Enhanced Telepresence and Green IT—The Next Evolution in the Internet

Distinguished Research Lecture

Cisco Research Center

San Jose, CA

September 24, 2009

Dr. Larry Smarr

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Harry E. Gruber Professor,

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Jacobs School of Engineering, UCSD

Twitter: lsmarr

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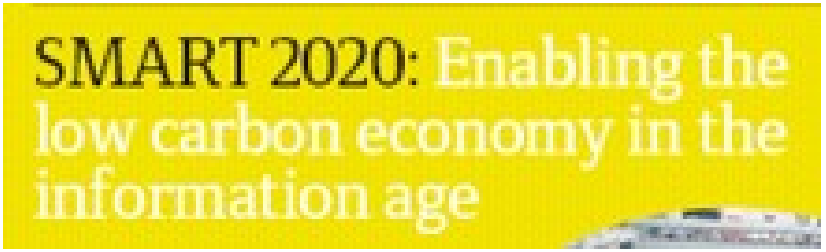
it²

The global Information and Communication Technology (ICT) industry produces GHGs equivalent to that produced by the aviation industry (~2-3 %). Furthermore, the ICT sector's emissions will nearly triple, in a business as usual scenario, from 2002 to 2020. On the other hand, the Climate Group estimates that transformative application of ICT to electricity grids, logistic chains, intelligent transportation and building infrastructure, and other social systems can reduce global GHG emissions by ~15%, five times ICT's own footprint! I will discuss three campus testbeds for exploring these complex tradeoffs. The first testbed is the NSF-funded GreenLight Project deployed at UCSD, which creates an instrumented data center allowing for detailed real time data measurements of the critical subcomponents and then making that data publically available on the web, so that the results can guide users who wish to lower the energy cost of computation and storage. The second testbed is the use of dedicated optical networks (operating at 10,000 Mbps) coupled to large tiled walls (with fractions of a billion pixels) and high definition (2 Mpixel/frame) or digital cinema (8Mpixel/frame) as "telepresence" systems for "sewing remote rooms together" as a way to reduce the need for transportation for national or global collaboration. Finally, I will analyze the use of campuses themselves, which are functionally small towns with their own power grids, commuter transportation systems, hospitals, and populations in the tens of thousands and so are at-scale Green IT Living Laboratories of the Greener Future.

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ICT Could be a Key Factor in Reducing the Rate of Climate Change

Applications of ICT
could enable emissions reductions
of 15% of business-as-usual emissions.
But it must keep its own growing footprint in check
and overcome a number of hurdles
if it expects to deliver on this potential.





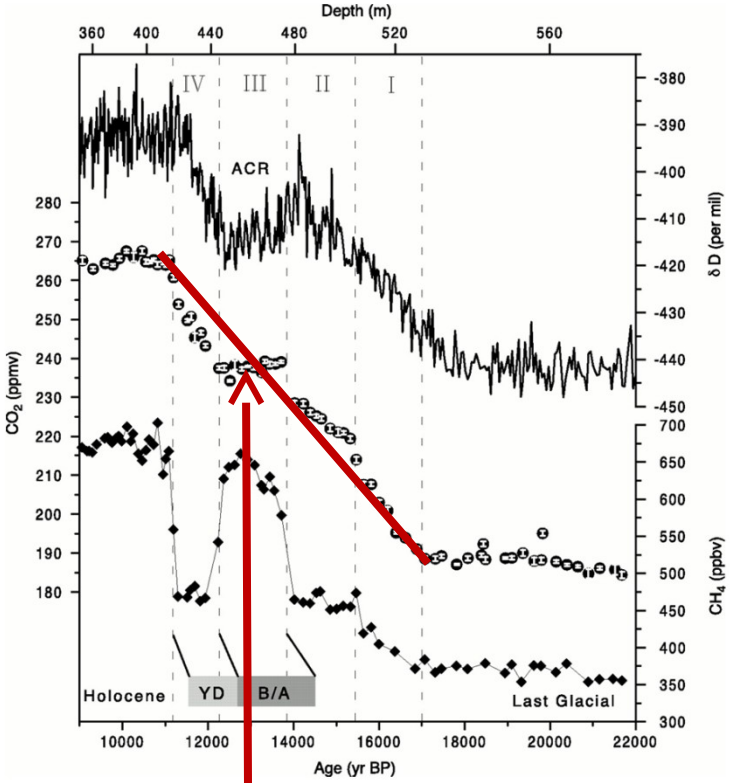
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www.smart2020.org

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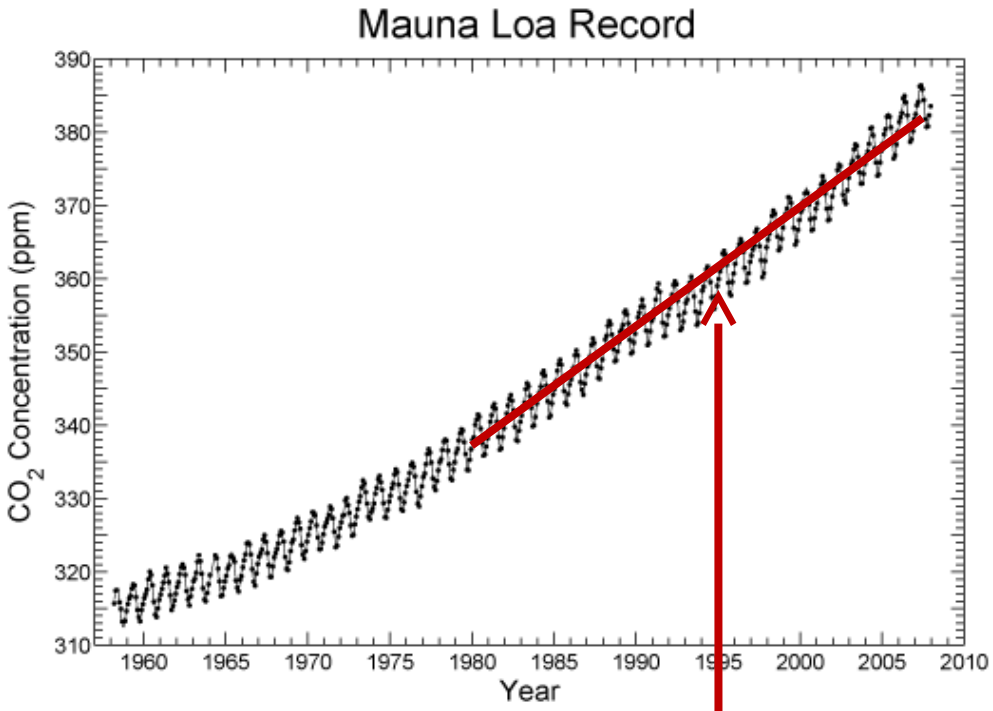
The Earth is Warming Over 100 Times Faster Today Than During the Last Ice Age Warming!

Monnin, et al., Science v. 291 pp. 112-114, Jan. 5, 2001.



CO_2 Rose From
185 to 265ppm (80ppm)
in 6000 years or
1.33 ppm per Century

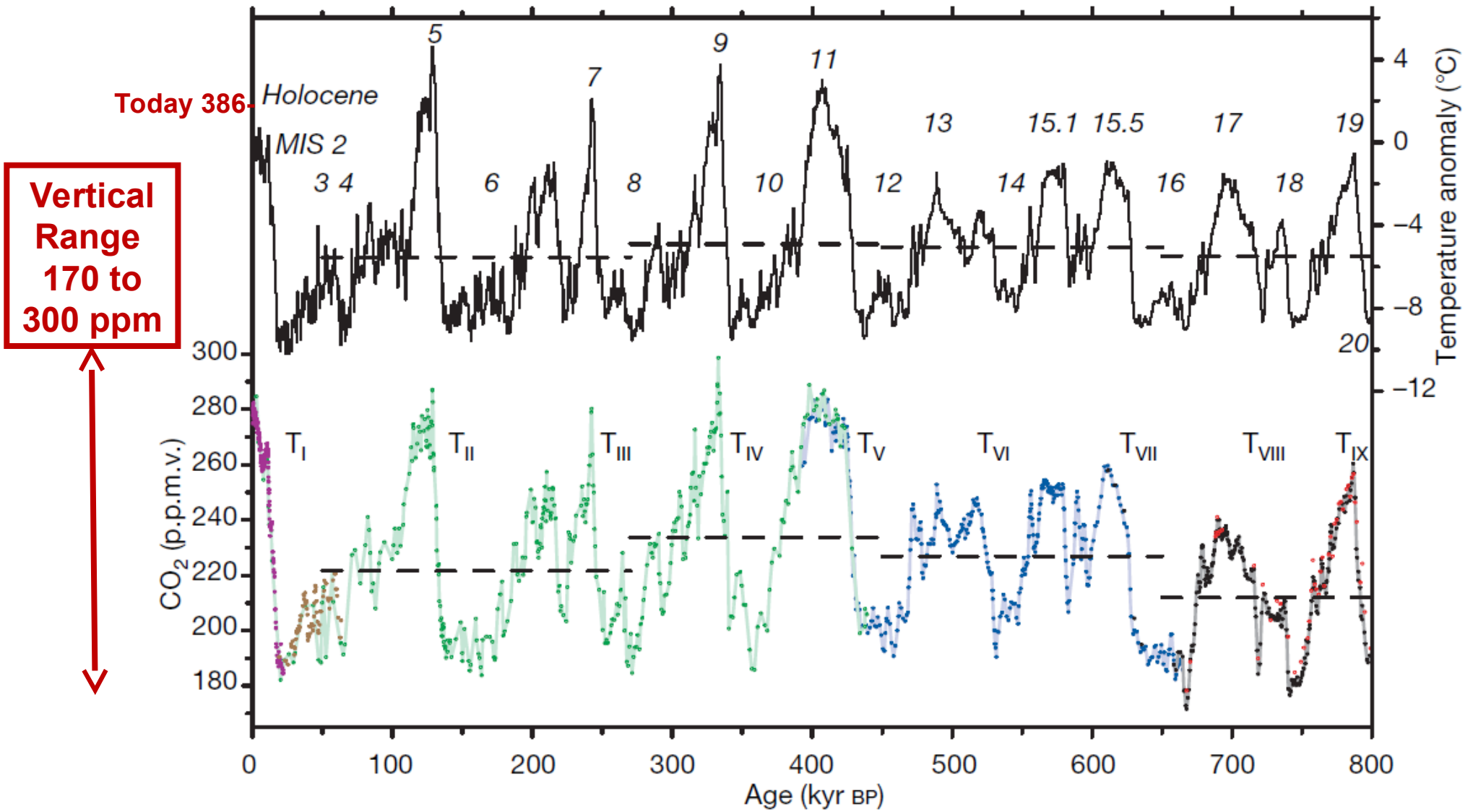
http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons.html



CO_2 Has Risen From
335 to 385ppm (50ppm)
in 30 years or
1.6 ppm per Year

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Antarctic Ice Cores Show CO_2 and Temperature Have Oscillated For 800,000 Years in a Narrow Range



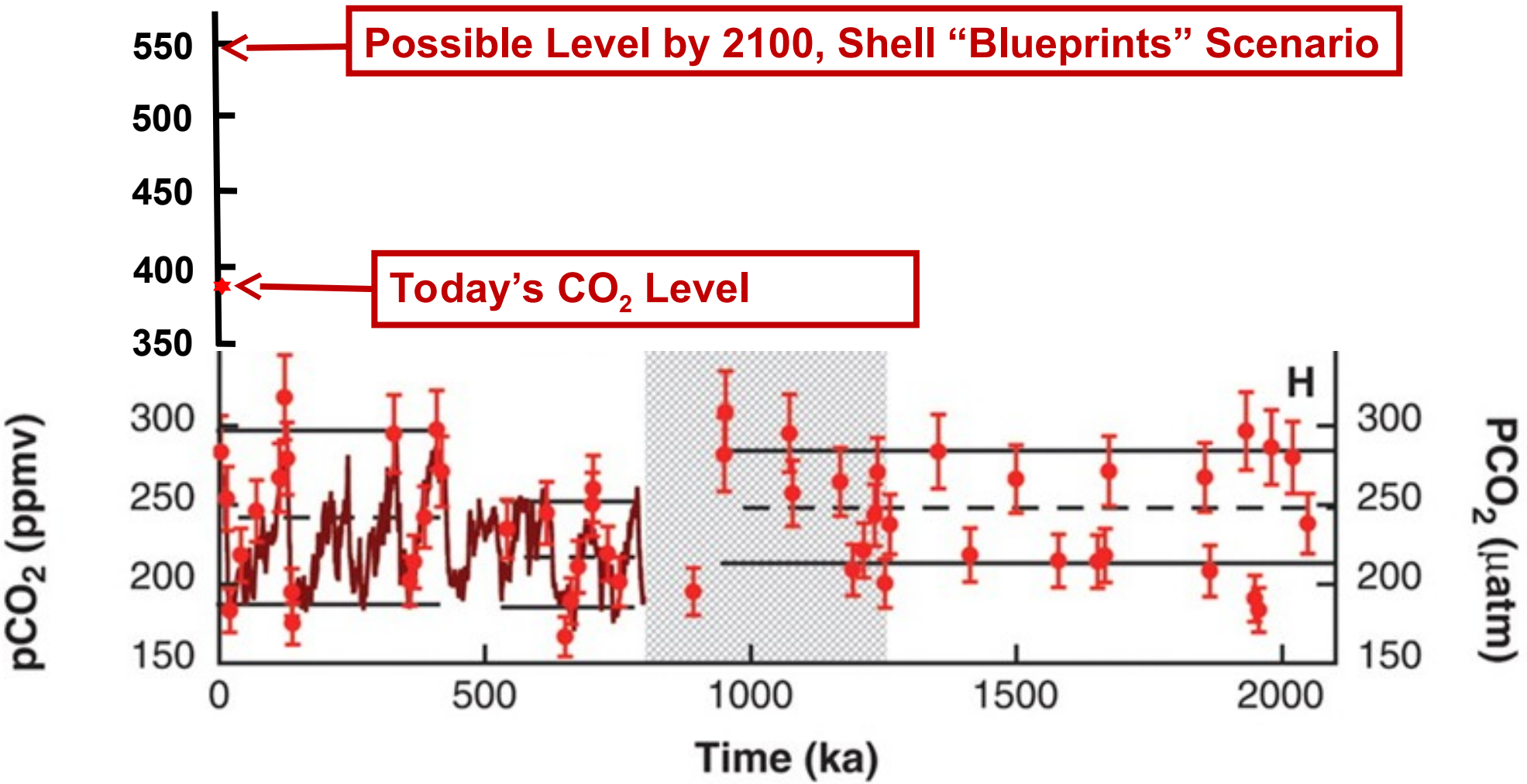
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Ice Cores: Luthi, et al. Nature may 15, 2008 v. 453 pp379-82

Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

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Ice Core Record Has Been Extended Using Plankton: Today's CO_2 is Higher Than in Last 2 Million Years!



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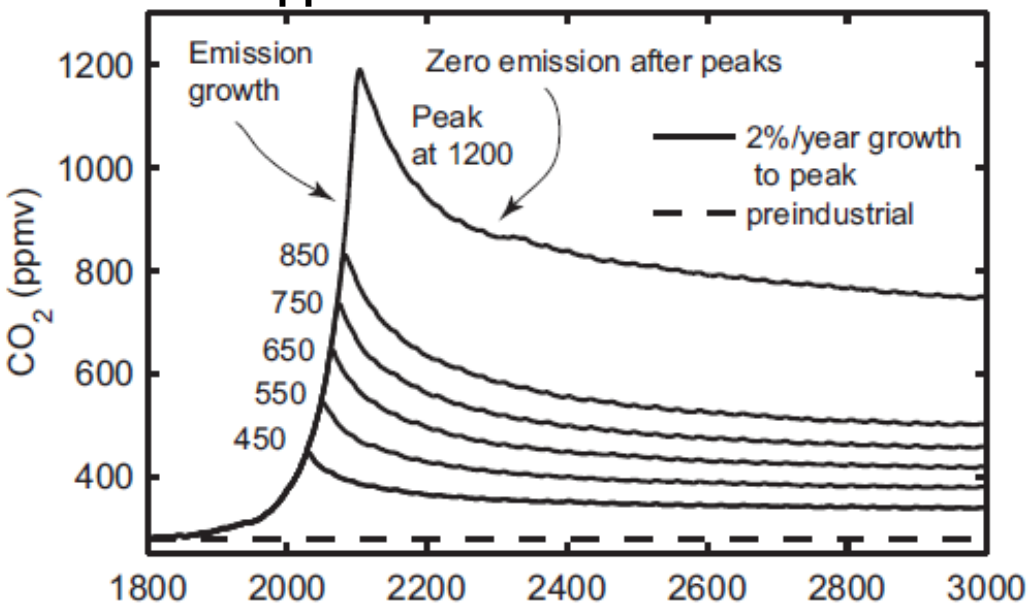
CO2: Hönisch, et al. Science 19 June 2009 Vol. 324. pp. 1551 - 1554

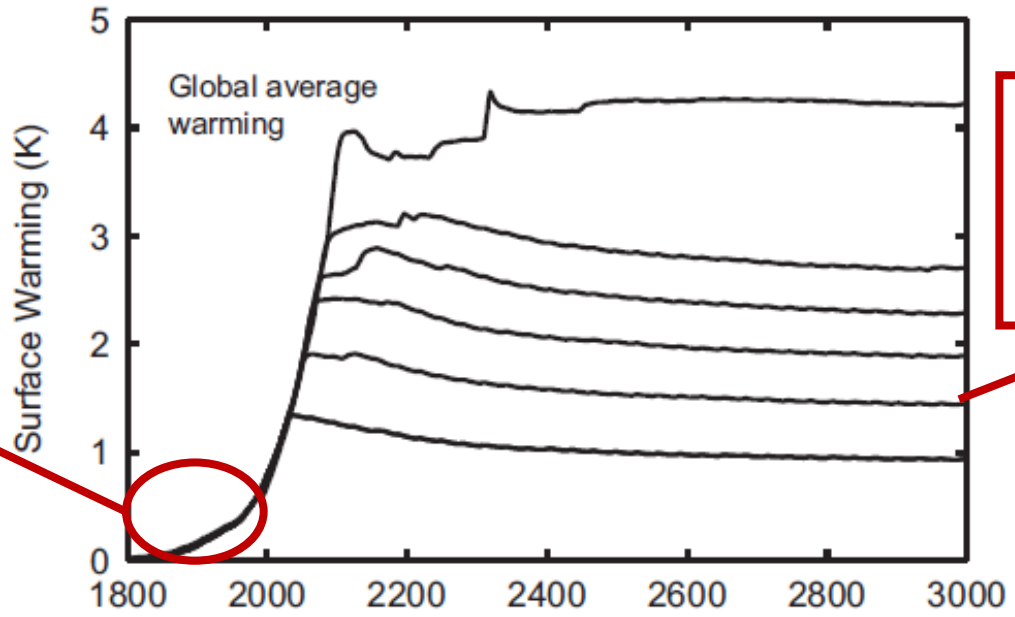
Homonid Images: *The Last Human*, G.J. Sawyer and V. Deak

We Are Transitioning to a New Climate State -- Unlike the Rapid Recovery with Acid Rain or Ozone Hole

Susan Solomon, et al., PNAS 2/10/2009 v. 106 pp1704-9

Assumes CO_2 Increases to a Maximum and Then Emissions Abruptly Stop





Warming During the Industrial Age -- Last 200 Years

Warming Persists for Over 1000 Years

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The IPCC Recommends a 25-40% Reduction Below 1990 Levels by 2020

- **On September 27, 2006, Governor Schwarzenegger signed California *the Global Warming Solutions Act* of 2006**
  - **Assembly Bill 32 (AB32)**
  - **Requires Reduction of GHG by 2020 Only to 1990 Levels**
    - **10% Reduction from 2008 Levels; 30% from BAU 2020 Levels**
    - **4 Tons of CO_2-equiv. Reduction for Every Person in California!**

- **The European Union Requires Reduction of GHG by 2020 to 20% Below 1990 Levels (12/12/2008)**

- **Neither the U.S. or Canada has an Official Target Yet**
  - **President Obama Has Endorsed the AB32 2020 Goal**

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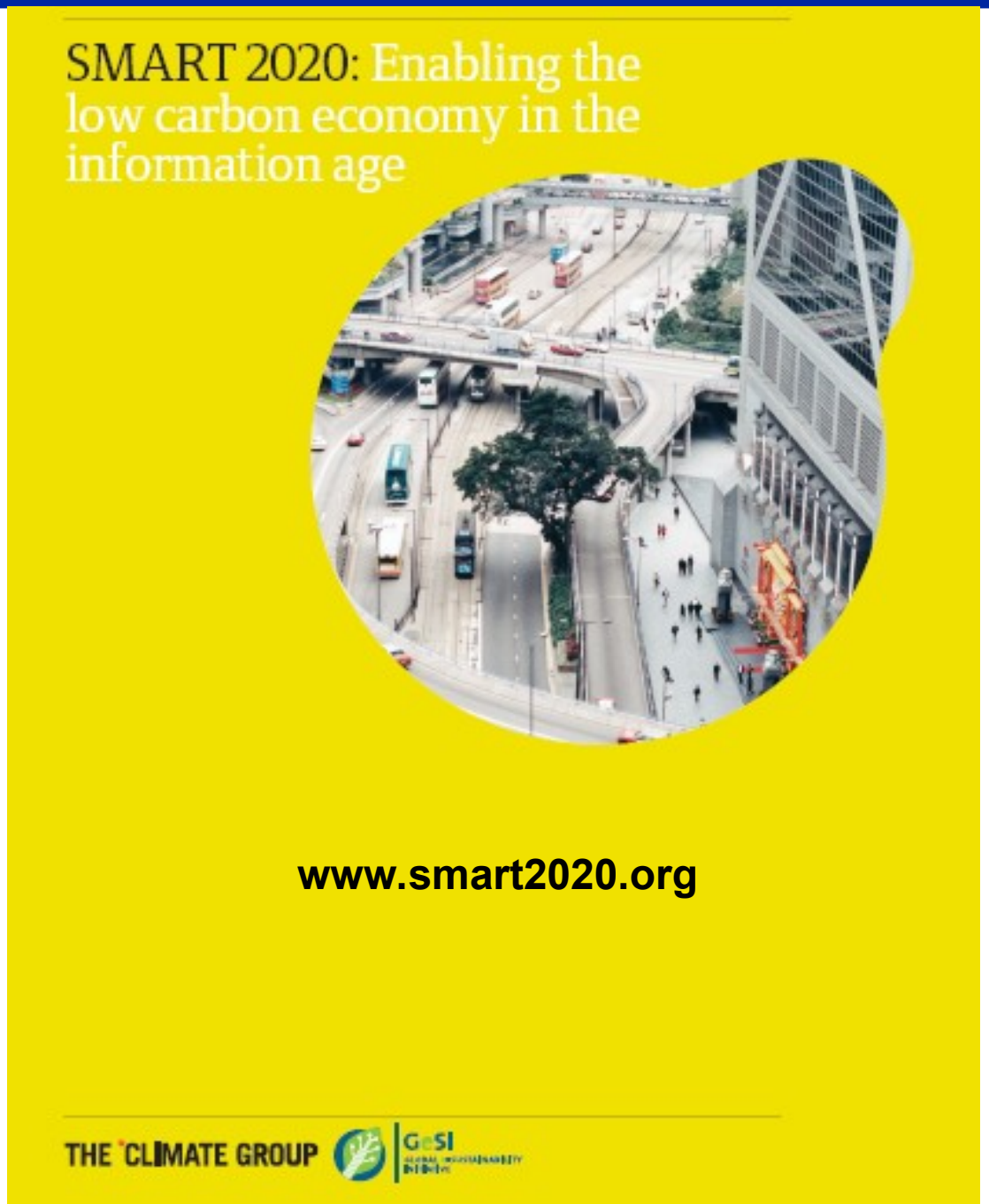
ICT is a Critical Element in Achieving Countries Greenhouse Gas Emission Reduction Targets

GeSI member companies:

- **Bell Canada,**
- **British Telecomm.,**
- **Plc,**
- **Cisco Systems,**
- **Deutsche Telekom AG,**
- **Ericsson,**
- **France Telecom,**
- **Hewlett-Packard,**
- **Intel,**
- **Microsoft,**
- **Nokia,**
- **Nokia Siemens Networks,**
- **Sun Microsystems,**
- **T-Mobile,**
- **Telefónica S.A.,**
- **Telenor,**
- **Verizon,**
- **Vodafone Plc.**

Additional support:

- **Dell, LG.**



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Application of ICT Can Lead to a 5-Fold Greater Decrease in GHGs Than its Own Carbon Footprint

While the sector plans to significantly step up the energy efficiency of its products and services, ICT's largest influence will be by enabling energy efficiencies in other sectors, an opportunity that could deliver carbon savings five times larger than the total emissions from the entire ICT sector in 2020.

--Smart 2020 Report

Major Opportunities for the United States*

- Smart Electrical Grids
- Smart Transportation Systems
- Smart Buildings
- Virtual Meetings

* Smart 2020 United States Report Addendum

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Developing Greener Smart Campuses as Societal Prototypes: Calit2 (UCSD & UCI)

- **Travel Substitution**
  - Commercial Teleconferencing
    - Polycom PC Client
    - LifeSize HD
    - Cisco Telepresence
  - Next Generation Global Telepresence
- **Coupling the Internet and the Electrical Grid**
  - Choosing non-GHG Emitting Electricity Sources
  - Measuring Demand at Sub-Building Levels
  - Reducing Local Energy Usage via User Access Thru Web

Student Video -- UCSD Living Laboratory for Real-World Solutions
www.gogreentube.com/watch.php?v=NDc4OTQ1 on UCSD

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UCI Named 'Best Overall' in Flex Your Power Awards
www.today.uci.edu/news/release_detail.asp?key=1859

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Cisco on Cisco TelePresence Deployment

Changing the Way We Work, Live, Play and Learn

- **533** Cisco TelePresence major cities globally
- US/Canada: **108** CTS 3000, **109** CTS 1000, **6** CTS 3200, 90 CTS 500, 3 CTS1300
- APAC: **29** CTS 3000, **34** CTS 1000, 14 CTS 500, 3 CTS 3200, 1 CTS1300
- Japan: **7** CTS 3000, **2** CTS 1000, 1 CTS 500, 1 CTS 3200, 1 CTS1300
- Europe: **31** CTS 3000, **35** CTS 1000, 5 CTS3200, 27CTS500, 2 CTS1300
- Emerging: **14** CTS 3000, 3 CTS1000, 1 CTS3200, 7 CTS 500

163 Major Cities in 45 countries

- **355K** TelePresence meetings scheduled to date. (**Weekly** average utilization in the past 30 days is **21,522** meetings)
- **473K** hours (average meeting is 1.25 hrs)
- **27K+** meetings with customers to discuss Cisco Technology over TelePresence

- **68K+** meetings avoided travel
- Conservative estimate of cost savings and productivity improvement
  - **~$296M to date**
- Metric tons of emissions saved:: **149,018**
- Equal to **>25,000+ cars** off the road

Calit2 Will Have CTS 1000s at UCSD and UCI

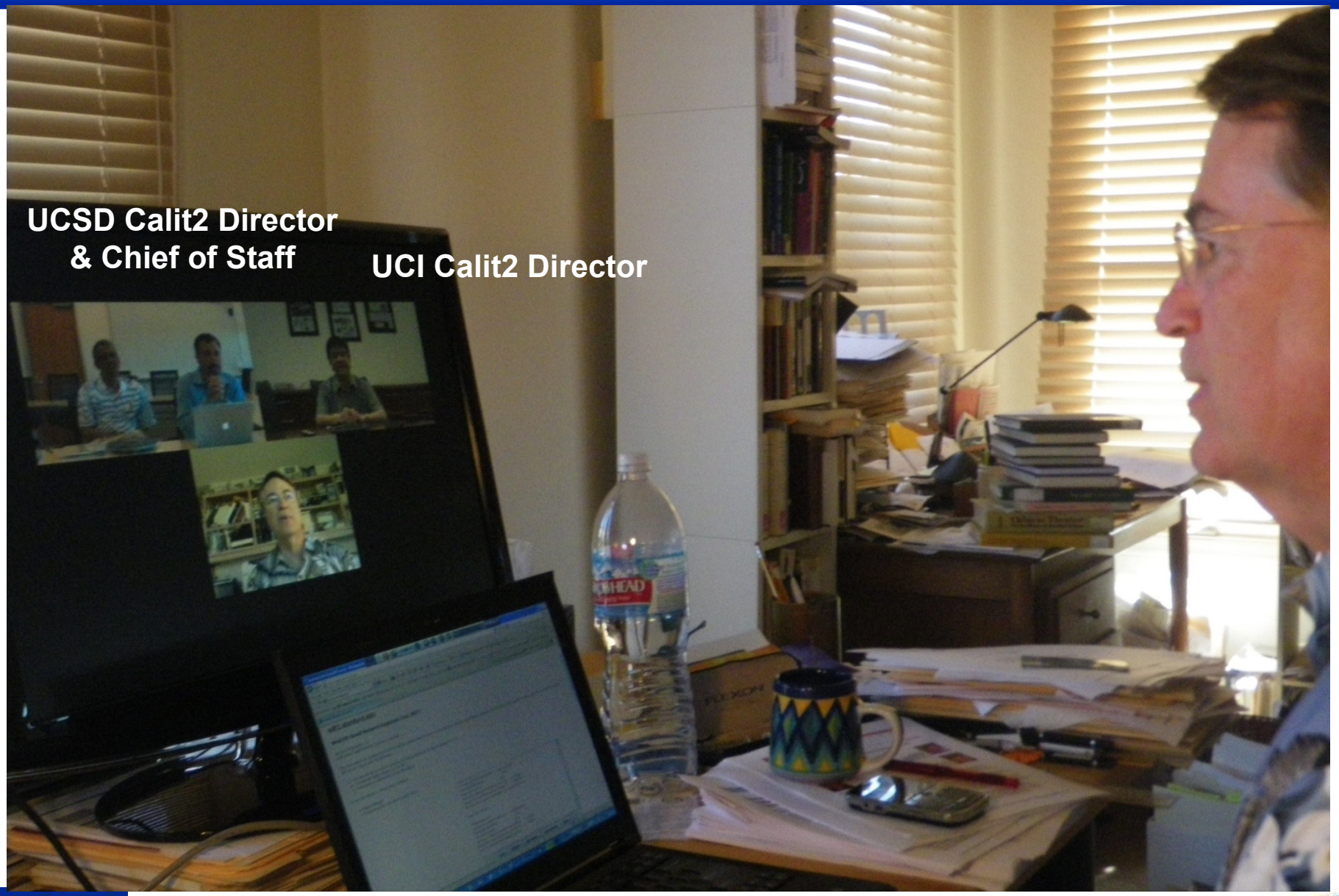


- **Overall average utilization 49%**

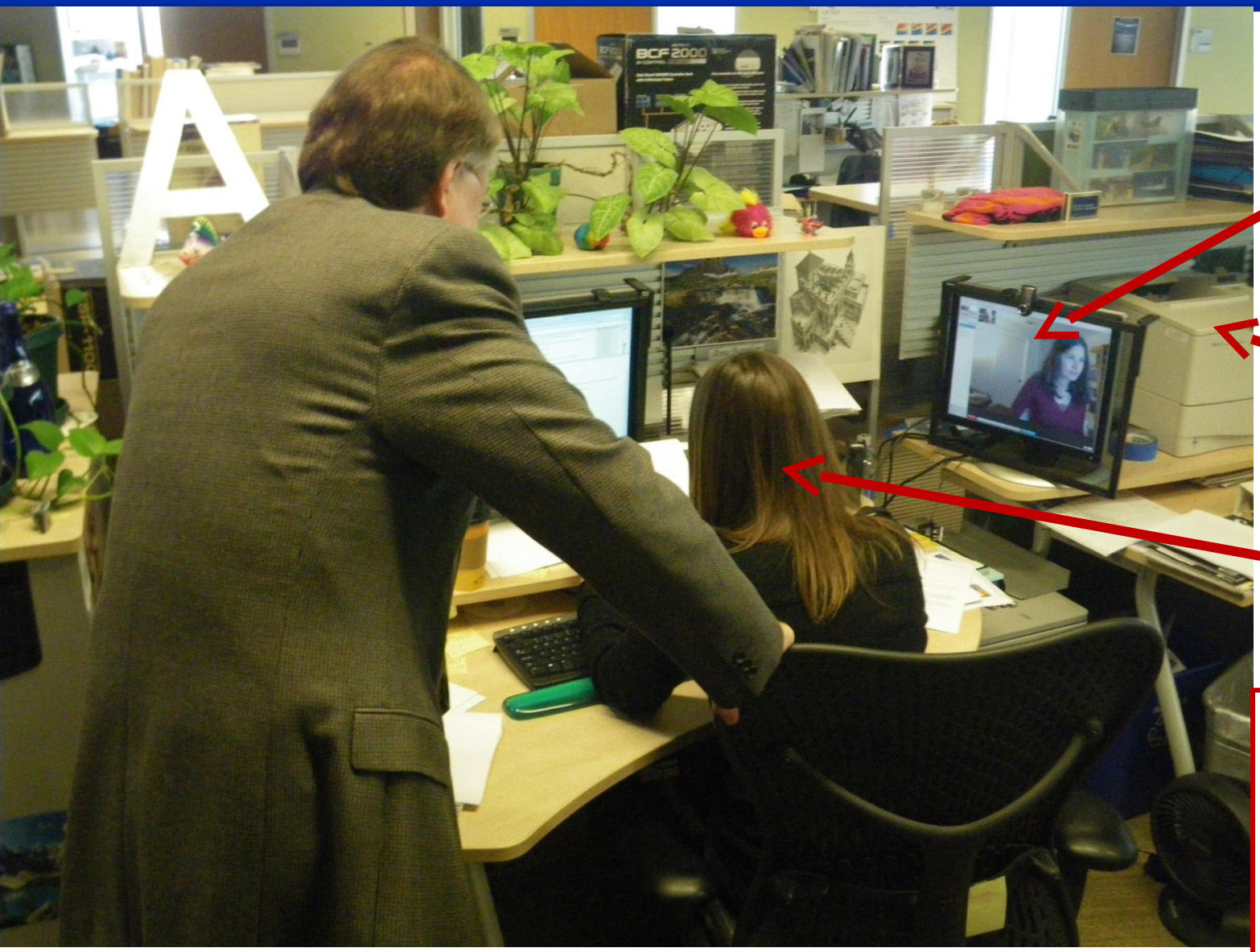
- **30K Multipoint mtgs**
- **Average 3,919 in past 30 days**

Updated Aug 2,2009….145 weeks after launch

I Link Into Commercial H.323 Videoconfernces From My Laptop at Home



Work at Home is the Same As at the Office



We Run Video Sykpe Continuously During Office Hours

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Linking the Calit2 Auditoriums at UCSD and UCI with LifeSize HD for Shared Seminars

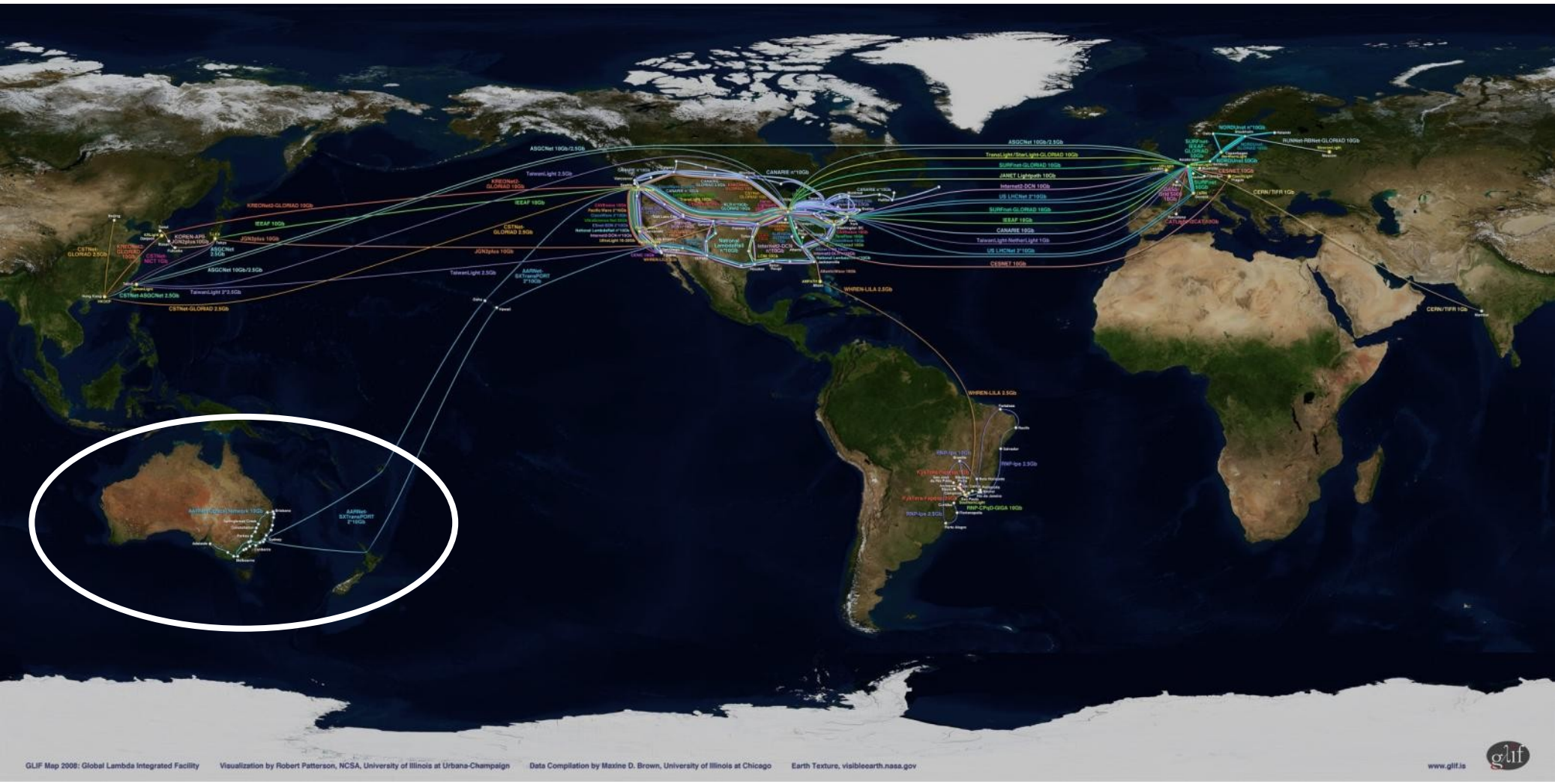


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Photo by Erik Jepsen, UC San Diego

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Global Innovation Centers are Being Connected with 10,000 Megabits/sec Clear Channel Lightpaths



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Research on 100 Gbps and 1 Tbps

Source: Maxine Brown, UIC and Robert Patterson, NCSA

Launch of the 100 Megapixel OzIPortal Kicked Off a Rapid Build Out of Australian OptIPortals



No Calit2 Person Physically Flew to Australia to Bring This Up!

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Covise, Phil Weber, Jurgen Schulze, Calit2
CGLX, Kai-Uwe Doerr , Calit2
http://www.calit2.net/newsroom/release.php?id=1421

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Victoria Premier, Senator Conroy, and Australian Deputy Prime Minister Asking Questions



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Using Qvidium Compressed HD ~ 140 Mbps

www.calit2.net/newsroom/release.php?id=1219

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University of Melbourne Vice Chancellor Glyn Davis in Calit2 Replies to Question from Australia



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HD Talk to Australia's Monash University from Calit2: Reducing International Travel



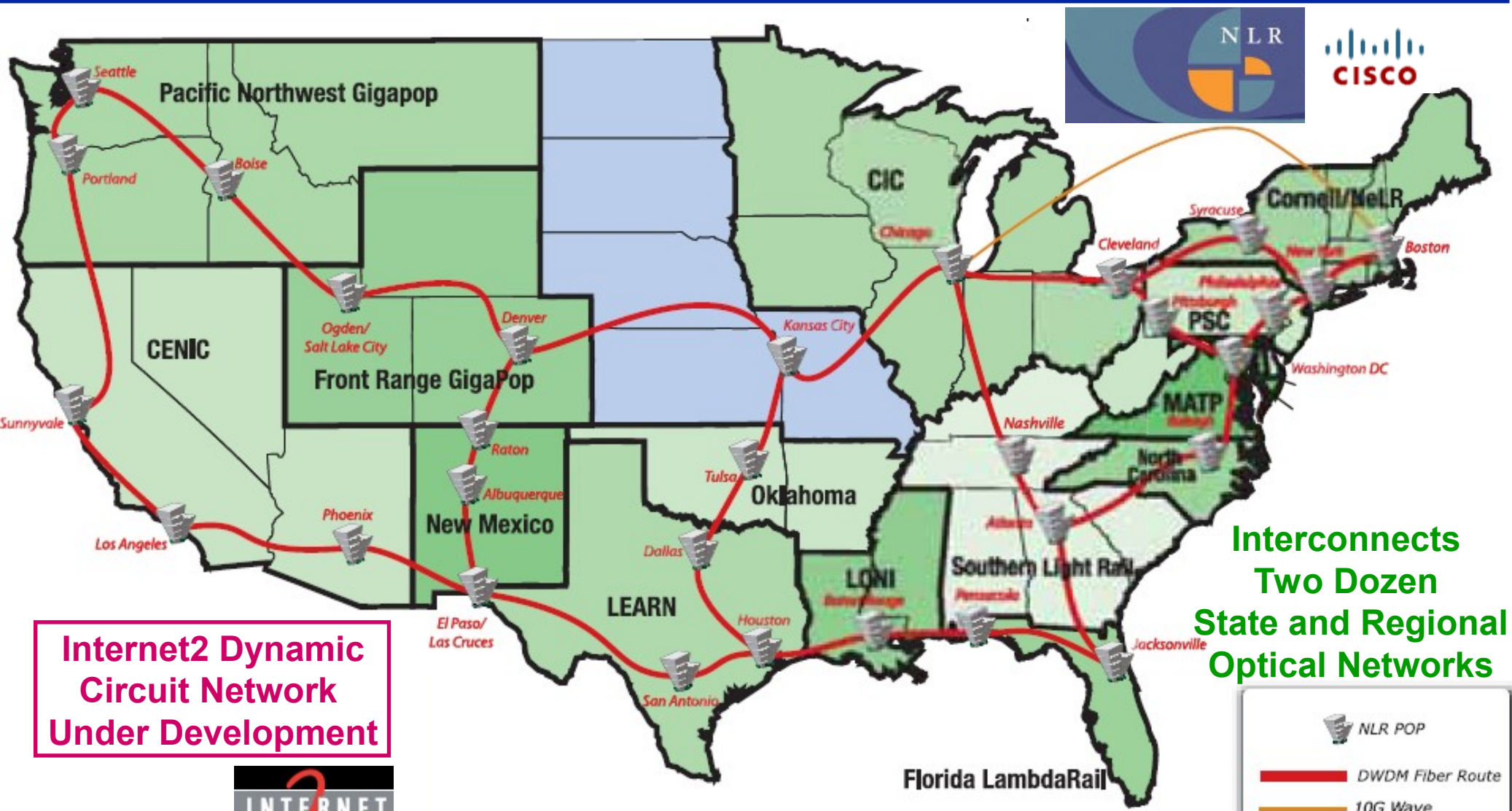
Qvidium Compressed HD ~140 mbps

Source: David Abramson, Monash Univ

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Today Dedicated 10Gbps Lightpaths Tie Together State and Regional Fiber Infrastructure



OptIPlanet Collaboratory Persistent Infrastructure Between Calit2 and U Washington



OptIPuter

Ginger Armbrust's Diatoms: Micrographs, Chromosomes, Genetic Assembly

ROCKS

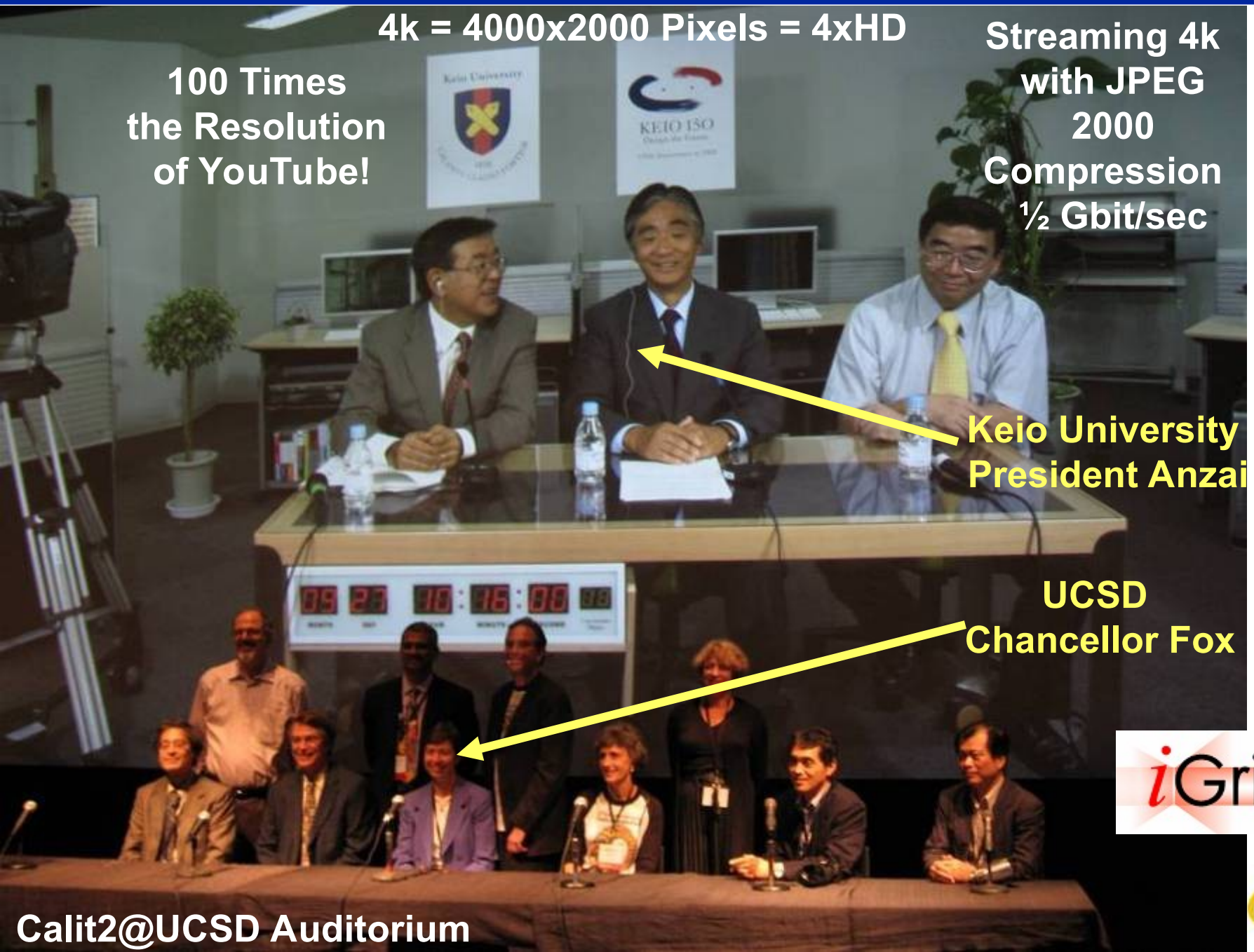




iHDTV: 1500 Mbits/sec Calit2 to UW Research Channel Over 10,000 Mbps Pacific Wave/CENIC Dedicated Optical Fiber

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Advanced Telepresence Meeting Using Digital Cinema 4k Streams



CineGrid

Lays Technical Basis for Global Digital Cinema

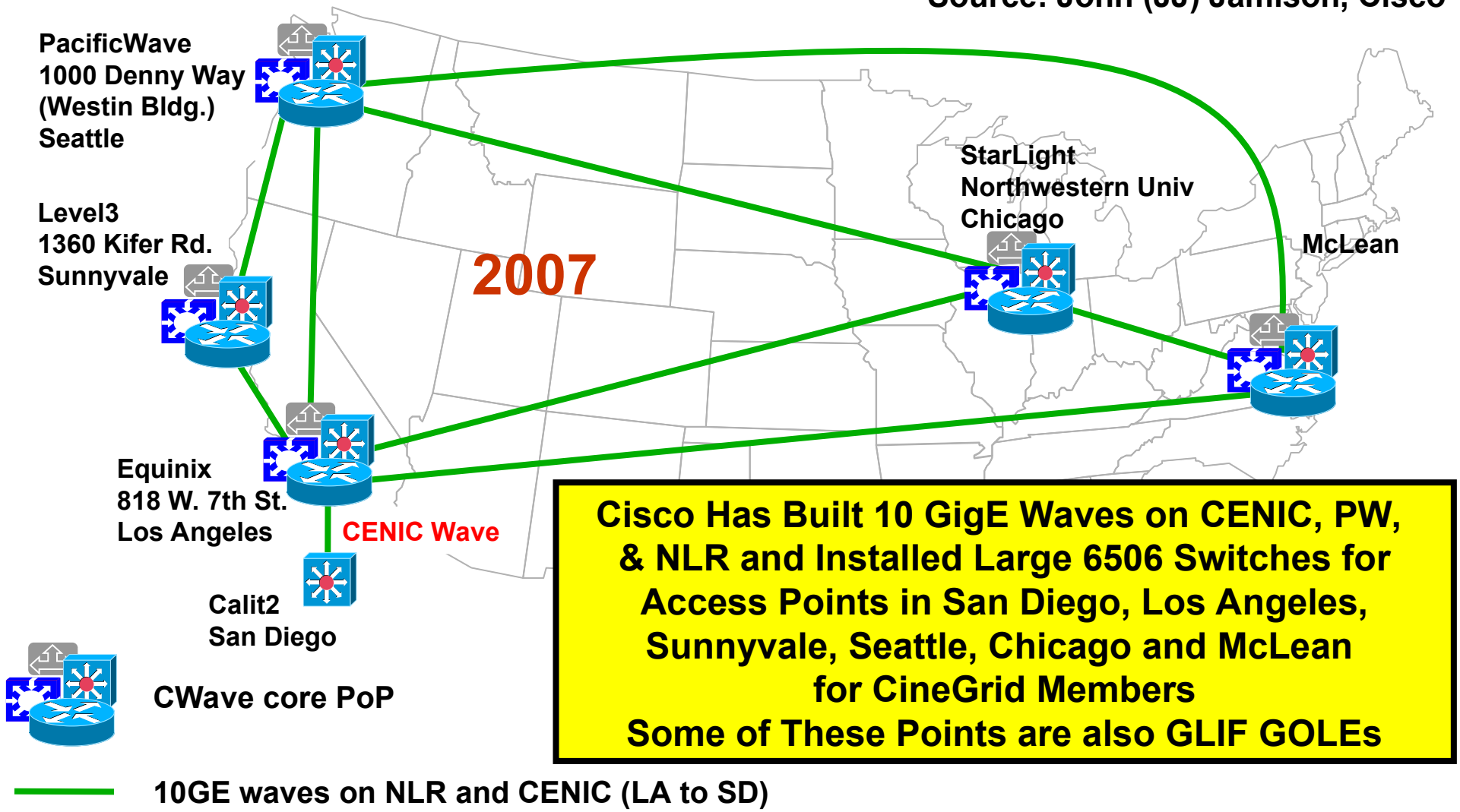
Sony
NTT
SGI

iGrid 2005

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Cisco CWave for CineGrid: A New Cyberinfrastructure for High Resolution Media Streaming*

Source: John (JJ) Jamison, Cisco



Cisco Has Built 10 GigE Waves on CENIC, PW, & NLR and Installed Large 6506 Switches for Access Points in San Diego, Los Angeles, Sunnyvale, Seattle, Chicago and McLean for CineGrid Members Some of These Points are also GLIF GOLEs

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CineGrid @ Holland Festival 2007
As Seen in the Calit2@UCSD Auditorium Live!



Era la Notte, June 2007

First Tri-Continental Premier of a Streamed 4K Feature Film With Global HD Discussion



CRCA

CISCO
C-wave
CineGrid

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4K Transmission Over 10Gbps--
4 HD Projections from One 4K Projector

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Toward a Data and Visualization Intensive Working Environment Across Remote Sites



UCSD cluster: 15 x Quad core Dell XPS with Dual nVIDIA 5600s
UCI cluster: 25 x Dual Core Apple G5

Building a Mixed Virtual/Physical Working Space: NASA Ames Adopts OptIPuter Collaboratory



From Start to This Image in Less Than 2 Weeks!

View from NASA Ames Lunar Science Institute Mountain View, CA

Virtual Handshake

LifeSize High Defn. Video Integrated With OptIPortal and Spatialized Audio

NASA Interest in Supporting Virtual Institutes

NASA Astrobiology Institute Is Next

CGLX
CROSS-PLATFORM CLUSTER GRAPHICS LIBRARY

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Source: Falko Kuester, Calit2; Michael Sims, NASA

Multi-User Global Workspace: San Diego, Chicago, Saudi Arabia

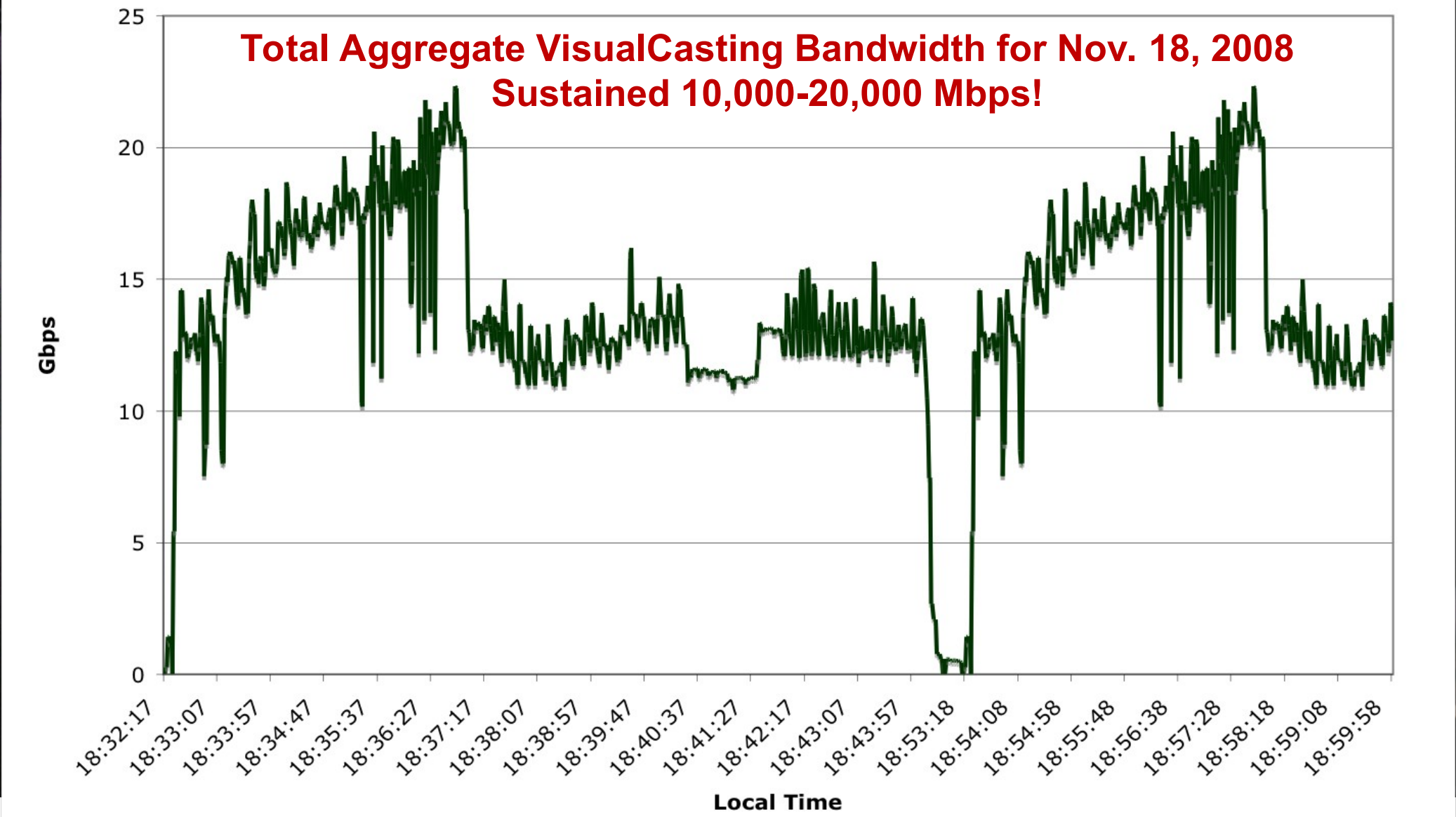


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Source: Tom DeFanti, KAUST Project, Calit2

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EVL's SAGE OptIPortal VisualCasting Multi-Site OptIPuter Collaboratory



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Source: Jason Leigh, Luc Renambot, EVL, UI Chicago

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Academic Research "OptIPlatform" Cyberinfrastructure: A 10Gbps Lightpath Cloud



End User OptIPortal



Instruments

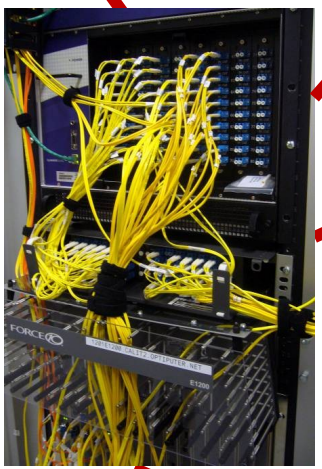


HD/4k Telepresence

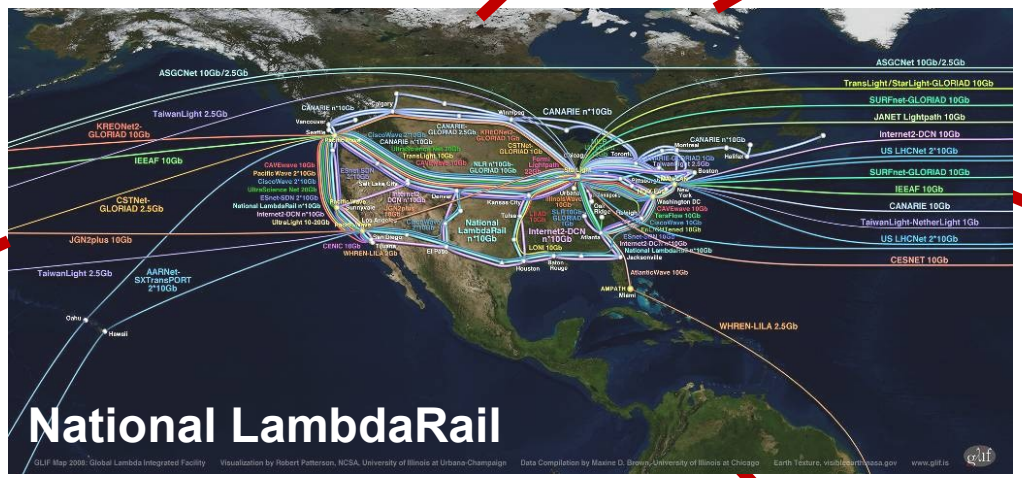


HD/4k Video Cams

HPC



10G Lightpaths



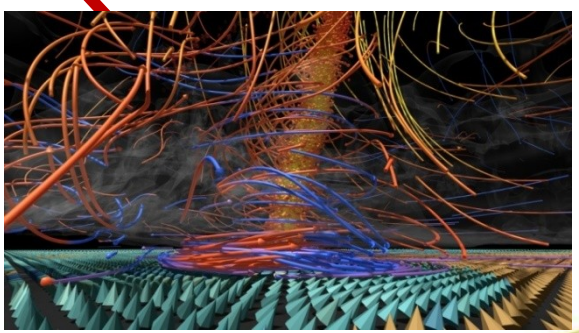
National LambdaRail

TeraGrid™

Campus Optical Switch



Data Repositories & Clusters



HD/4k Video Images

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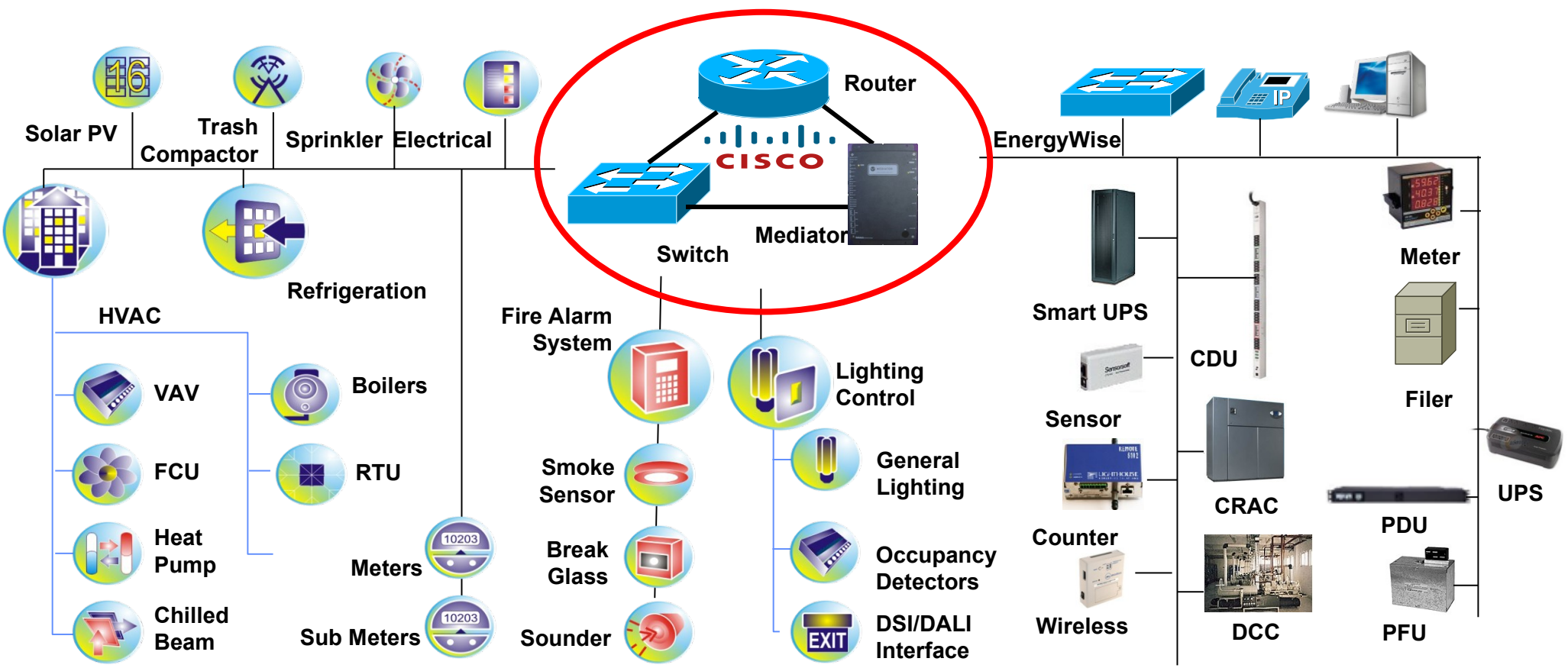
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Cisco Vision: Mediating the Smart Building

Energy Dashboards, Demand Response, Fault Detection, Event Reporting, SmartGrid, etc.

Open XML Interface

Network as a Platform to Connect, Aggregate and Normalize



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Source: Dave Clute, Cisco Connected Real Estate

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Real-Time Monitoring of Building Energy Usage: UCSD Has 34 Buildings On-Line



Import/Production
Meter Reads
Vista

UCSD MAP | HOUSING

Real Time Cost Per Hour $ 2,570
Real Time kW Usage 30,238 kW

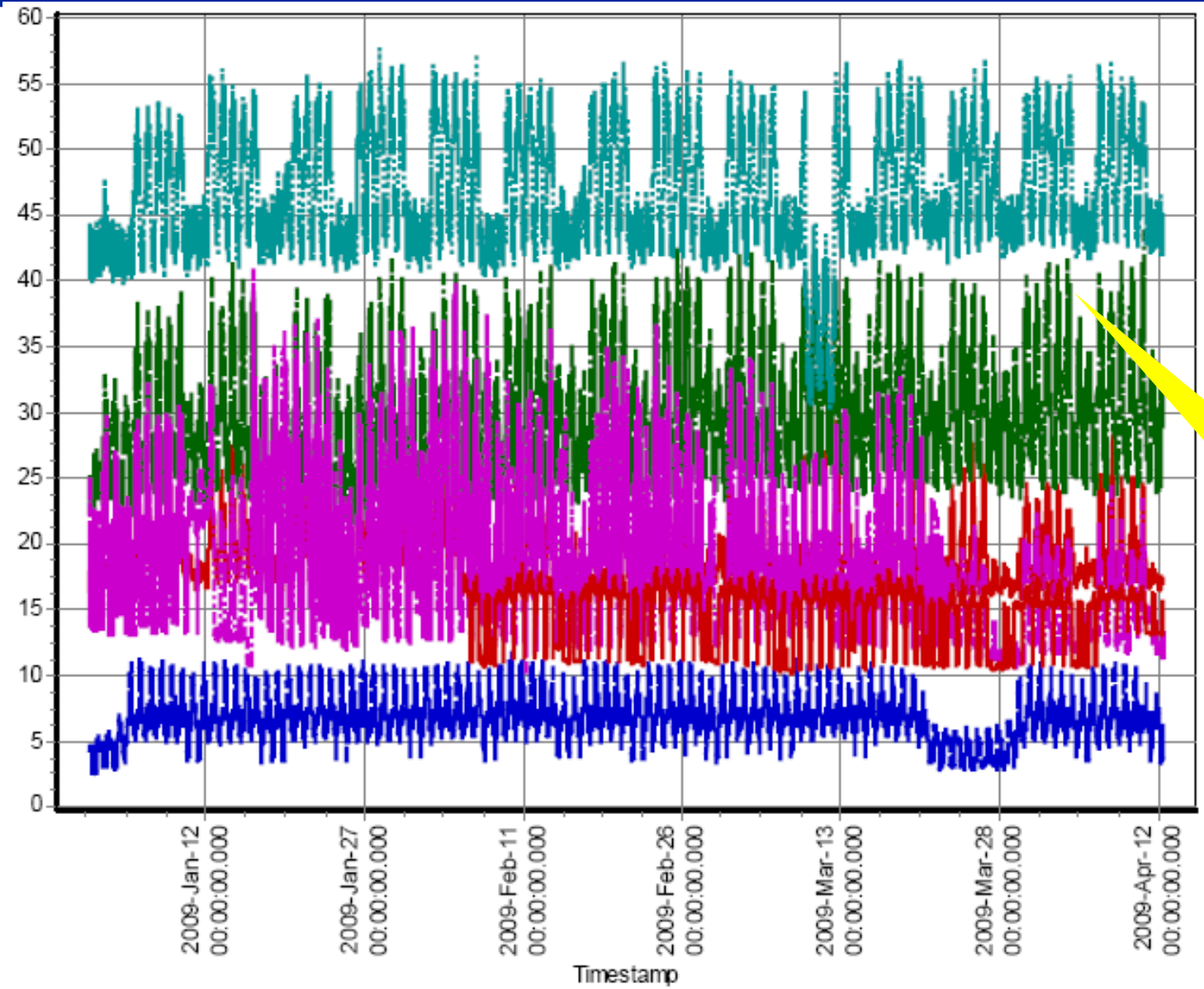
	SIO	UCSD Medical Center La Jolla	Warren Campus University Center	East Campus	Muir Campus
Current Month:					
Monthly Cost ($)	66,121	64,277	138,097	18,564	67,143
kWh del	777,893 kWh	756,204 kWh	1,624,674 kWh	218,400 kWh	789,923 kWh
Previous Month:					
Monthly Cost ($)	149,881	148,692	320,149	42,478	157,613
kWh del	1,763,309 kWh	1,749,312 kWh	3,766,459 kWh	499,744 kWh	1,854,266 kWh
Realtime Values:					
kW inst	2,546 kW	2,665 kW	5,475 kW	638 kW	2,404 kW

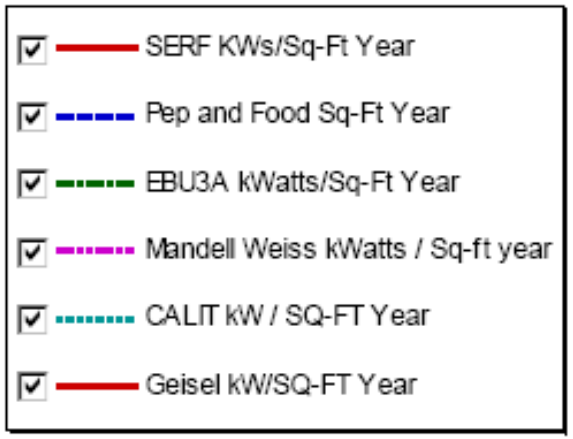
	SOM	North Campus	Revelle Campus	Central Plant	UCSD Total
Current Month:					
Monthly Cost ($)	19,075	30,163	236,794	93,913	734,148
kWh del	224,414 kWh	354,860 kWh	2,785,807 kWh	1,104,854 kWh	8,637,030 kWh
Previous Month:					
Monthly Cost ($)	45,133	67,085	557,638	184,830	1,673,499
kWh del	530,982 kWh	789,230 kWh	6,560,443 kWh	2,174,474 kWh	19,688,219 kWh
Realtime Values:					
kW inst	715 kW	1,022 kW	8,777 kW	3,947 kW	30,238 kW

http://mscada01.ucsd.edu/ion/

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Comparision Between UCSD Buildings: kW/sqFt Year Since 1/1/09





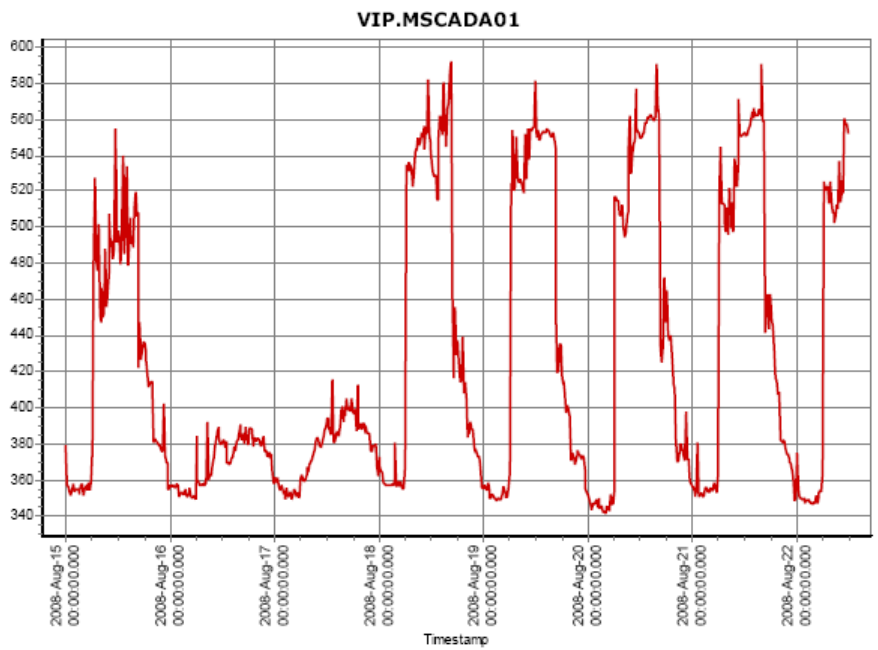
Calit2 and CSE are Very Energy Intensive Buildings

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Power Management in Mixed Use Buildings: The UCSD CSE Building is Energy Instrumented

- 500 Occupants, 750 Computers
- Detailed Instrumentation to Measure Macro and Micro-Scale Power Use
  - 39 Sensor Pods, 156 Radios, 70 Circuits
  - Subsystems: Air Conditioning & Lighting
- Conclusions:
  - Peak Load is Twice Base Load
  - 70% of Base Load is PCs and Servers
  - 90% of That Could Be Avoided!





Source: Rajesh Gupta, CSE, Calit2

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International Symposia on Green ICT: Greening ICT and Applying ICT to Green Infrastructures

CUBIN

Symposium on Sustainability of the Internet and ICT

THE UNIVERSITY OF MELBOURNE

November 25 & 26, 2008, The University of Melbourne

Webcasts Available at:
www.calit2.net/newsroom/article.php?id=1456

Greening the Internet Economy

ICT & GLOBAL CHANGE

California Public Utilities Commission

Calit2

Co-Hosted By Calit2 & CPUC

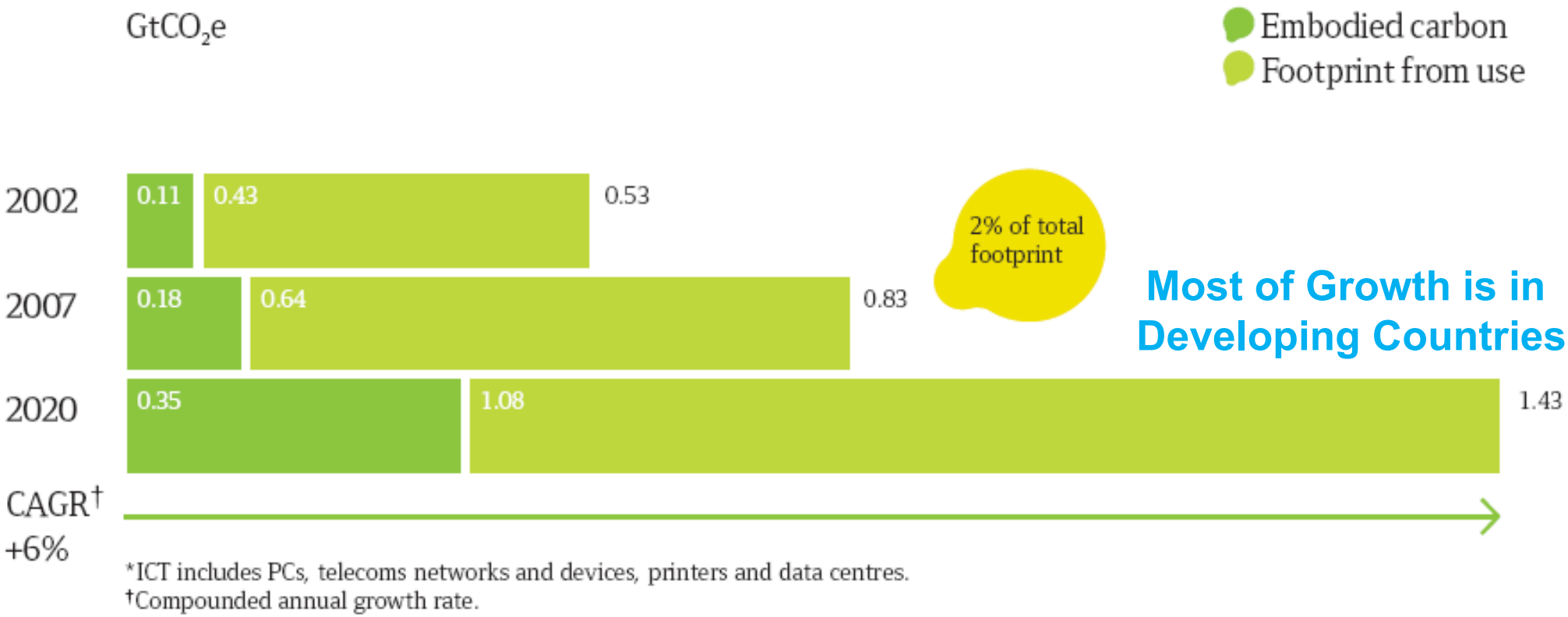
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January 22-23, 2009



The Global ICT Carbon Footprint is Roughly the Same as the Aviation Industry Today

But ICT Emissions are Growing at 6% Annually!



Most of Growth is in Developing Countries

the assumptions behind the growth in emissions expected in 2020:

- **takes into account likely efficient technology developments that affect the power consumption of products and services**
- **and their expected penetration in the market in 2020**

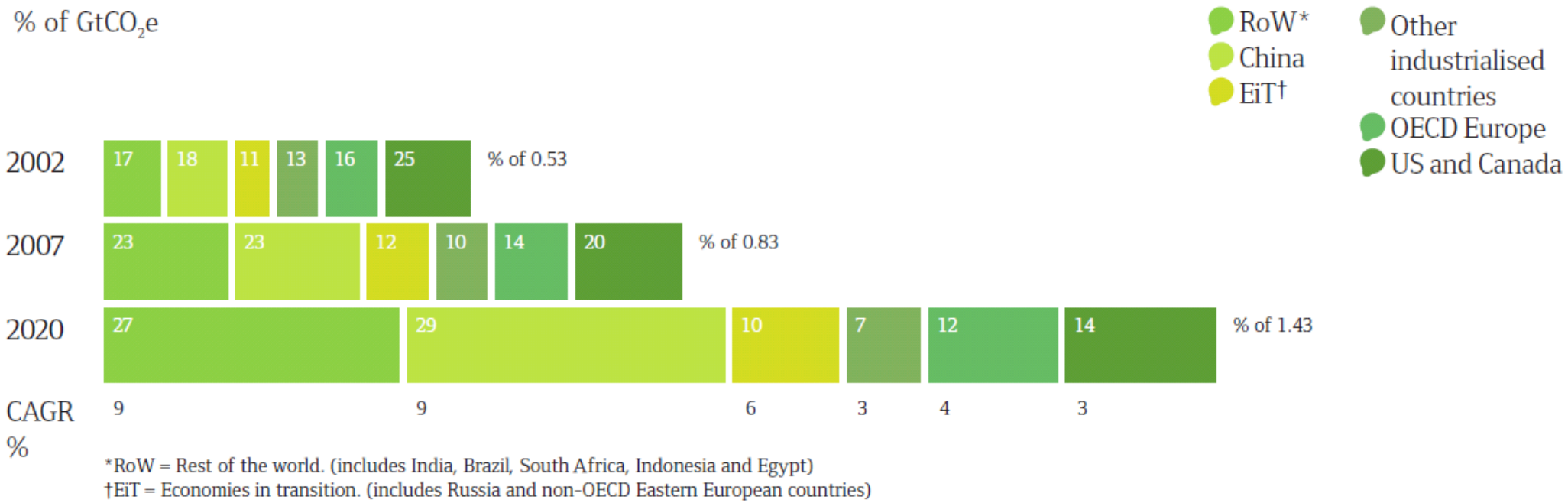
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www.smart2020.org

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Reduction of ICT Emissions is a Global Challenge – U.S. and Canada are Small Sources

U.S. and Canada Together Fall From 25% to 14% of Global ICT Emissions by 2020



*RoW = Rest of the world. (includes India, Brazil, South Africa, Indonesia and Egypt)
†EiT = Economies in transition. (includes Russia and non-OECD Eastern European countries)

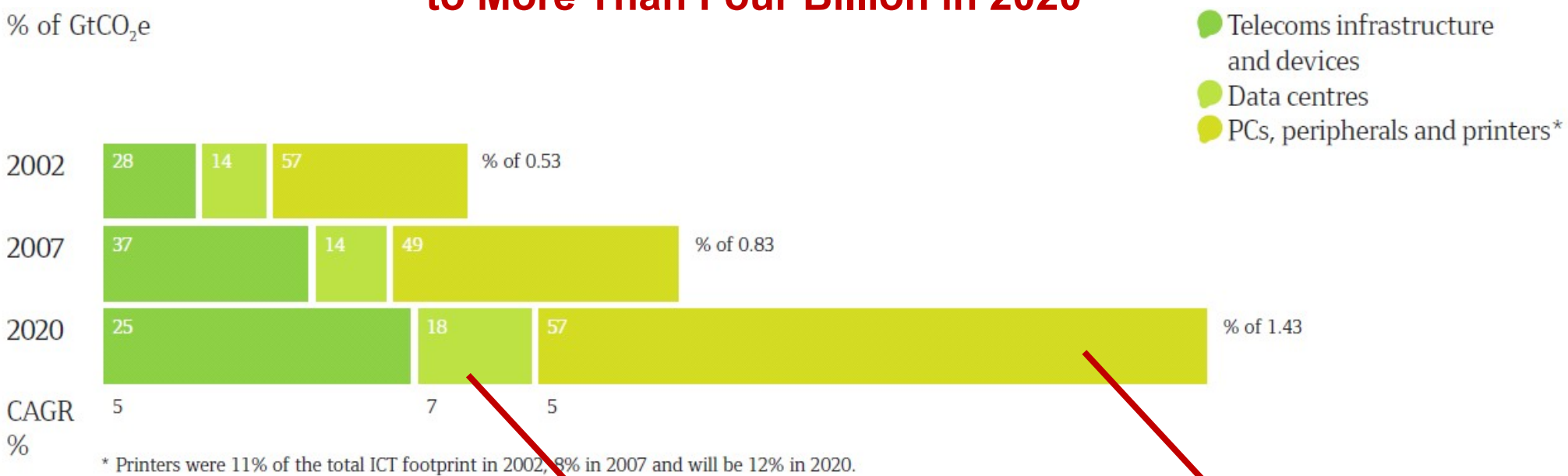
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The Global ICT Carbon Footprint by Subsector

The Number of PCs (Desktops and Laptops) Globally is Expected to Increase from 592 Million in 2002 to More Than Four Billion in 2020



Data Centers Are Rapidly Improving

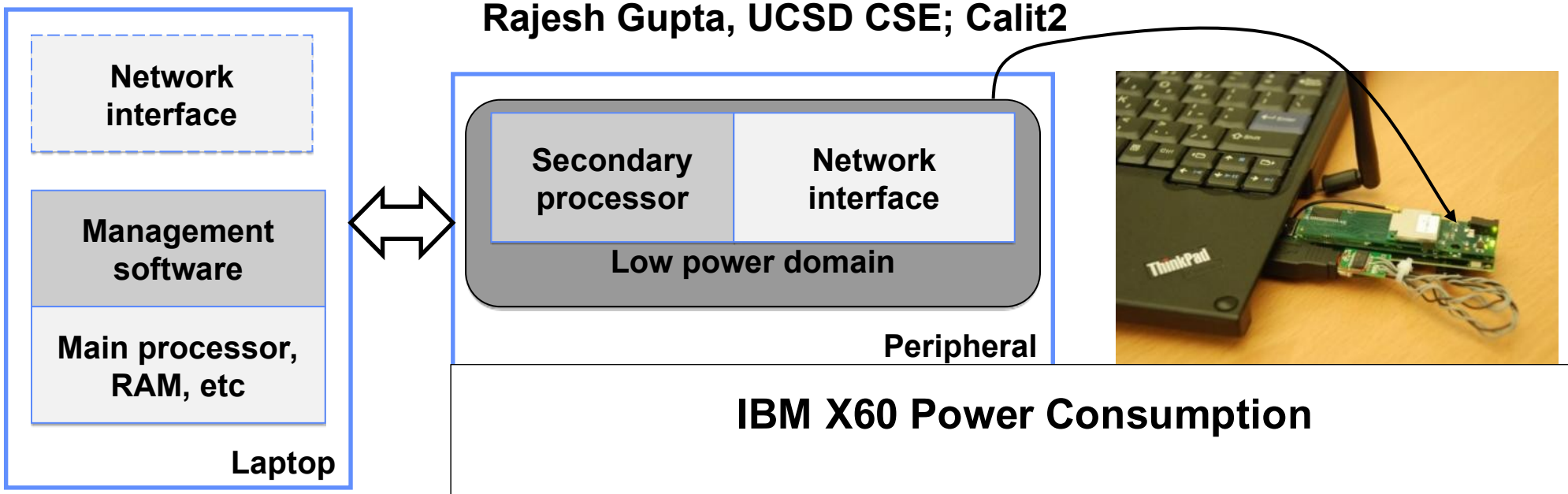
PCs Are Biggest Problem

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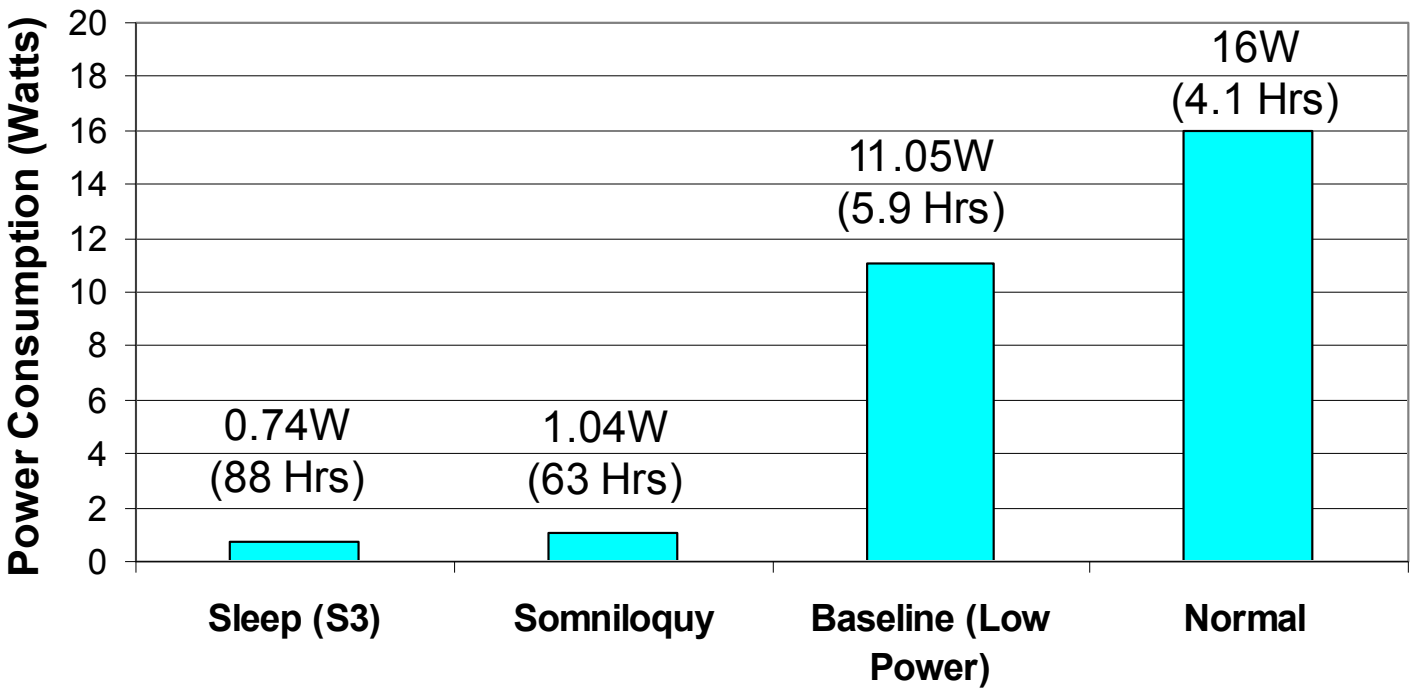
www.smart2020.org

Can We Reduce the Energy Used By PCs Via Putting Machines To Sleep Transparently?

Rajesh Gupta, UCSD CSE; Calit2



Somniloquy Enables Servers to Enter and Exit Sleep While Maintaining Their Network and Application Level Presence



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ICT Industry is Already Acting to Reduce Carbon Footprint

Cisco Green



HP's Green Business Technology Initiative



Innovative Dynamic Smart Cooling

Cut cooling costs in the data center as much as 40%.

» Learn more

Buying Green

updated 10:47 a.m. EST, Wed November 28, 2007

Google pushes 'green' power initiative

Intel Becomes Largest Purchaser of Green Power in the U.S.

Company Tops EPA Green Power Partner List, Vows to Drive for Greater Efficiency While Spurring Growth in Renewable Market

How Microsoft is going green

Biodiesel trucks, solar-powered data centers are just a couple (environmentally friendly track

By John Fontana , Network World , 01/09/2008

IBM Project Big Green

Big Green Banner

Project Big Green is a $1 billion investment to dramatically increase the efficiency of IBM products. New IBM products and services,

Research Needed on How to Deploy a Green CI



- **Computer Architecture**
  - Rajesh Gupta/CSE
- **Software Architecture, Clouds**
  - Amin Vahdat, Ingolf Kruger/CSE
- **CineGrid Exchange**
  - Tom DeFanti/Calit2
- **Visualization**
  - Falko Kuster/Structural Engineering
- **Power and Thermal Management**
  - Tajana Rosing/CSE
- **Analyzing Power Consumption Data**
  - Jim Hollan/Cog Sci
- **Direct DC Datacenters**
  - Tom Defanti, Greg Hidley

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http://greenlight.calit2.net

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The UCSD Center for Networked Systems: A Calit2 Affiliated Center



Member Companies

Center Faculty



Research Interests

Project Proposals

Diverse Research Projects

- Multiple Faculty
- Multiple Students
- Multidisciplinary
- CNS Research Theme

Center for Networked Systems
UCSanDiego

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http://cns.ucsd.edu/

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CNS and Cisco: A History of Collaboration

- Cisco Acquires NetSift Corporation in 2006
  - Co-founders: George Varghese and Sumeet Singh
- Exploring Technology Transfers Around Data Center Networking and Cloud Computing (Vahdat)
- Ongoing Research Interactions with Varghese
- Cisco/IronPort Collaboration with Savage/Voelker
- Recent UCSD Cisco Hires:
  - Varun Almaula
  - Vina Ermagan
  - Nelson Huang
  - Alexander Loukissas

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Source: Amin Vahdat, CNS UCSD

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New Techniques for Dynamic Power and Thermal Management to Reduce Energy Requirements



NSF Project Greenlight

- Green Cyberinfrastructure in Energy-Efficient Modular Facilities
- Closed-Loop Power &Thermal Management

Dynamic Power Management (DPM)

- Optimal DPM for a Class of Workloads
- Machine Learning to Adapt
  - Select Among Specialized Policies
  - Use Sensors and Performance Counters to Monitor
  - Multitasking/Within Task Adaptation of Voltage and Frequency
  - Measured Energy Savings of Up to 70% per Device

Dynamic Thermal Management (DTM)

- Workload Scheduling:
  - Machine learning for Dynamic Adaptation to get Best Temporal and Spatial Profiles with Closed-Loop Sensing
  - Proactive Thermal Management
  - Reduces Thermal Hot Spots by Average 60% with No Performance Overhead

QUALCOMM hp invent Sun microsystems Texas Instruments Inc. YAHOO! CISCO DARPA NSF SRC Semiconductor Research Corporation Los Alamos NATIONAL LABORATORY EST. 1943 U.S. DEPARTMENT OF ENERGY National Institutes of Health The Nation's Medical Research Agency

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System Energy Efficiency Lab (seelab.ucsd.edu)
Prof. Tajana Šimunić Rosing, CSE, UCSD

see it²

Zero Carbon GreenLight Experiment: DC-Powered Modular Data Center

- **Concept—Avoid DC to AC to DC Conversion Losses**
  - Computers Use DC Power Internally
  - Solar and Fuel Cells Produce DC
  - Both Plug into the AC Power Grid
  - Can We Use DC Directly (With or Without the AC Grid)?

Sun Box <200kWatt

- **DC Generation Can Be Intermittent**
  - Depends on Source
    - Solar, Wind, Fuel Cell, Hydro
  - Can Use Sensors to Shut Down or Sleep Computers
  - Can Use Virtualization to Halt/Shift Jobs
- **Experiment Planning Just Starting**
  - Collaboration with Sun and LBNL
  - NSF GreenLight Year 2 and Year 3 Funds

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Source: Tom DeFanti, Calit2; GreenLight PI

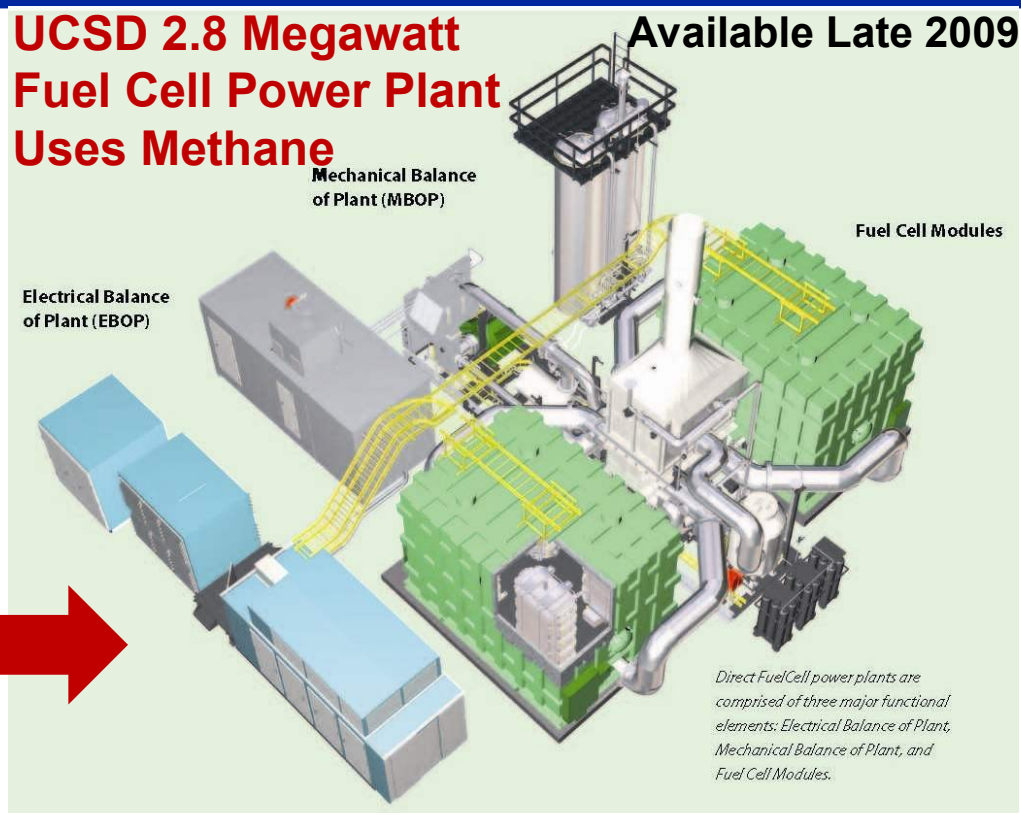
UCSD is Installing Zero Carbon Emission Solar and Fuel Cell DC Electricity Generators

San Diego's Point Loma Wastewater Treatment Plant Produces Waste Methane



UCSD 2.8 Megawatt Fuel Cell Power Plant Uses Methane

Available Late 2009



Use to Power Local Data Centers

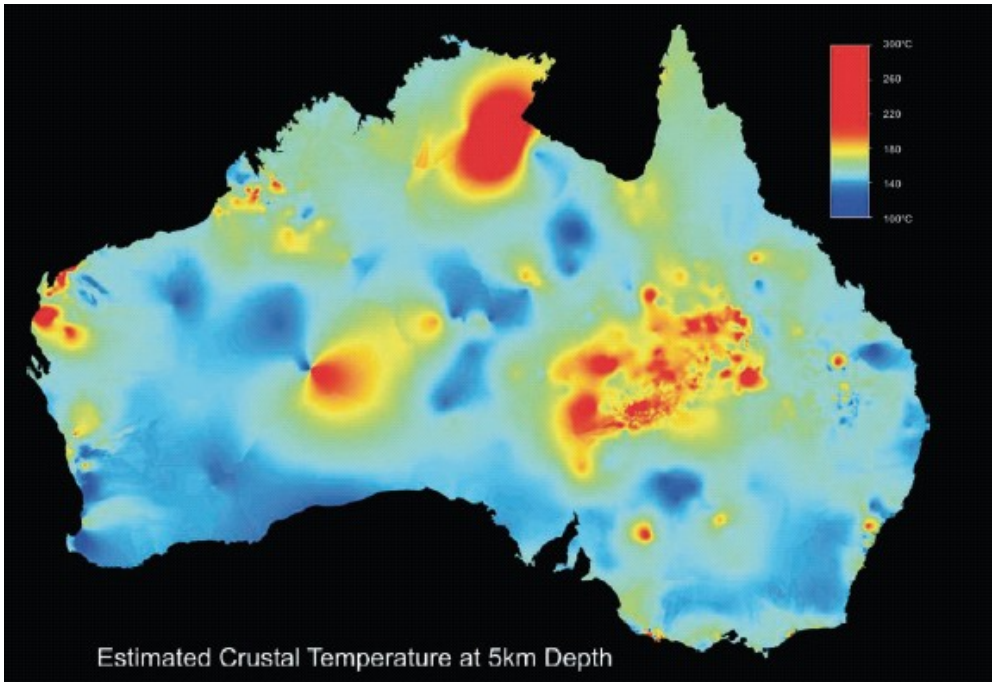


2 Megawatts of Solar Power Cells Being Installed

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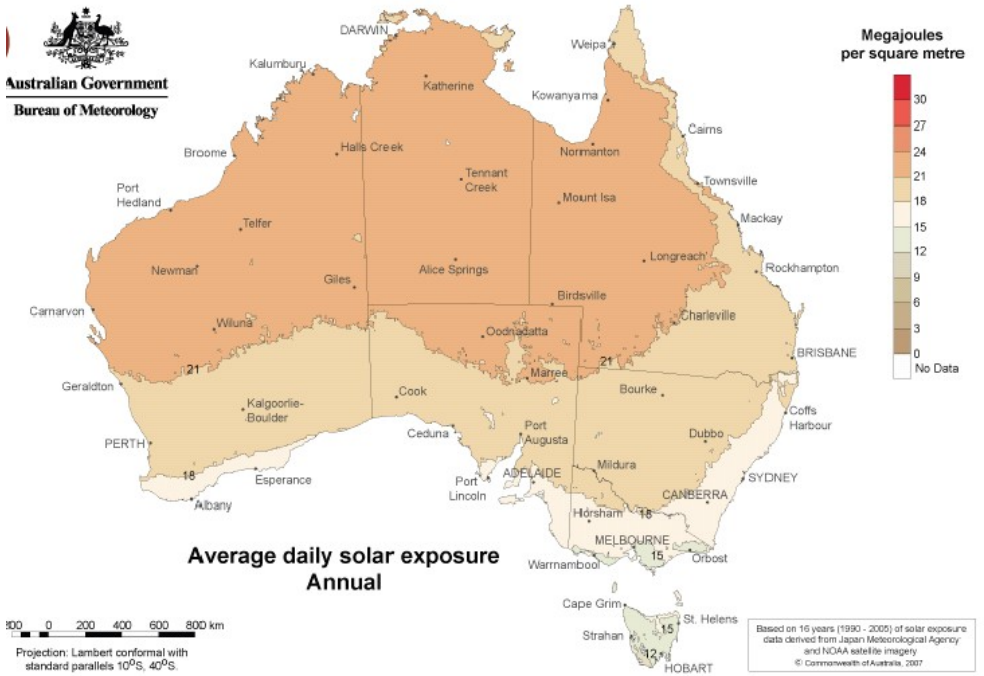
Australia—the Zero Carbon Energy Future



Temperatures at 5 km.
After Budd et al. Australian Geothermal Energy Conference 2008

Placing a data centre at the zero carbon energy source -- the cost of fibre optic cable is ~5-10% the cost of electricity transmission.

A Fiber/HVDC Smart Grid Flows Both Bits and Electrons!



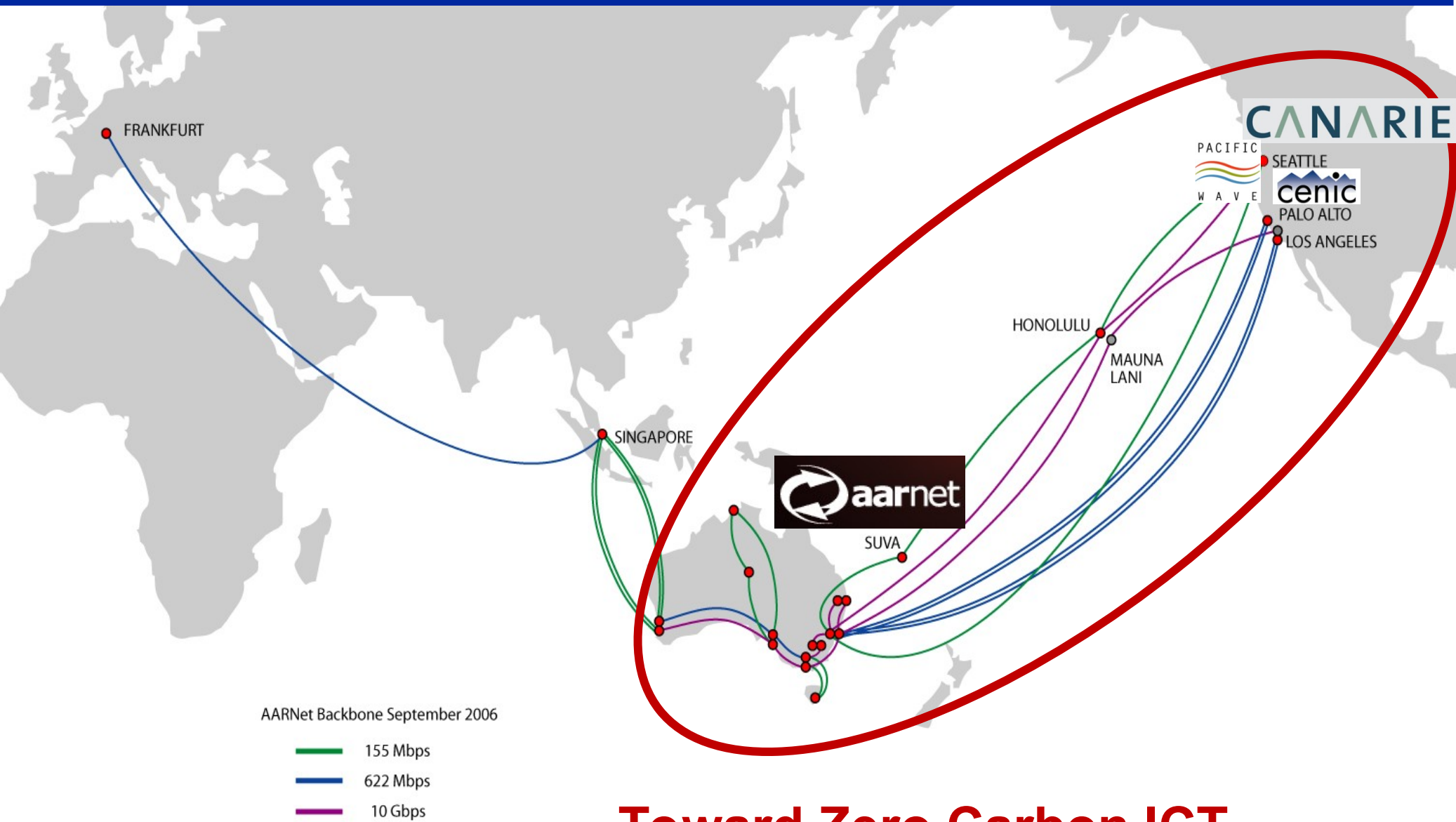
GEODYNAMICS LIMITED

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Source: Geodynamics, Limited

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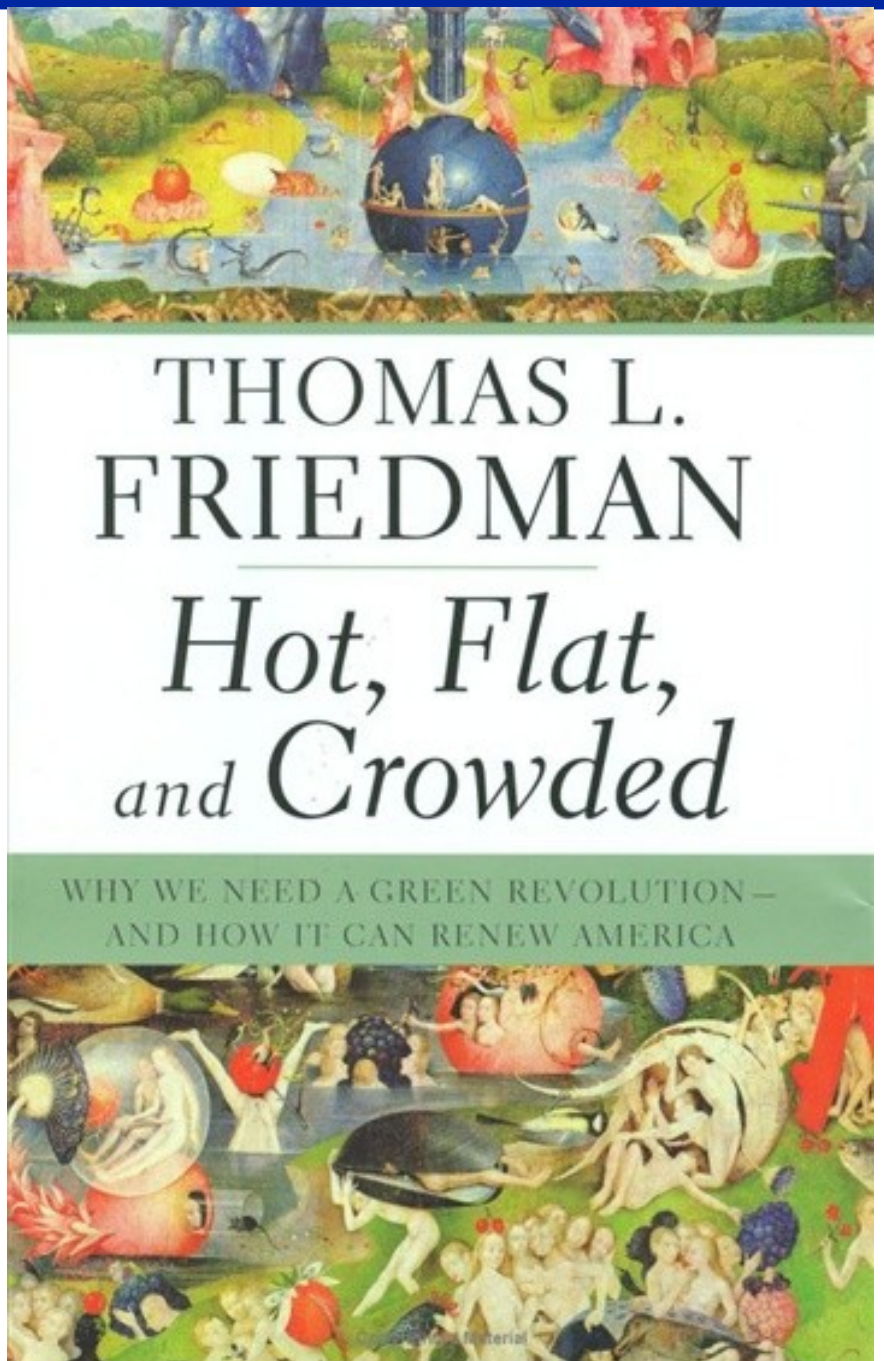
Coupling AARNet - CENIC/PW - CANARIE Optical Nets: An Australian-U.S.-Canada Green Cloud Testbed



Toward Zero Carbon ICT

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“It Will Be the Biggest Single Peacetime Project Humankind Will Have Ever Undertaken”



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