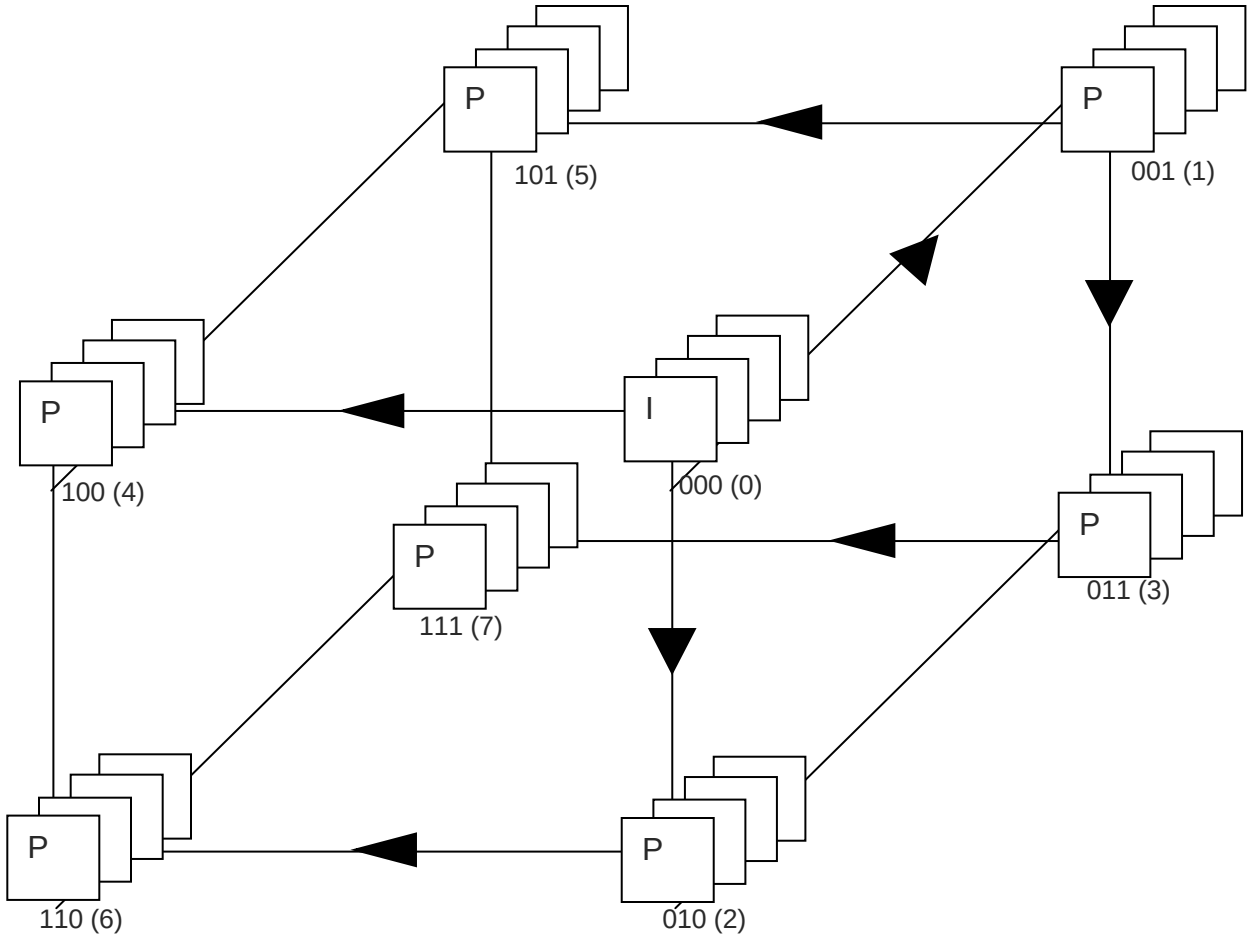


- Disadvantage: sequential dependencies
- N cameras → (N-1) views must be decoded

Reference Views for an Eight Camera Array

View No. (V_i)	Reference Views (V_j)
0 (000)	-
1 (001)	0
2 (010)	0,1
3 (011)	0,1,2
4 (100)	0,1,2,3
5 (101)	0,1,2,3,4
6 (110)	0,1,2,3,4,5
7 (111)	0,1,2,3,4,5,6

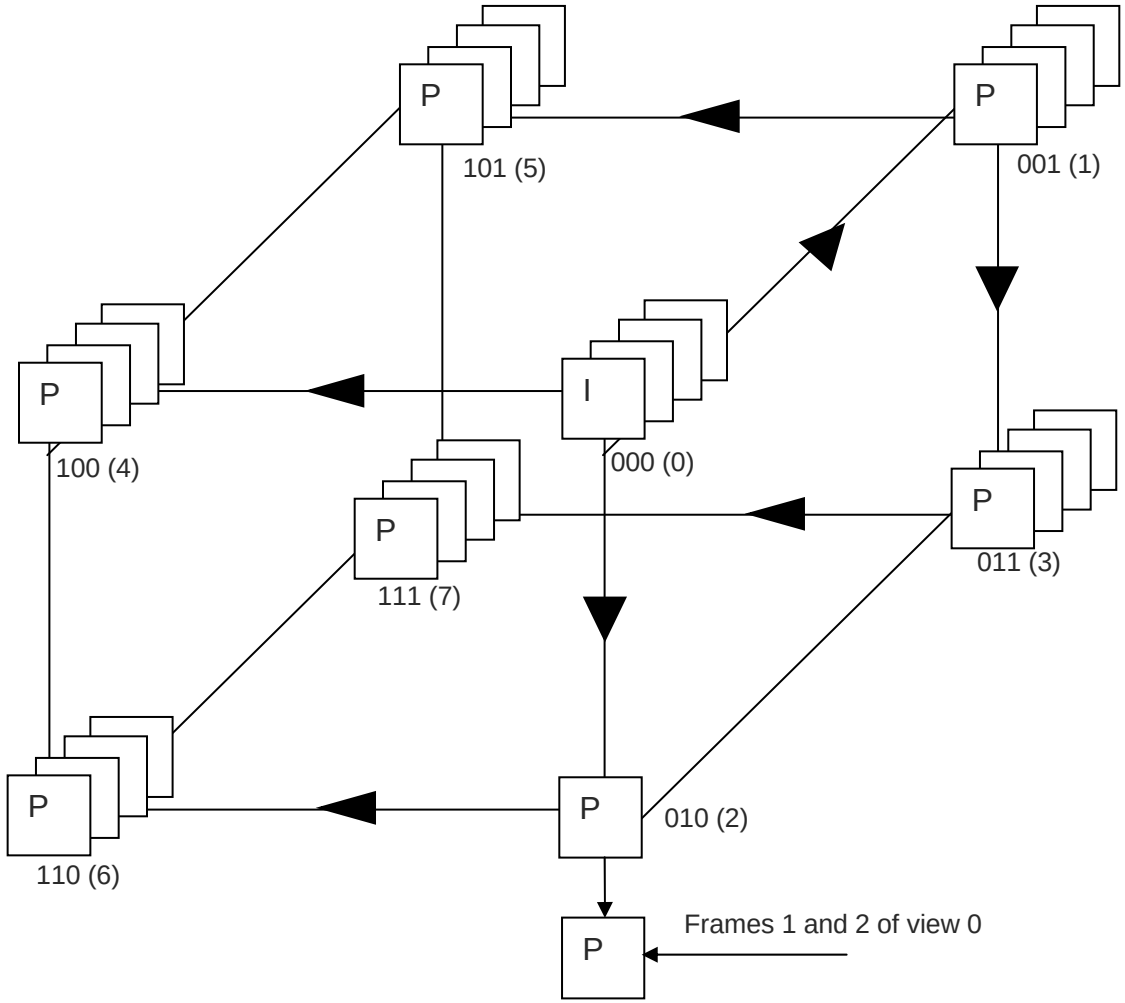
Hypercube with 8 Nodes (Cameras)



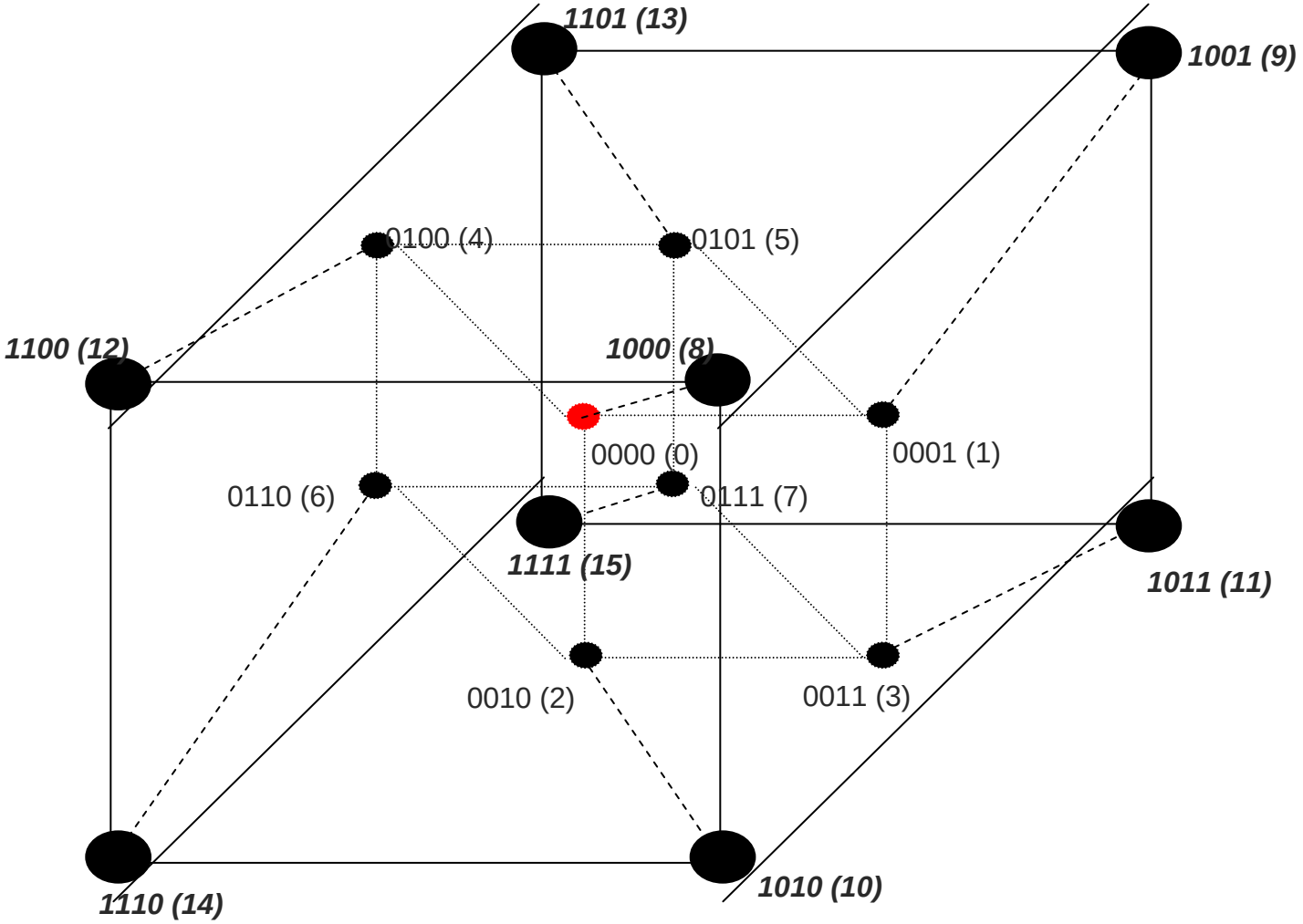
Reference Views for an Eight Camera Array in Hypercube

View No. (V_i)	Reference Views (V_j)
0 (000)	-
1 (001)	0
2 (010)	0
3 (011)	0,1
4 (100)	0
5 (101)	0,1
6 (110)	0,2
7 (111)	0,1,3

Encoding Subsequent P-Frames in Hypercube Structure



Hypercube with 16 Nodes (Cameras)

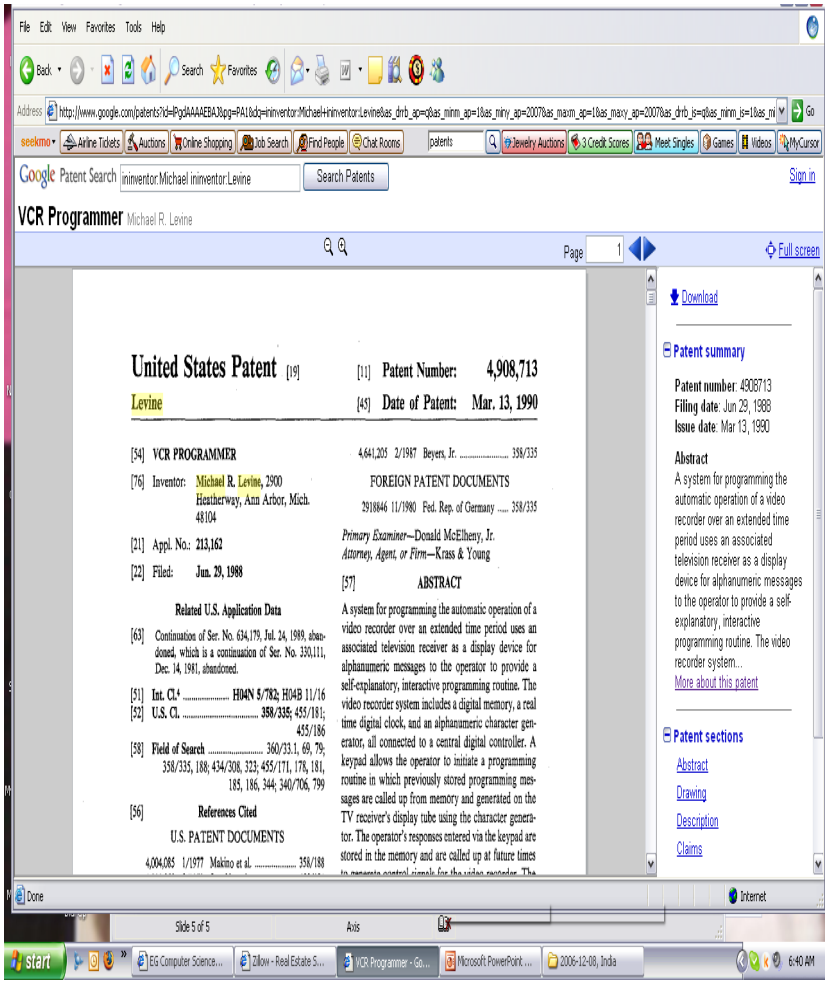


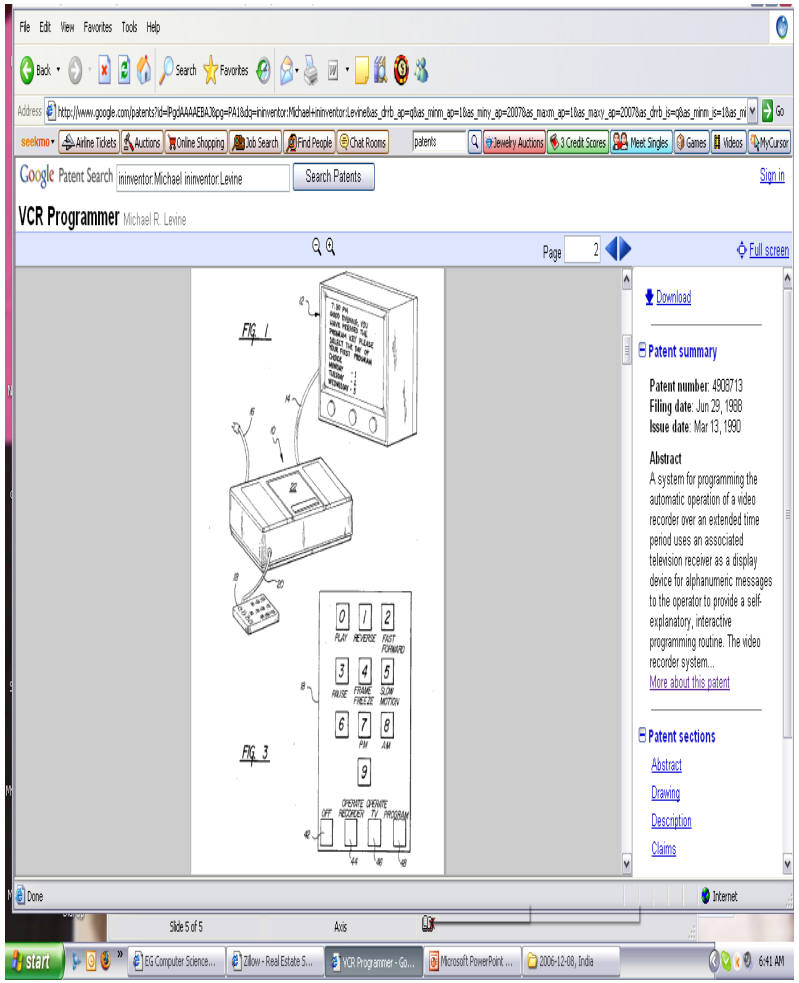
Summary

- The proposed apparatus for coding multiple-views video sequences consists of a video encoder and decoder
- When the number of cameras increases, existing solutions create a very large dependency chains resulting in huge computational cost for extracting the corresponding views at the receiver side.
- The proposed prediction structure based on hypercube minimizes these dependencies and scales well with the number of cameras
- Due to reduced number of dependencies, the proposed solution allows extracting specific camera views much easier and faster than existing solutions.

Inspiration: Michael Levine's Patent – VCR Programmer

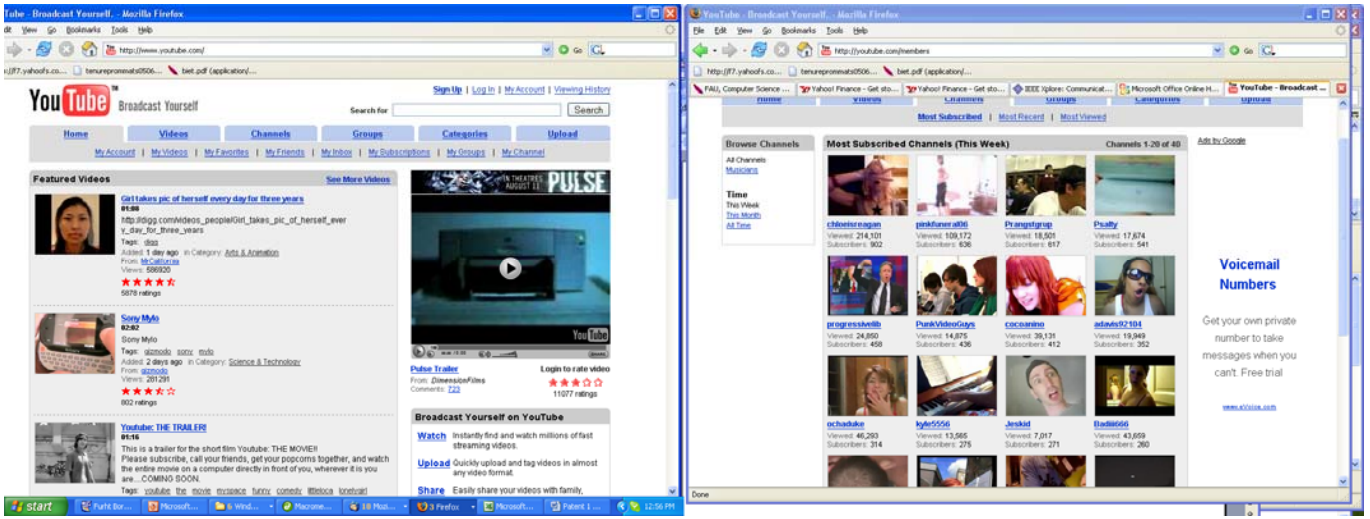
(Mike received 25 cents from each VCR sold)



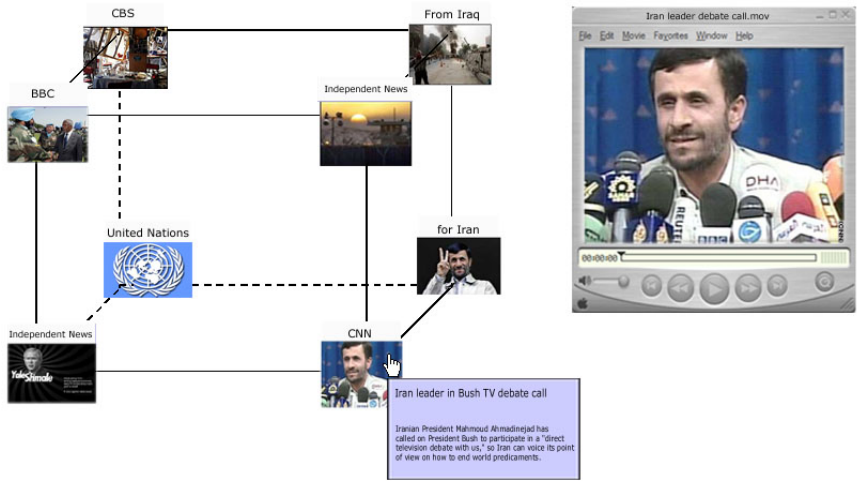


Current Video and Image-Based Applications

- Examples: youtube, current.tv, lulu.tv
- Old, sequential look
- Navigation through the system: by selecting various categories or by using Search function
- Sequential (linear structure) does not provide exciting user's experience (especially for young generation!)



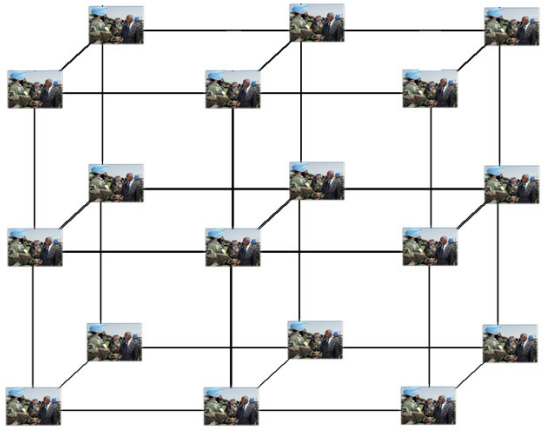
New Cube-Based Interface

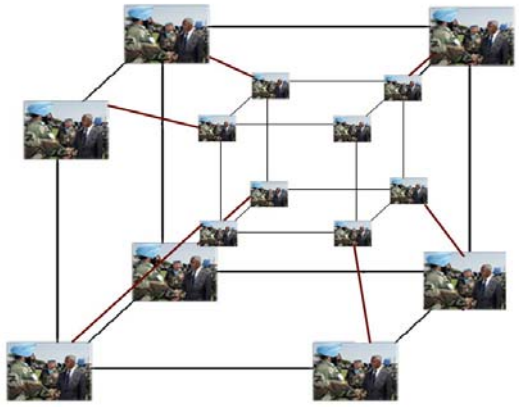


- **Each node is linked to a specific video**
- **The content creator can combine video clips from different sources and create a 3D view**
- **As the user traverses a node (video icon) with the mouse, textual information about the related video appears on the screen**
- **Content-based retrieval features**
- **Approved as a provisional patent**

Hypercube Extensions

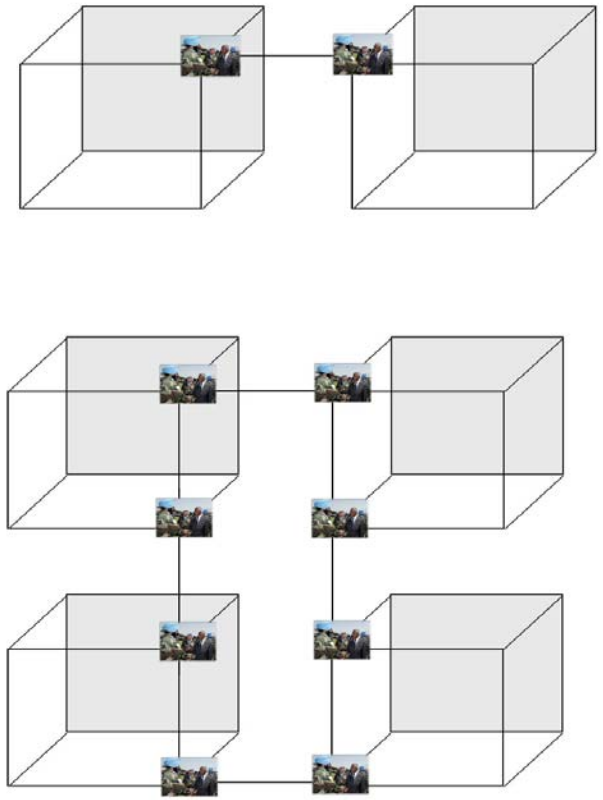
- Basic cube can be extended to provide more information
- This allows an effective visualization of a large video archives
- The user gets more exciting experience in traveling through the space or time and searching for videos (or images)





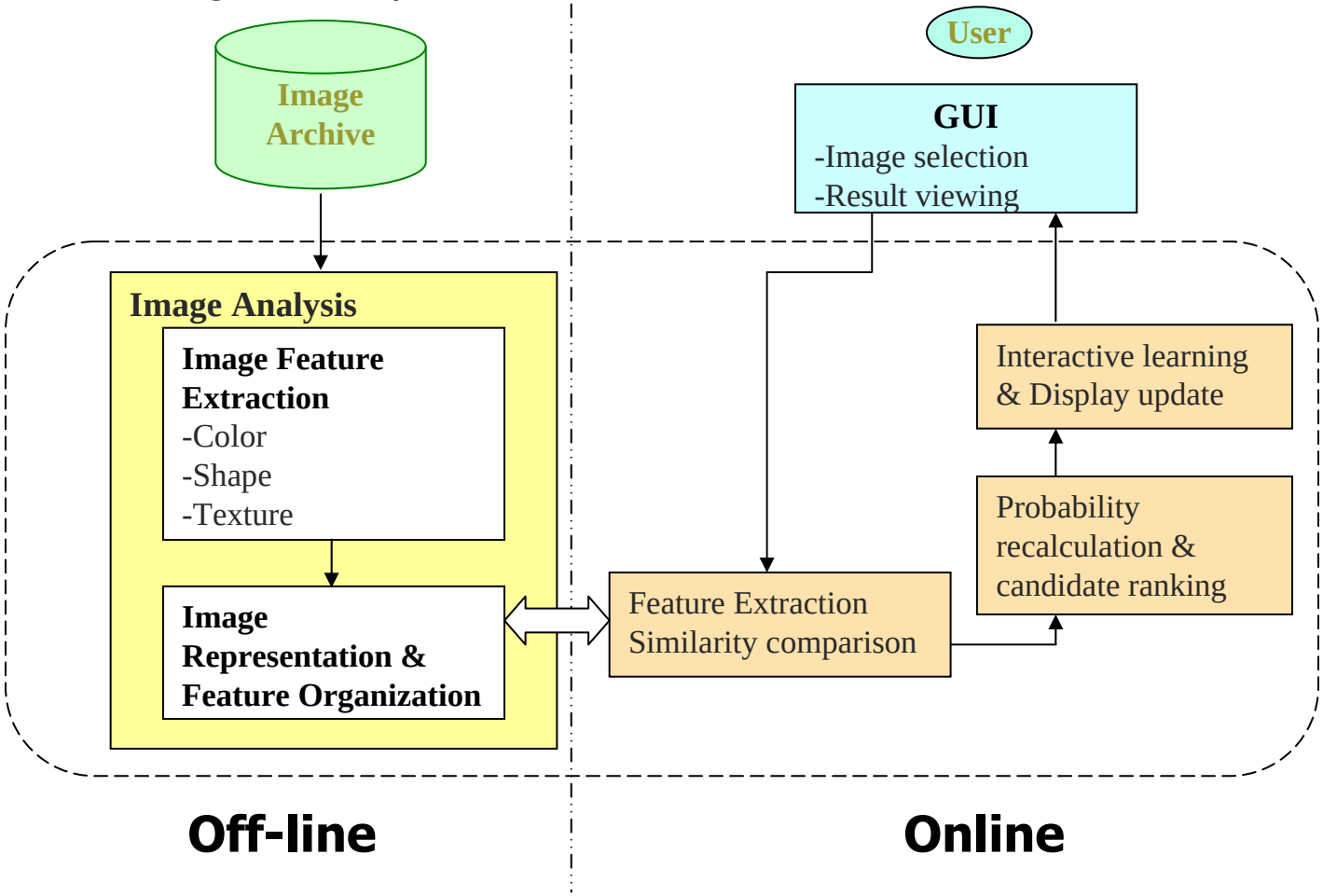
Multi-Level Hypercubes

- Another scenario: connecting space-connected with time-connected cubes



Content-Based Retrieval Features

- Requires intelligent interpretation of the contents



Applications

- Cataloging and retrieving video data
- Organization and retrieval of (personal) image databases
- Digital yearbooks
- Navigating social networks
- Applications for 3D screens
- Mobile phone applications