HD Video Communication

Trends & Underlying Technology

The Talk

- 3 Questions For You

- Why Video Communication? Why now? Why HD?

- Compression 101

- Lifesize

First Question?

- >400m users, +328k per day, 40% use video

- Skype? iChat? OCS? ooVoo?, TokBox? Avistar? CMA?, Movi2? Sightspeed? Mirial? vCon? Scopia? Google? Vidyo? Web Conferencing? X-Meeting? vidSoft? Gizmo? Marratech? VQ eConf? UC?

Second Question?

- Cisco TP, Halo, Polycom, Tandberg, Lifesize, Teleris

Second Question?

- Cisco TP, Halo, Polycom, Tandberg, Lifesize, Teleris

Second Question?

- Cisco TP, Halo, Polycom, Tandberg, Lifesize, Teleris

Third Question?

- Who has HD at home?

What's Driving the Growth?

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the data

Corporate Travel Down, Telecommuting Up

TELECOMMUTING HIT record highs and business travel dropped off dramatically as oil prices surged last summer, according to research firm TNS Global, which conducted two surveys for headset maker Plantronics. An astonishing 48 percent of all knowledge workers telecommuted at least one day per week, up sharply from 35 percent in the same period the previous year. Two-fifths reported cutbacks in travel at their corporations; more than a third said they had cut down on their own business travel.

Beth Johnson, a vice president of marketing at Plantronics, says that though the price of a barrel of oil has plummeted—from an all-time high of US $147 in July to just one-third of that in early January—telecommuting hasn't fallen, and business travel hasn't risen. Reason: the miserable shape of the overall economy.

The survey defined knowledge workers broadly to include all full-time office workers who use a computer and common software applications for their daily work. —STEVEN CHERRY

Sources: Plantronics, TNS Global
PHOTO: TIM HALL/GETTY IMAGES

19% said that **corporate travel** had decreased
↓ **40%** or more

35% said that **teleconferencing** had increased
↑ **40%** or more

33% said that **Web-based meetings** had increased
↑ **40%** or more

48% of all knowledge workers **telecommute** one day per week or more

47% of women say that **corporate travel** has decreased in the past year, compared to 37% of men.

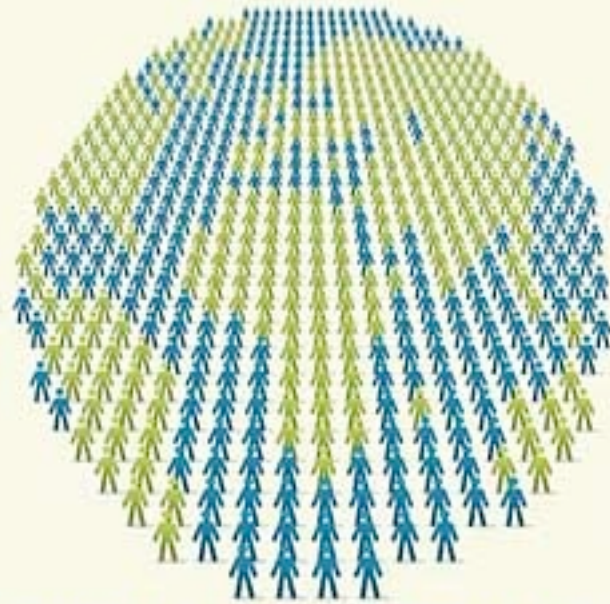**37%** of women report increased use of **Web-based meetings**, compared to 28% of men.

68 NA · IEEE SPECTRUM

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Wednesday, February 25, 2009

$34.93 / $1.79

THOMAS L. FRIEDMAN
THE WORLD IS FLAT

A BRIEF HISTORY OF THE TWENTY-FIRST CENTURY

FURTHER UPDATED AND EXPANDED // RELEASE 3.0 // PICADOR

Is This Sustainable?

- 40,000,000 miles in trains expensed

- 63,000,000 miles in cars expensed

- 120,000,000 miles in planes expensed

- $250,000,000 per year

- "was" increasing at 30% per year

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What's Driving The Growth

Economic Climate

- Skyrocketing fuel costs
- Travel has become miserable, inconvenient, and time consuming
- Growing focus on climate change and carbon footprint

Business Drivers

- Irreversible march toward globalization
- Competitive environment requires faster time-to-market
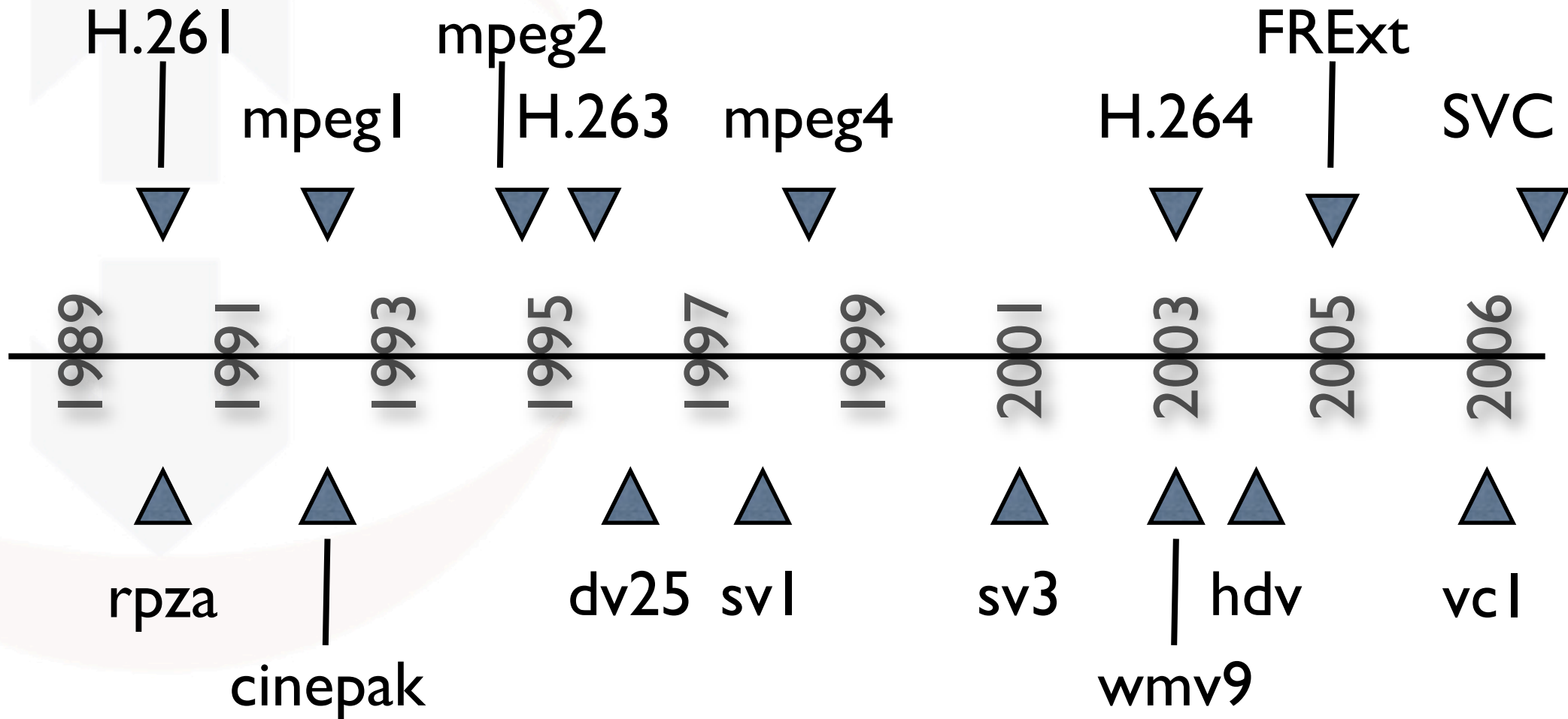- Focus on ROI and cost savings at an all time high

Compelling User Experience

- High Definition brings realism of experience
- Network capacity to handle 1Mbps+ HD video calls
- Dramatically improved price/ performance (HD <$5,000/site)

Now more than ever, in today's economic climate, companies are implementing cost-saving, business-efficiency alternatives

History of Video Compression (come along way in 20 years)

H.261 | mpeg1 | mpeg2 | H.263 | mpeg4 | H.264 | FRExt | SVC

1989 | 1991 | 1993 | 1995 | 1997 | 1999 | 2001 | 2003 | 2005 | 2006

rpza | cinepak | dv25 | sv1 | sv3 | wmv9 | hdv | vc1

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QT Codecs 1991

- 68K class processor (20-40 MHz, $6269 + $3K)
- Bandwidth (CD 150kB/s, HD 2mB/s, NuBus 10 mB/s)
- Hard drives (80 MB)
- RAM (4 MB)
- Codecs (Video, Animation, Graphics, Raw)
- 160x120 @ 5-10 fps
- Kid King beats QT to 1.0 demo (500kbps, 6 fps)

Road Pizza 1989

- Extended color cell compression

- 4x4 blocks

- 1 luminance (Y) at every pixel

- Only 2 colors for every 4x4 block

- 6:1 compression ratio

- colors quantized to 5b made it 8:1

- extensions made it 12:1

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Road Pizza

- Not very accurate

- Not adaptive

- So increase the block types

  - normal, antialiased, constant color

- Symmetrical encode/decode!!!

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Quickly go to 1998

- Cinepak

- Sorenson Video 1 & 2

- Highly asymmetrical (30:1 - 100:1)

- Problem with MPEG1 & 2 - "... it puts the power of creation in the hands of a few capitalist-corporate-industrial-complex producers"

- Sarah MacLachlan demo

  - 850 kbps, 24 fps, 320x240 (4x!!)

DV - changed the rules

- Firewire developed in 1990

- First DV cameras available in 1997 ($3K)

- Solved 10 year old AV I/O problem - HUGE

- 25 mbps, 720x480 @ 30 fps

- Enabled applications like iMovie and FCP

- 2006 - HDV appears for HD camcorders

- Big Bike DV Demo

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HDV Cameras

Brings us to 2003 H.264

- Most modern standard based video codec

- 2x the efficiency of MPEG2

- Video codec used in Blue-Ray, HD-DVD, iTunes, video iPod, Sony PSP, sat TV, ...

- Lifesize operates up to 1280x720 @ 30p

  - Raw data rate is 27 mpix/sec (663 mbps)

  - Lifesize coded rate (Auto) is ~850 kbps

  - Lifesize Room 200 is 1920x1080 @ 30p

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2008 - AVC Cameras

Visual Illusions
Stepping Feet

Visual Illusions
# Lilac Chaser

Vid Compression 101

- Colorspaces

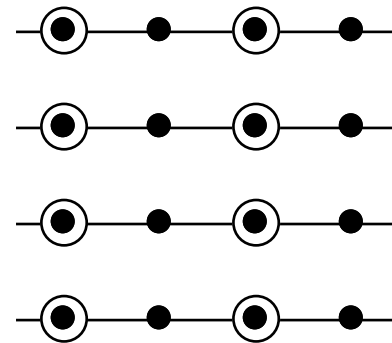- Macroblock

- I, B, P frame types

ColorSpaces

- Mathematical representation of a set of colors

- Many colorspaces (RGB, YUV, CMYK)

- YCbCr (ITU-R BT601) is popular for video

- There are many formats of YCbCr

  - 4:4:4 - Pro gear

  - 4:2:2 - BetaCam SP, DVCPro

  - 4:2:0 - consumer MPEG1, 2, 4, H.264

  - 4:1:1 - consumer miniDV NTSC
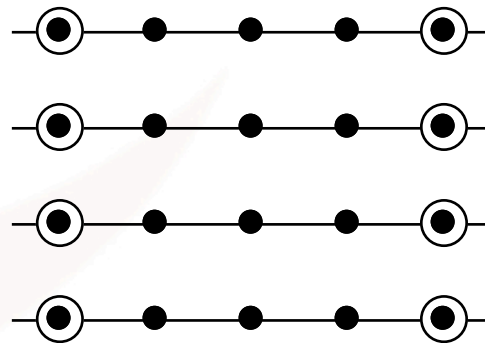
- The eye is more sensitive to Y, so subsample CbCr

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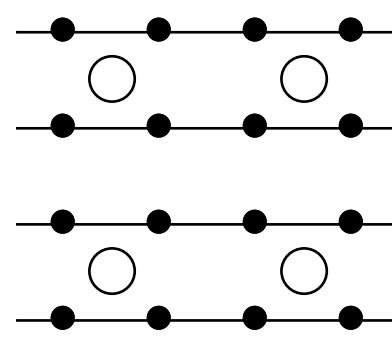
YCbCr Formats
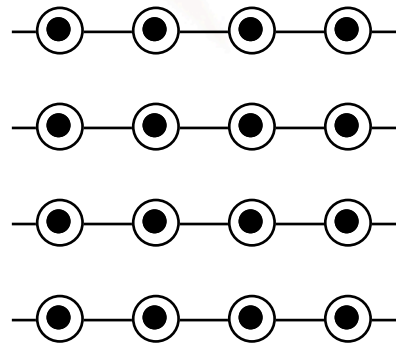
4:4:4 Cosited

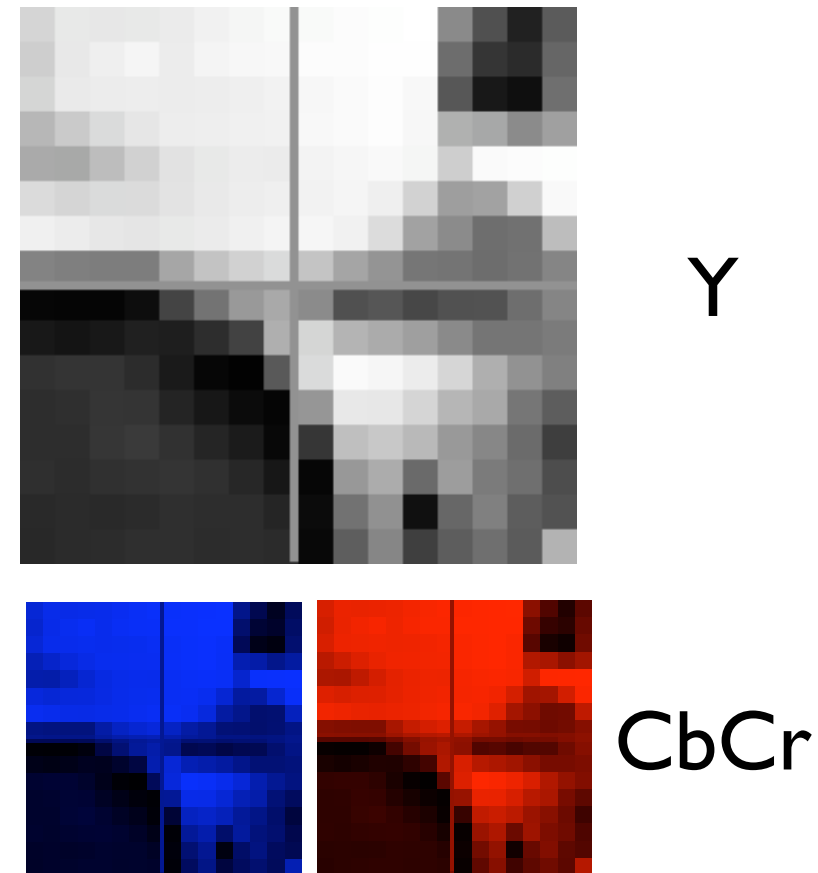4:2:2 Cosited

4:1:1 Cosited

4:2:0

● Y Sample

○ CbCr pair Sample

Picture

Macroblock

1 Macroblock
=
4 8x8 blocks
=
16x16 pixels

Macroblock & YCbCr

16 pixels

16 lines

Y

CbCr
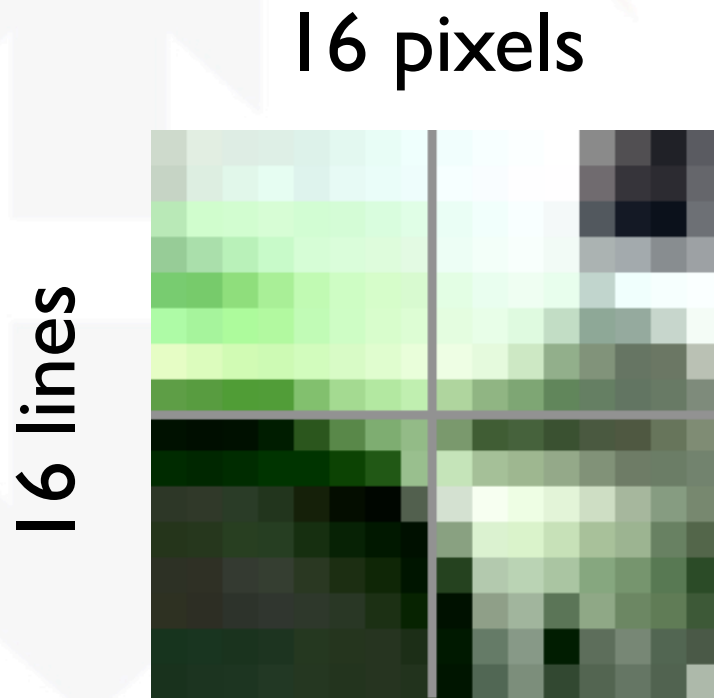
# I, B, P Frames

- I (INTRA) frames are simply pictures

- P & B (INTER) take advantage of temporal redundancy

- Example sequences

  - IIIIII... - No dependency on any other frame

  - IPIP... - Dependent on previous frame

  - IBPI... - Dependent on previous and future frames

- Typical sequences

  - DVD - I B B P B B P B B P B B P I ...

  - Lifesize - I P P P P P P P P P P P ... (until errors)

Simple Compression

- RGB->YCbCr (lossy)

- 8x8 FDCT (Integer x-form in H.264)

- 6 8x8 DCT blocks make up a Macroblock

- Quant (lossy)

- Zig-Zag

- Variable Length Coding

- Motion estimation

RGB->YCbCr (4:2:0)

12:6
Compression
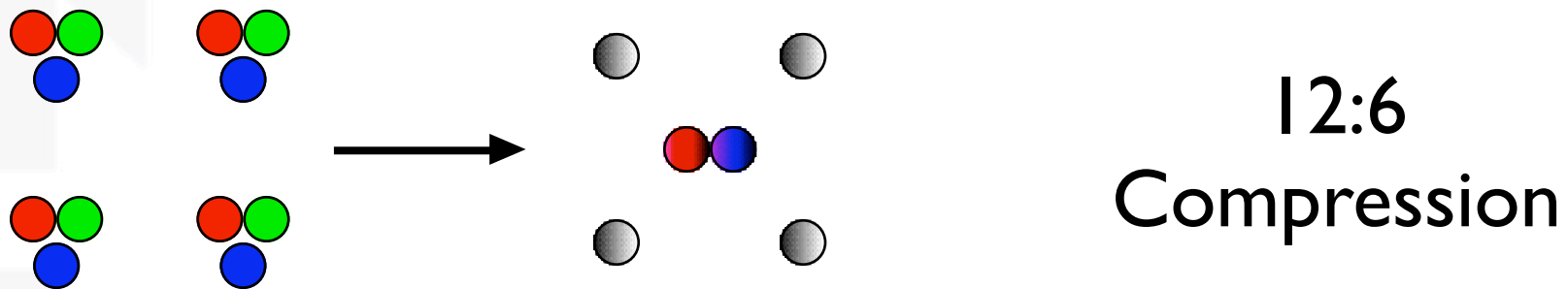
- $Y = 0.257R' + 0.504G' + 0.098B' + 16$

- $Cb = -0.148R' - 0.291G' + 0.439B' + 128$

- $Cr = 0.439R' - 0.291G' - 0.071B' + 128$

Example 8x8 FDCT Input

```
140 144 147 140 140 155 179 175
144 152 140 147 140 148 167 179
152 155 136 167 163 162 152 172
168 145 156 160 152 155 136 160
162 148 156 148 140 136 147 162
147 167 140 155 155 140 136 162
136 156 123 167 162 144 140 147
148 155 136 155 152 147 147 136
```

Forward DCT

- There are 4 Y's, 1 Cb, and 1 Cr in a macroblock

- Macroblock describes 16x16 block of pixels

- FDCT operates on one 8x8 block at a time

- Transform from one representation to another

  - Time domain -> frequency domain

- Transform is reversible and ~loseless

- Works because most video images are made up of low frequency information and we can heavily quantize (lossy) the higher frequency components

Example FDCT output

186	-18	15	-9	23	-9	-14	19
21	-34	26	-9	-11	11	14	7
-10	-24	-2	6	-18	3	-20	-1
-8	-5	14	-15	-8	-3	-3	8
-3	10	8	1	-11	18	18	15
4	-2	-18	8	8	-4	1	-7
9	1	-3	4	-1	7	-1	-2
0	-8	-2	2	1	4	-6	0

Quantization

- Quantization matrix is used based on the quality of compression desired

- Older/simpler formats are fixed quant

- The goal is to drive as many coef to 0 as possible. The threshold to be non-zero increases as you move to higher frequencies.

Quantization Example

3	5	7	9	11	13	15	17
5	7	9	11	13	15	17	19
7	9	11	13	15	17	19	21
9	11	13	15	17	19	21	23
11	13	15	17	19	21	23	25
13	15	17	19	21	23	25	27
15	17	19	21	23	25	27	29
17	19	21	23	25	27	29	31

↓

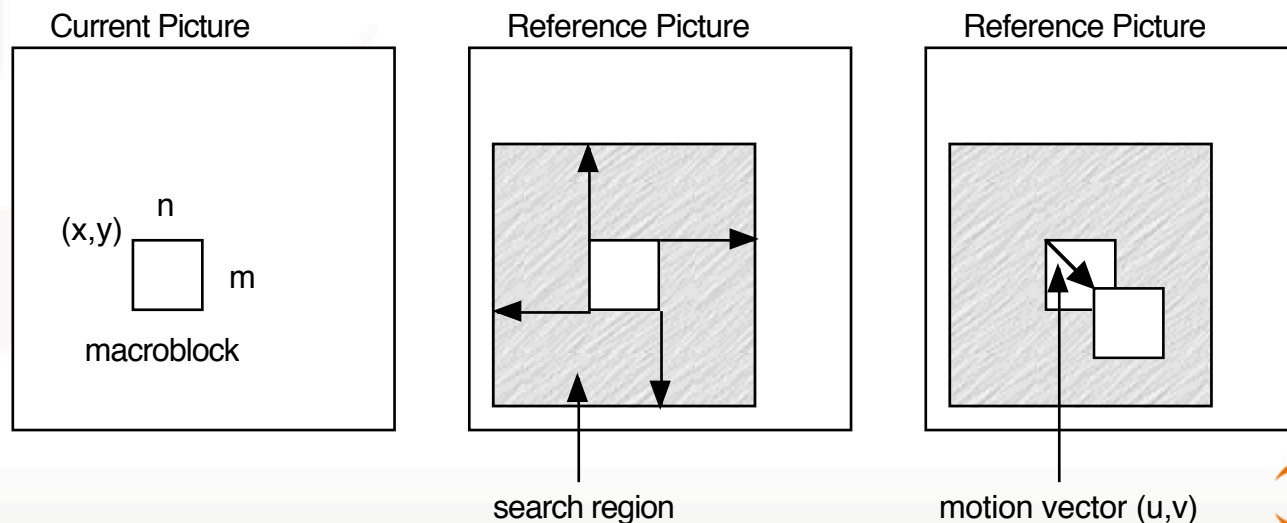| 186	-18	15	-9	23	0	0	0
21	-34	26	0	0	0	0	0
-10	-24	0	0	-18	0	-20	0
0	0	14	-15	0	0	0	0
0	0	0	0	0	0	0	0
0	0	-18	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

ZigZag, Run Amp Pairs, VLC

- Zig Zag order through the FDCT/Q output

- Generate run, amp pairs

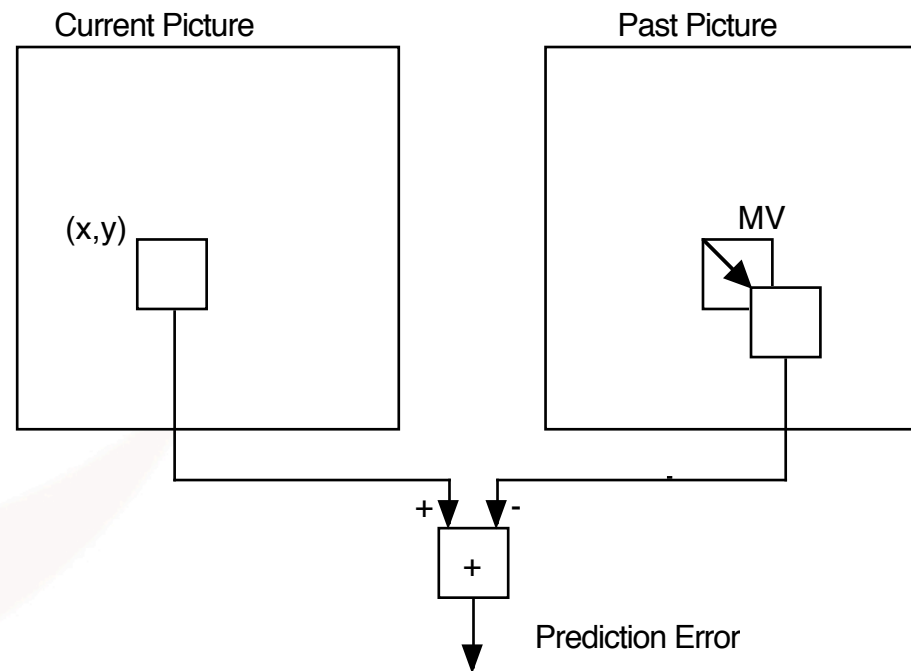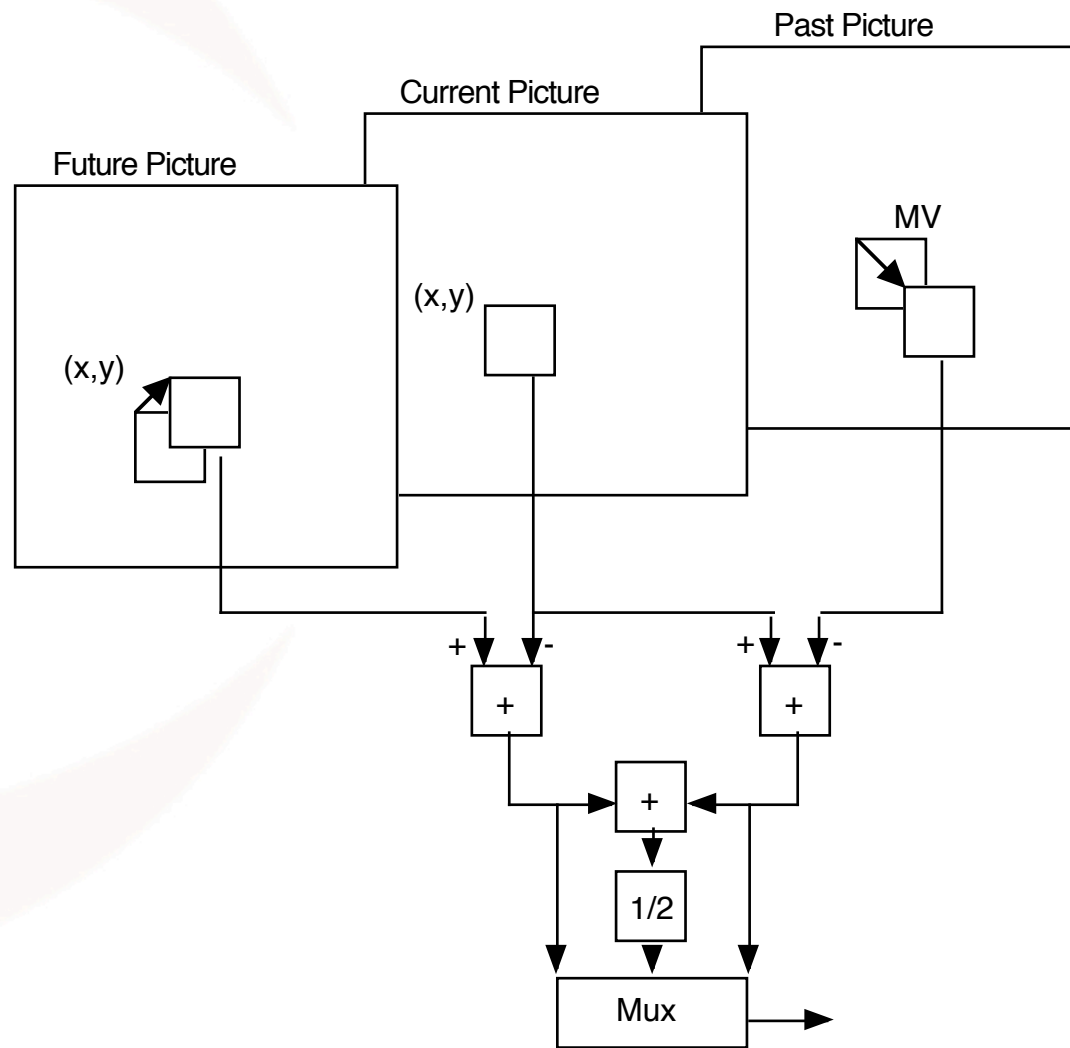- Code the pairs with common patterns that are encoded with fewer bits
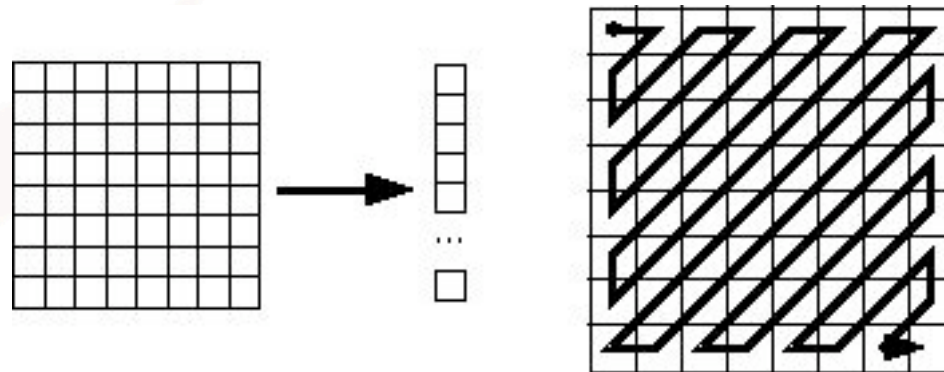
Motion Estimation

- ME is very expensive

- Very efficient in terms of bitstream size

  - I (156 kbits), P (62 kbits), B (16 kbits)

Current Picture

(x,y) n

m

macroblock

Reference Picture

Reference Picture

search region

motion vector (u,v)

ME - Forward (P)

ME - Bidirectional (B)

High Definition Video Communications
Just Got Better

LifeSize® Communications
The Global Leader in High Definition Video Communications

- LifeSize Pioneered HD Video Communications
  - HD is the game changer, the foundation for telepresence
  - Founded 2003 by industry veteran Craig Malloy, to deliver on the promise of video communications

- Global presence and distribution
  - Headquartered Austin, TX with 13 offices worldwide
  - Extensive partner network with products sold in over 80 countries
  - Key strategic partners including CSC, Dell, Hitachi, Siemens and TechData

- Fastest growing in the industry
  - Revenue growth 150%+ annually
  - Thousands of customers
  - Growing at 5x market

LifeSize Product Line Q4 2008
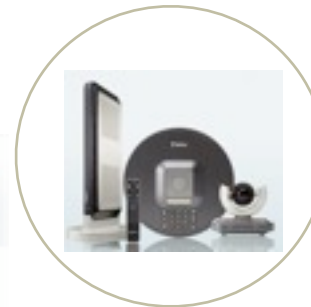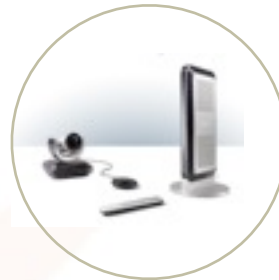## High Definition Video Communications and Telepresence

Conference line

New

Room line

New

Team line

New

LifeSize® Express™
$4,999

LifeSize® Team MP™
$8,999

LifeSize® Team 200™
$10,999

LifeSize® Room™
$12,999

LifeSize® Room200™
$16,999

LifeSize® Conference Room™
$39,999

LifeSize® Conference 200™
$49,999

*MSRP prices in USD

Page

LifeSize®

Introducing
LifeSize Room 200
The world's first Full HD Video Communications System

- New codec, new camera architecture delivers Full HD
  - ➔ Highest available resolution 1080p30
  - ➔ Best motion handling and ½ the latency with 720p60

- Full-motion video and content with 720p30 dual streams

- High Definition now under 1Mbps
  - ➔ 768kbps 720p30   1.1Mbps 720p60   1.7Mbps 1080p30

- Intelligent features, compact design
  - ➔ 6-way Continuous Presence (4 visible sites) MCU with transcoding
  - ➔ All digital I/O – faster throughput, clearer signal
  - ➔ Compact, sleek unit – less than half the size of comparable solutions

Lifesize Bitstream

- 1280x720

- 30 fps

- 1 mbps

What Did I Forget?

- Audio - Wideband Audio Codecs

- Comm - H.323, SIP, H.460

- Data - H.239, BFCP

- Challenges - Latency, Errors, AV Sync, ...

- Book a Demo

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Q & A

- ... and Show and Tell

- Contact Me:

  - <u>cking@lifesize.com</u>

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