Universities as "Smart Cities" in a Globally Connected World - How Will They be Transformed?

Monash University ITS Strategic Planning Session

RE-INVENT to RE-POSITION – TRANSFORMED BY ICT

August 20, 2009

Dr. Larry Smarr

Director, California Institute for Telecommunications and Information Technology

Harry E. Gruber Professor,

Dept. of Computer Science and Engineering

Jacobs School of Engineering, UCSD

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Abstract

By thinking of universities as “Smart Cities,” they can play a vital role in shaping Australia’s future through research and “living the dream” as early adopters of new technologies, in the process re-inventing themselves to harness the opportunities to provide advanced educational services to a global community. The universities that anticipate and plan for this future will prosper. Two challenges in particular loom large for Australia, the roll out of the National Broadband Network and the countries response to climate change. I believe universities can play a leadership role in each and will present what I have learned in my two weeks in Australia discussing these issues.

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Australia's National Broadband Network (NBN) Can Be Leveraged to Speed Climate Goals

- **NBN Goals**
  - Connect 90% of Households with Fiber in Eight Years
  - Remaining 10% by Satellite or Wireless
  - 100 Mbit/s Broadband Per House
  - Driven by Consumer Internet, Telephone, Video
    - "Triple Play", eHealth, eCommerce…
- **"Smart" Electric Grid**
  - Reduce Household and Building Energy Usage
  - Avoid Peak Loading
  - Plug-In Hybrid with Renewable Electricity Generation
- **Video Conferencing to Avoid Transportation**
- **Cloud Computing and Storage at Renewable Sites**

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IBES

Institute for a BROADBAND-ENABLED SOCIETY

- **IBES Launched by Minister Conroy in July 2009**
- **Focus on technologies and broadband applications for the benefit of society**
- **Strong links to Industry through Industry Partner Program**
  - **Currently 15 company members (telcos, vendors, service providers, etc)**
  - **Provides "neutral ground", for development of broadband applications and debate and siscussion of issues and policies**
- **The nerve centre of IBES is an NBN Test-Bed Laboratory**
  - **Performance and interoperability testing of hardware and software**
  - **Incubator space for SMEs**
  - **Links to other labs via AARNet**

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Broadband for the Benefit of Australian Society

- **Multi-disciplinary research team, includes researchers from**
  - **Medicine, Sociology, Anthropology, Economics,**
  - **Engineering, Computer Science, Architecture,**
  - **Education, Law and Environmental Sciences**

- **Focus on benefits for society, e.g.**
  - **Health, Education, Environmental Monitoring,**
  - **Smart Grids, Green Networking and Security,**
  - **Social Networking, Digital Spaces and Connected Communities**
  - **e-Commerce and -Government**

- **Close links to industry, government, and to research teams in other universities and institutions**

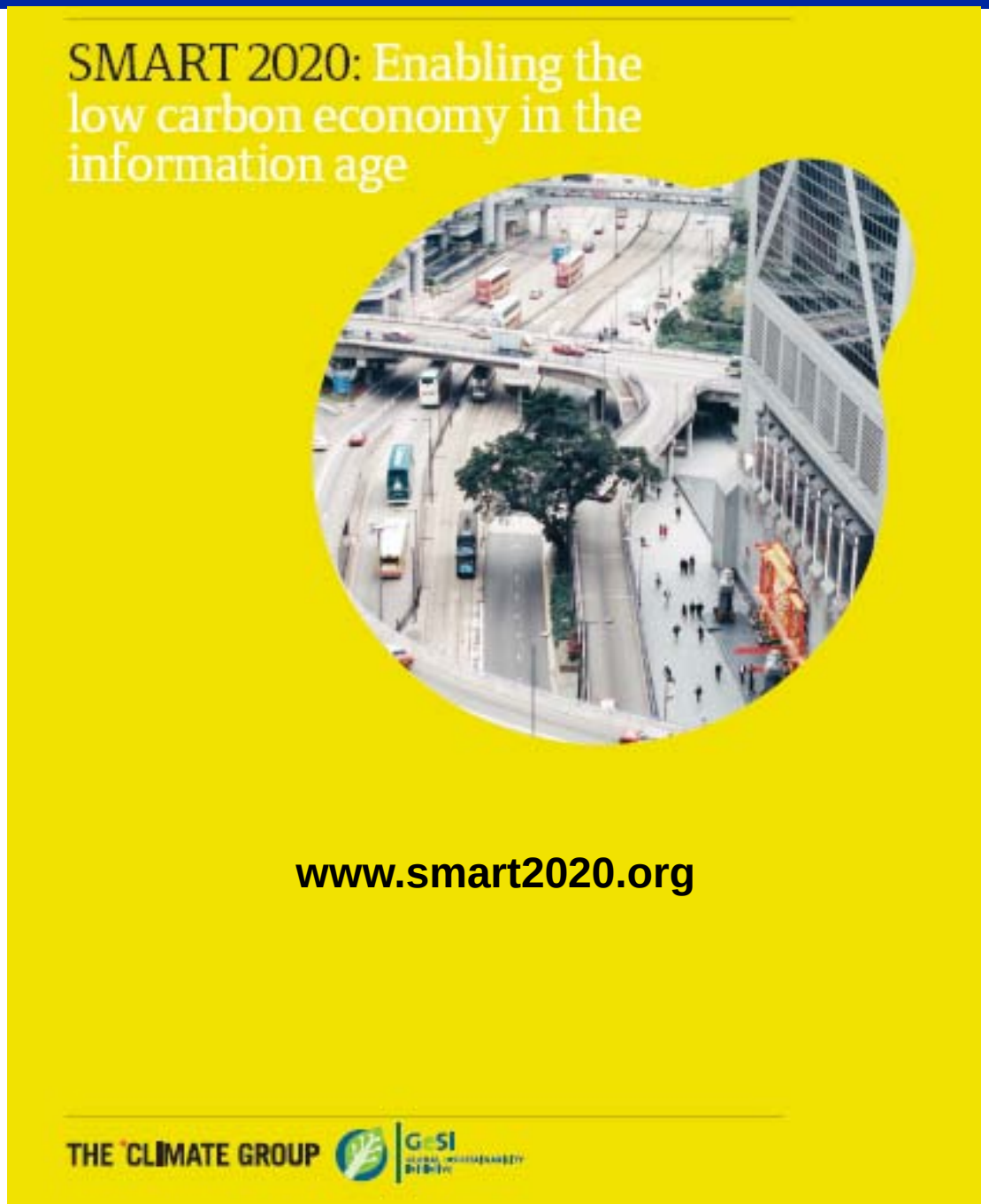
ICT is a Critical Element in Achieving Countries Greenhouse Gas Emission Reduction Targets

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.**

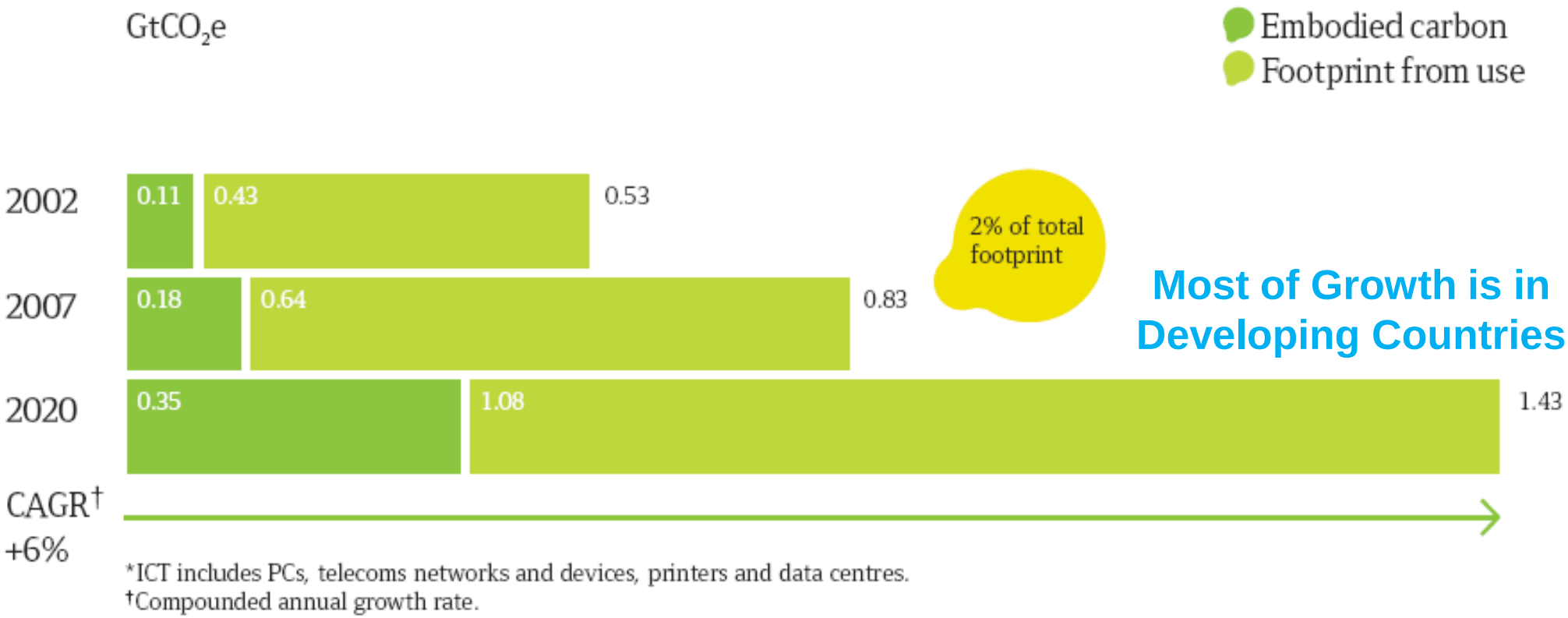


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The Global ICT Carbon Footprint is Roughly the Same as the Aviation Industry Today

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

Next Stage: Developing Greener Smart Campuses Calit2 (UCSD & UCI) Prototypes

- **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
- **Transportation System**
  - Campus Wireless GPS Low Carbon Fleet
  - Green Software Automobile Innovations
  - Driver Level Cell Phone Traffic Awareness
- **Travel Substitution**
  - Commercial Teleconferencing
  - Next Generation Global Telepresence

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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

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

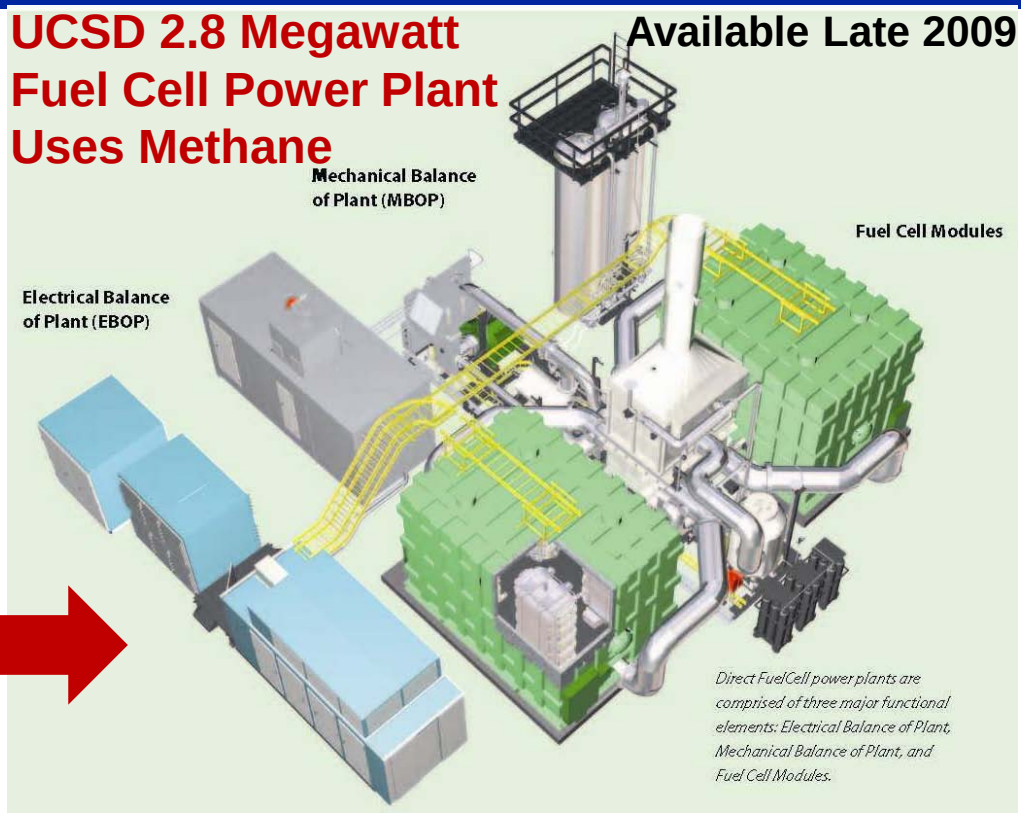
UCSD is Installing Zero Carbon Emission Solar and Fuel Cell DC Electricity Generators

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

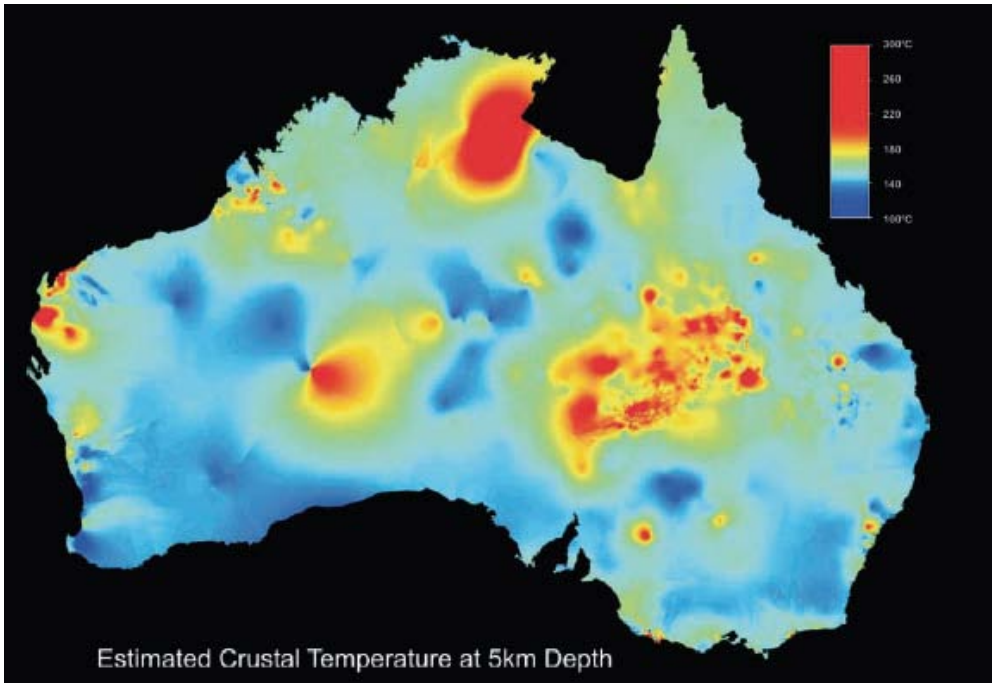


2 Megawatts of Solar Power Cells Being Installed

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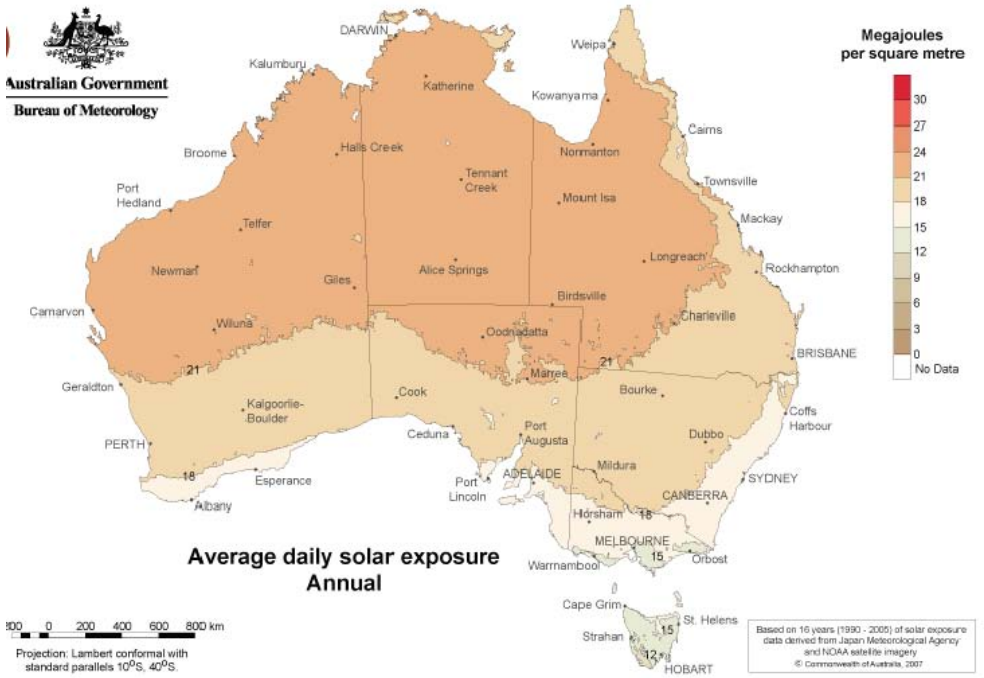
Australia—the Zero Carbon Energy Future



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!

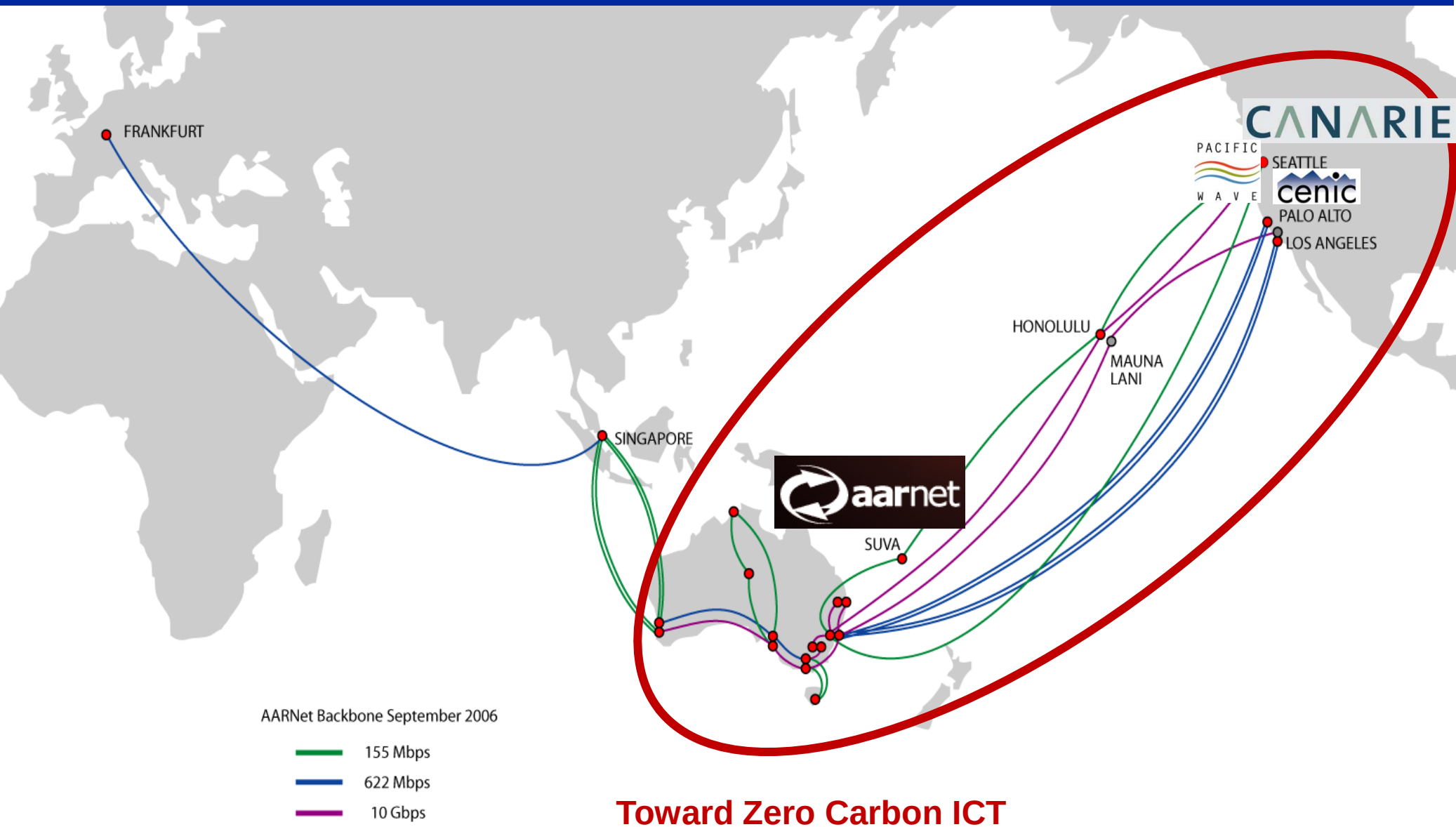


GEODYNAMICS LIMITED

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Source: Geodynamics, Limited

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



Toward Zero Carbon ICT

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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**

www.smart2020.org

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Applying ICT – The Smart 2020 Opportunity for Reducing GHG Emissions by 7.8 $GtCO_2e$

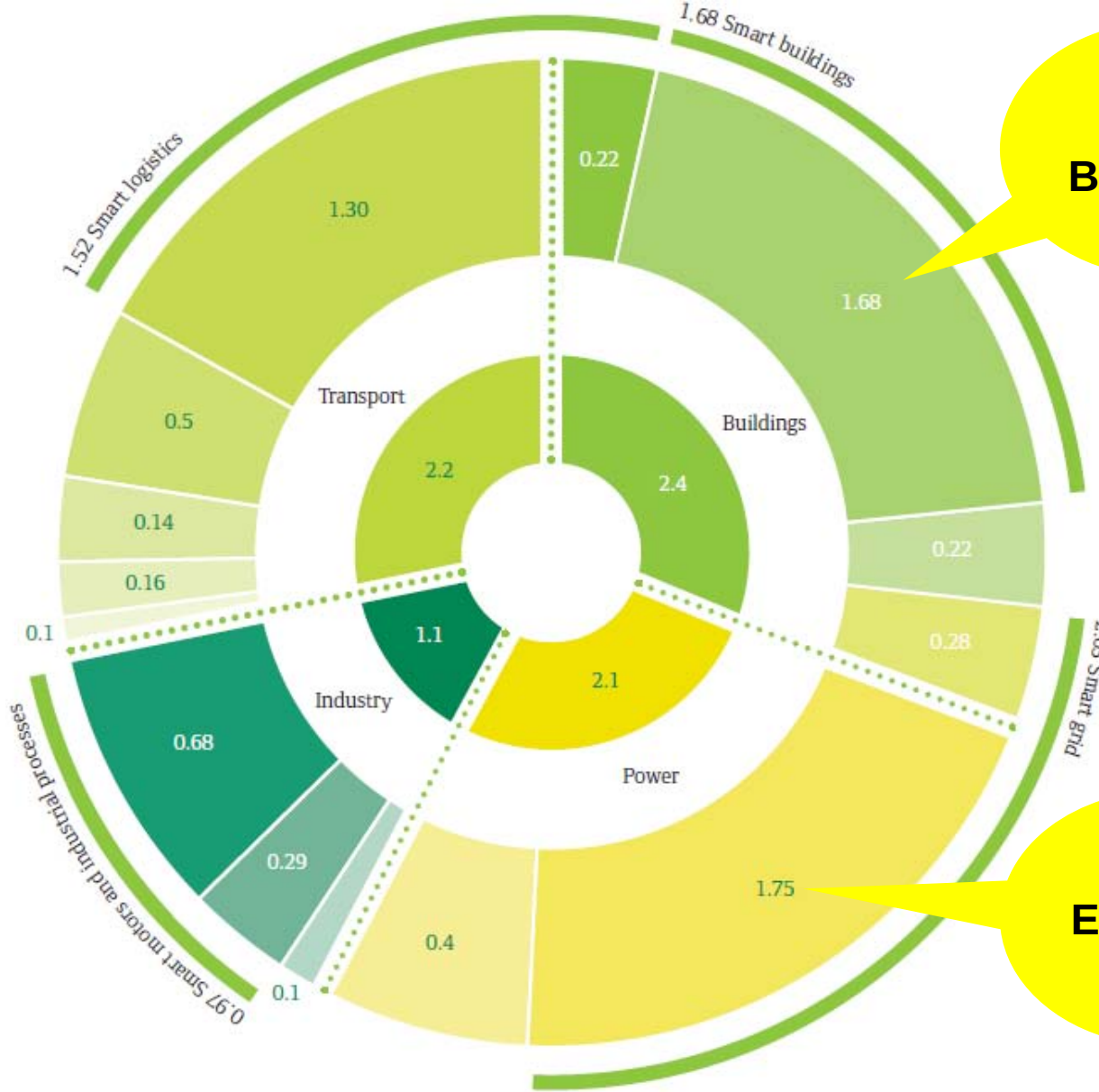
www.smart2020.org

Industry
- Smart motors
- Industrial process automation
- Dematerialisation* (reduce production of DVDs, paper)

Transport
- Smart logistics
- Private transport optimisation
- Dematerialisation (e-commerce, videoconferencing, teleworking)
- Efficient vehicles (plug-ins and smart cars)
- Traffic flow monitoring, planning and simulation

Buildings
- Smart logistics†
- Smart buildings
- Dematerialisation (teleworking)
- Smart grid‡

Power
- Smart grid
- Efficient generation of power, combined heat and power (CHP)



Smart Buildings

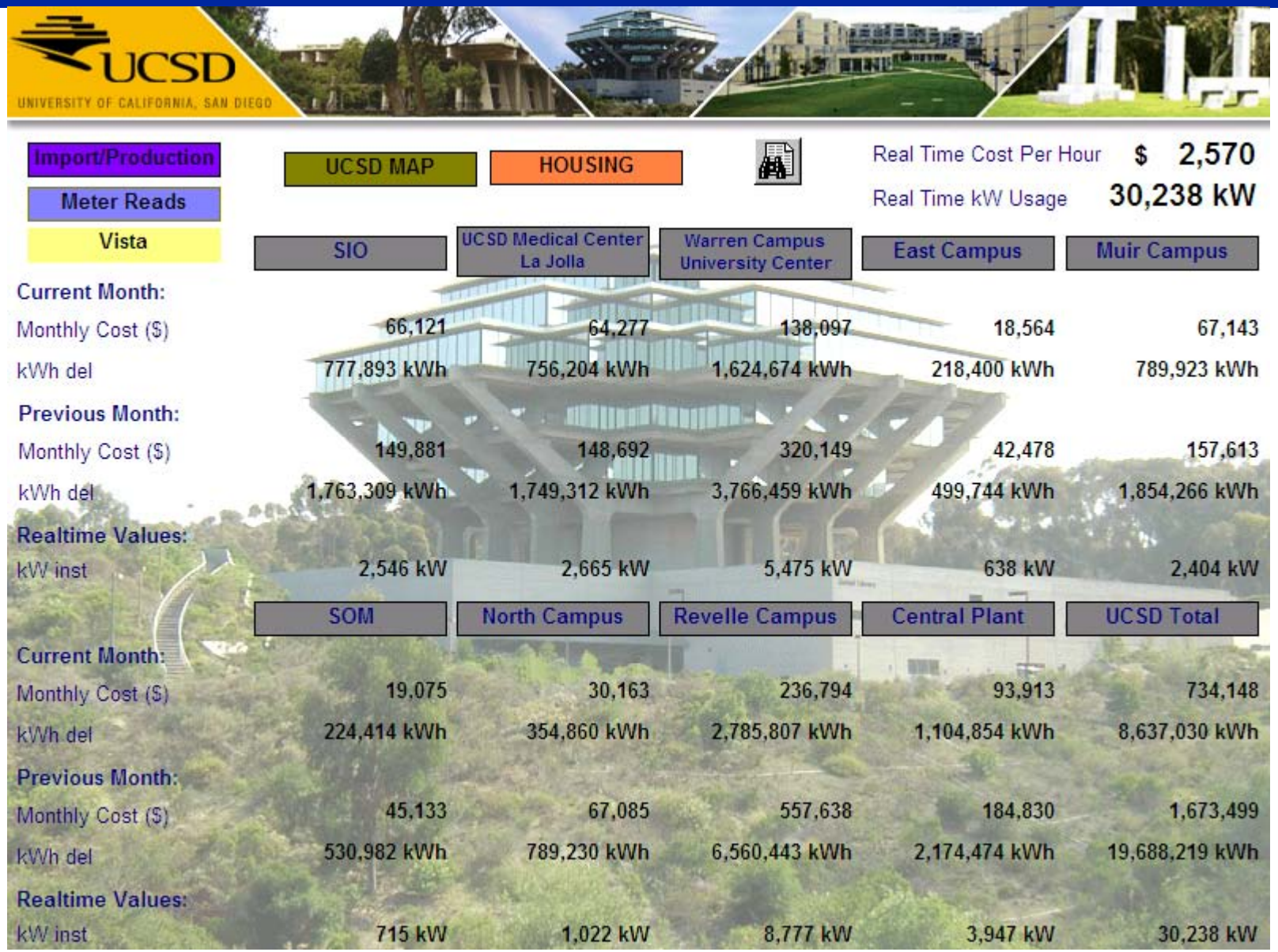
Smart Electrical Grid

Recall Total ICT 2020 Emissions are 1.43 $GtCO_2e$

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

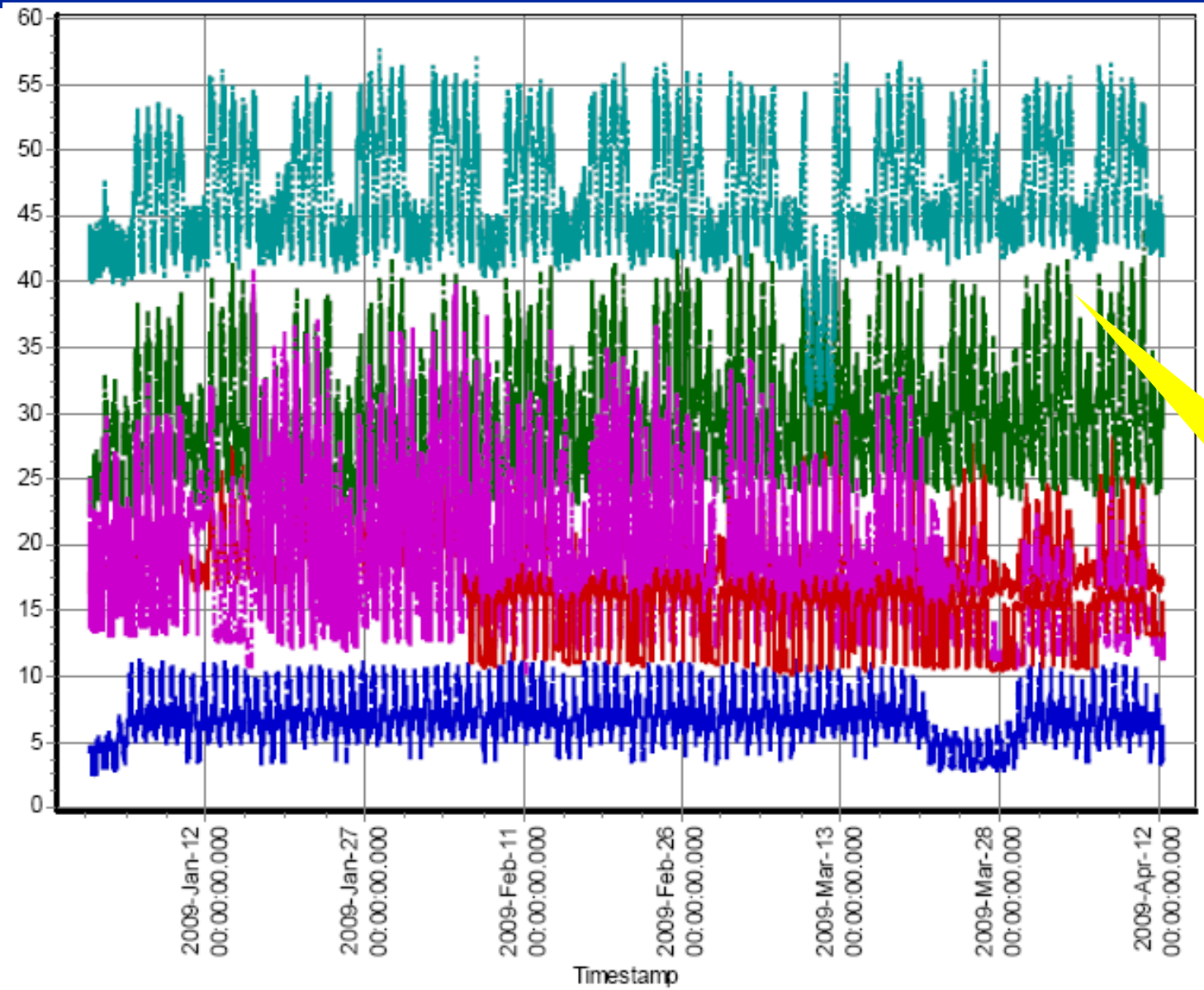


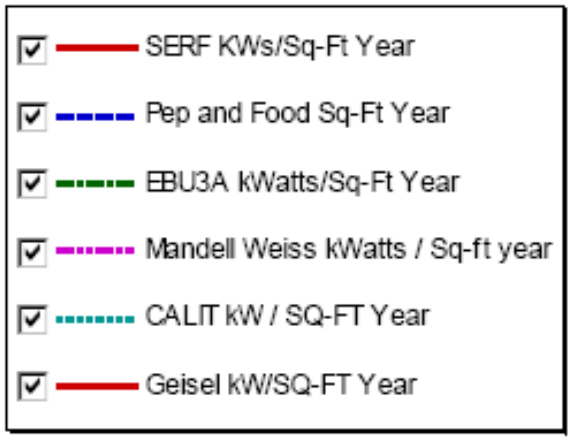
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http://mscada01.ucsd.edu/ion/

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





Calit2 and CSE are Very Energy Intensive Buildings

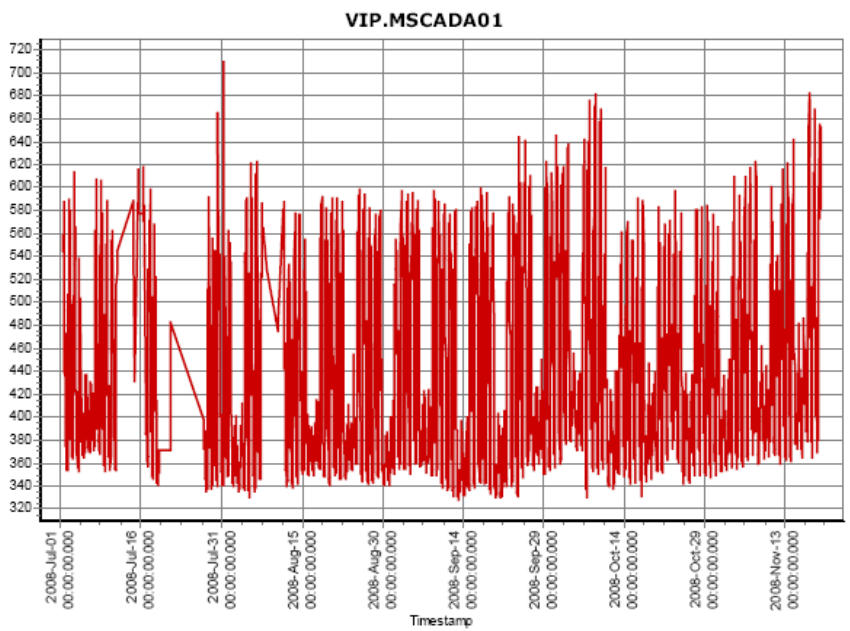
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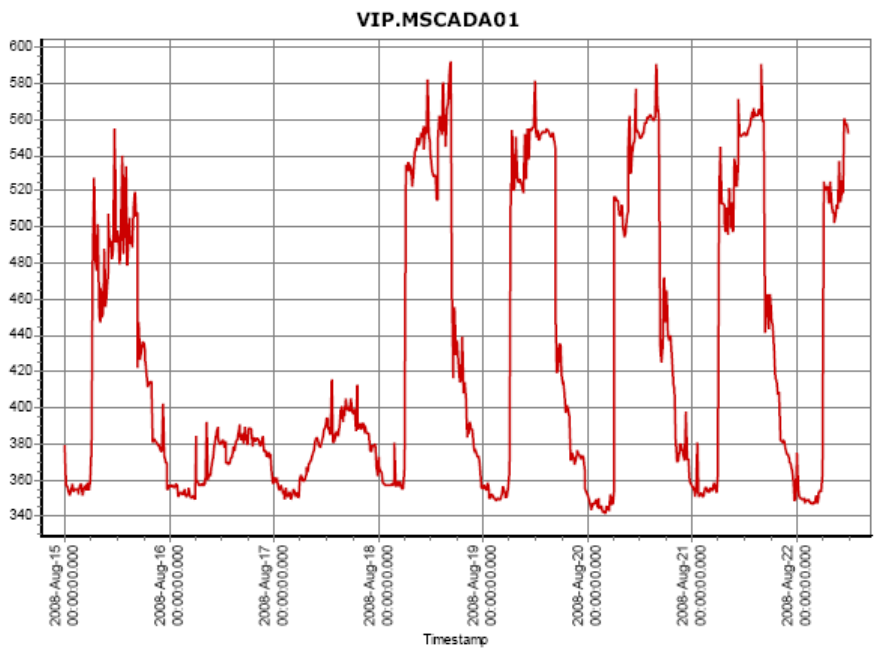
it2

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**





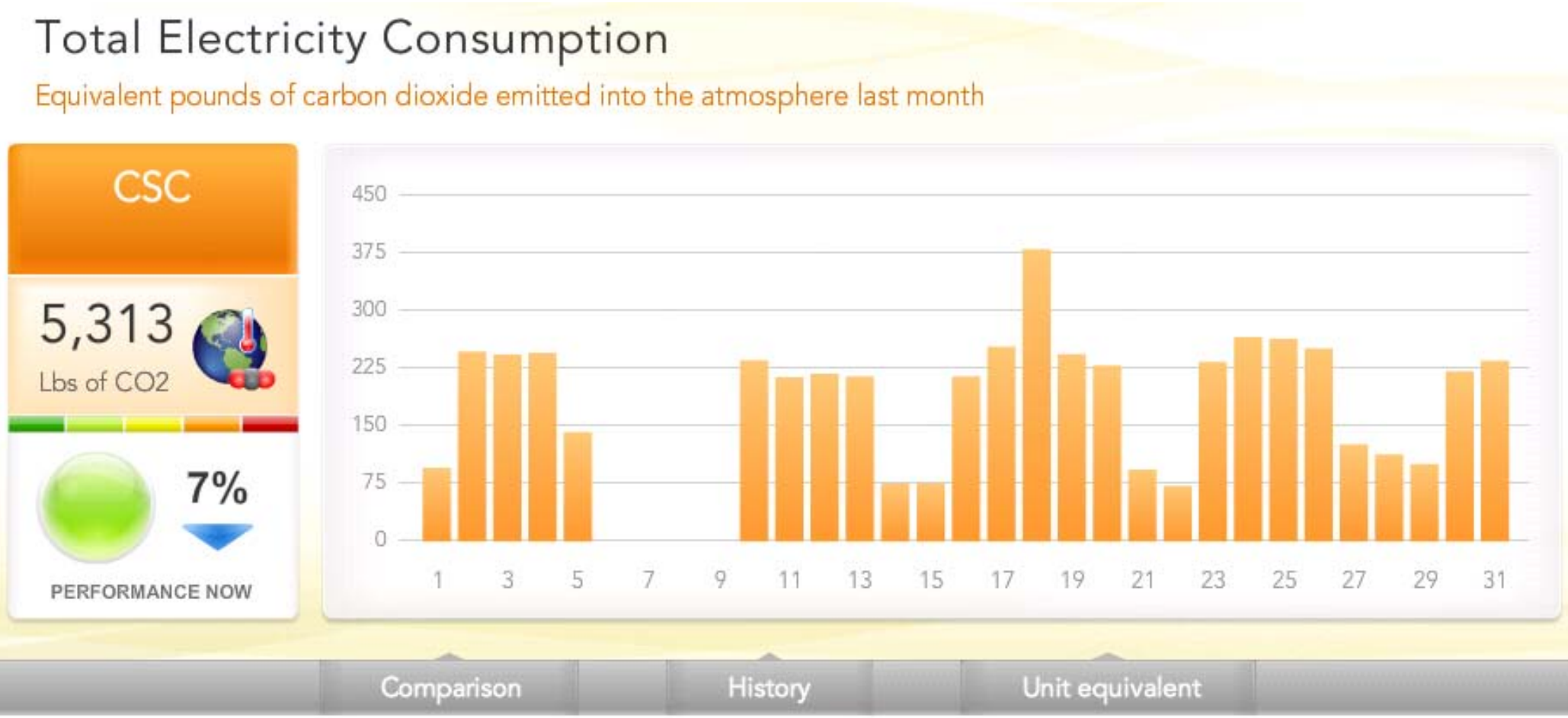


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Source: Rajesh Gupta, CSE, Calit2

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UCSD is Experimenting with Smart Building User Interfaces



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http://buildingdashboard.com/clients/ucsandiego/

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Reducing Traffic Congestion: Calit2 California Peer-to -Peer Wireless Traffic Report

- **Citizen to Citizen Accident Reports**
- **Real-Time Freeway Speeds**
- **"Leave Now" Paging Services**

20,000+ Users
> 1000 Calls Per Day

San Diego
(866) 500 0977



LA & OC
(888) 9 CALIT2



Bay Area
(888) 4 CALIT2



http://traffic.calit2.net

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Source: Ganz Chockalingam, Calit2

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Making Cars Cleaner Requires Software Engineering-- Calit2 Established the Automotive Software Workshop

AUTOMOTIVE SOFTWARE WORKSHOP SAN DIEGO 2004



90 % of all Auto Innovations are Now Software-Driven

- **Over 10 Million Lines of Code in Your Car!**
- **Sponsors: Calit2, NSF, EU, DFG**
- **50:50 Participation Industry/Academia**
- **Next Instance Planned For 2009**
- **Industry Participants Include:**

Ford
TOYOTA InfoTechnology Center, U.S.A., Inc.
DAIMLER
VALIDAS validated quality
BMW
TOYOTA
GM
BOSCH
AbsInt Angewandte Informatik
vector
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Source: Ingolf Krueger, Calit2

Launch of ZEVnet Fleet of Wireless Cars-- First Calit2 Testbed for Intelligent Transportation



April 18,
Irvine,
www.zevi

Toyota Delivers Plug-in Prius to UC Irvine and UC Berkeley as Part of Clean Mobility Partnership



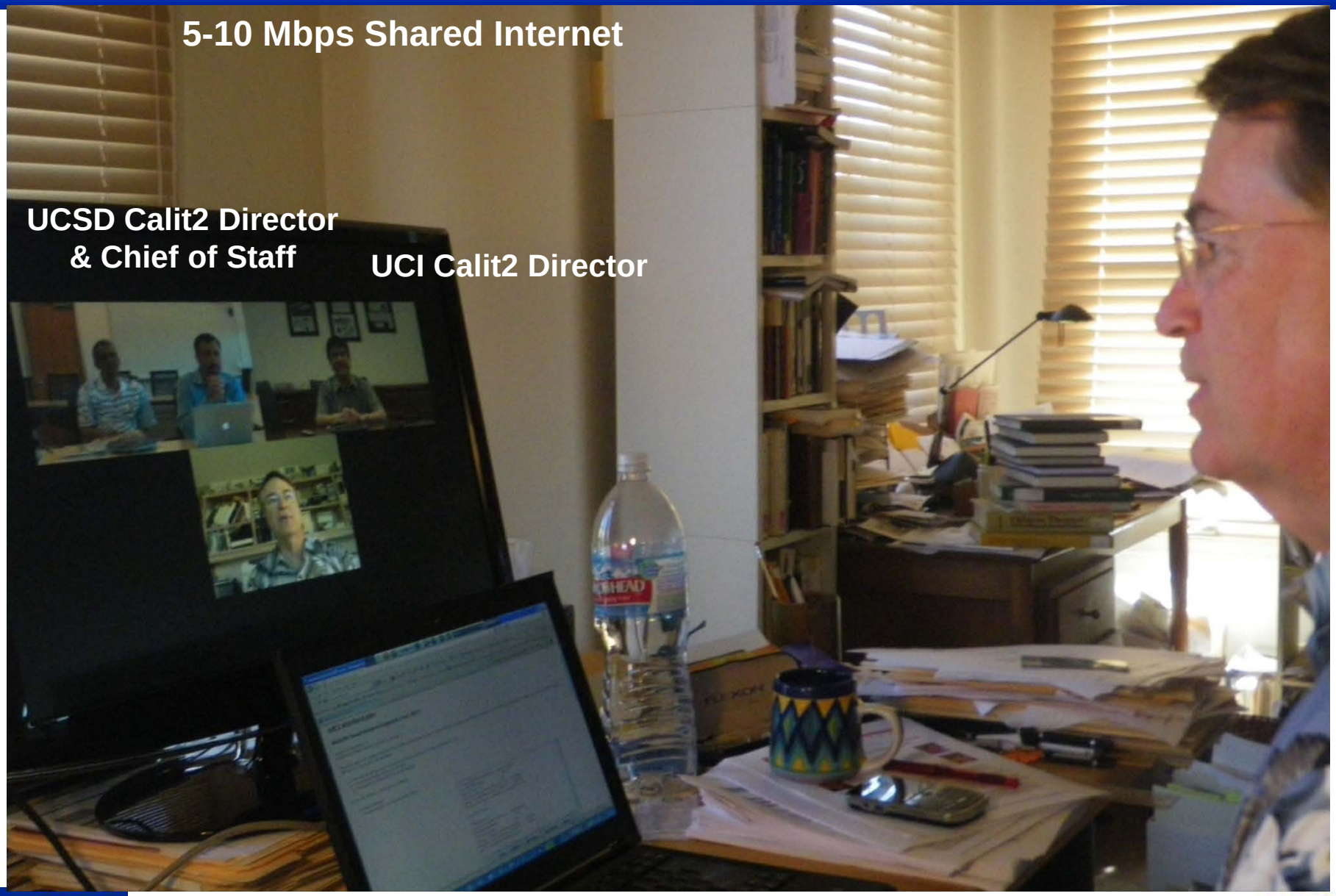




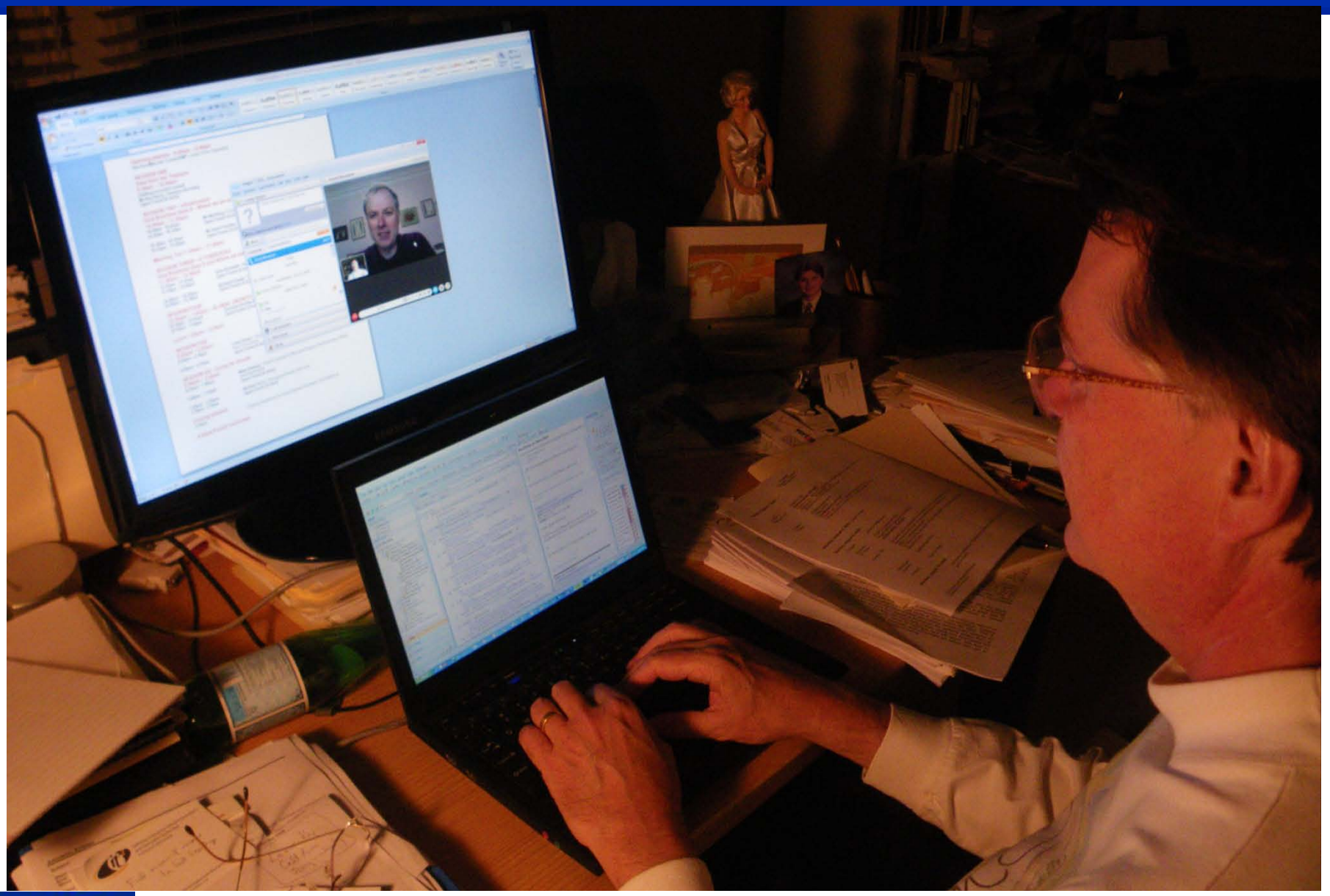


TORRANCE, Calif., Nov. 9, 2007 -- Toyota Motor Sales, U.S.A.,

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



It Doesn't Matter Where in the Broadband World The Other Person Lives

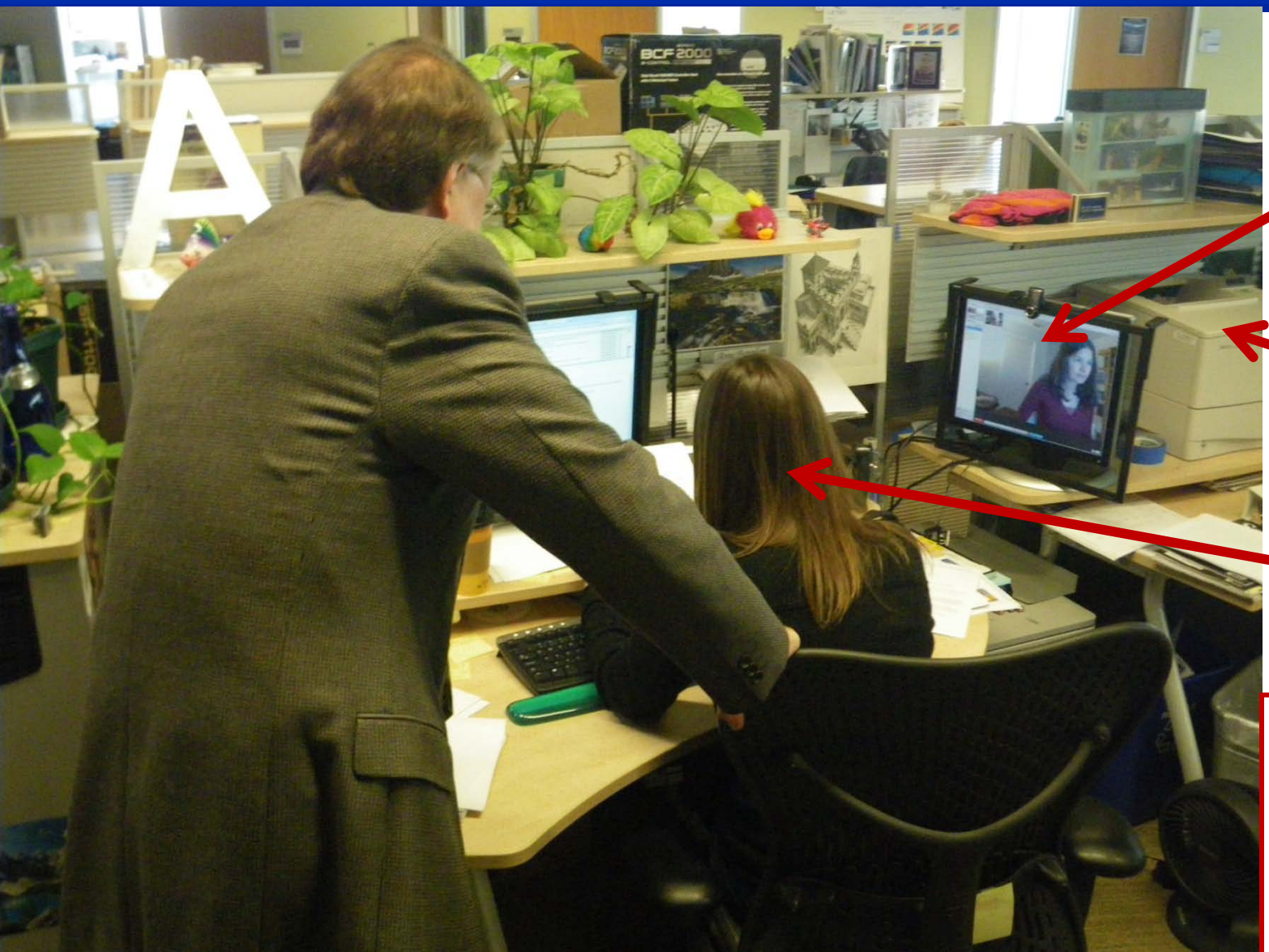


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David Abramson, Monash University, and Me
Discussing My Upcoming Trip to Melbourne

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Work at Home is the Same As at the Office



Virtual Kristen

Kristen Prints Here For Amy

Real Amy

Kristen Reads My Email, Sets My Calendar. Works With Amy on My Trips

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We Run Video Sykpe Continuously During Office Hours

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Calit2 is Exploring Cisco Telepresence Over Lambdas

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

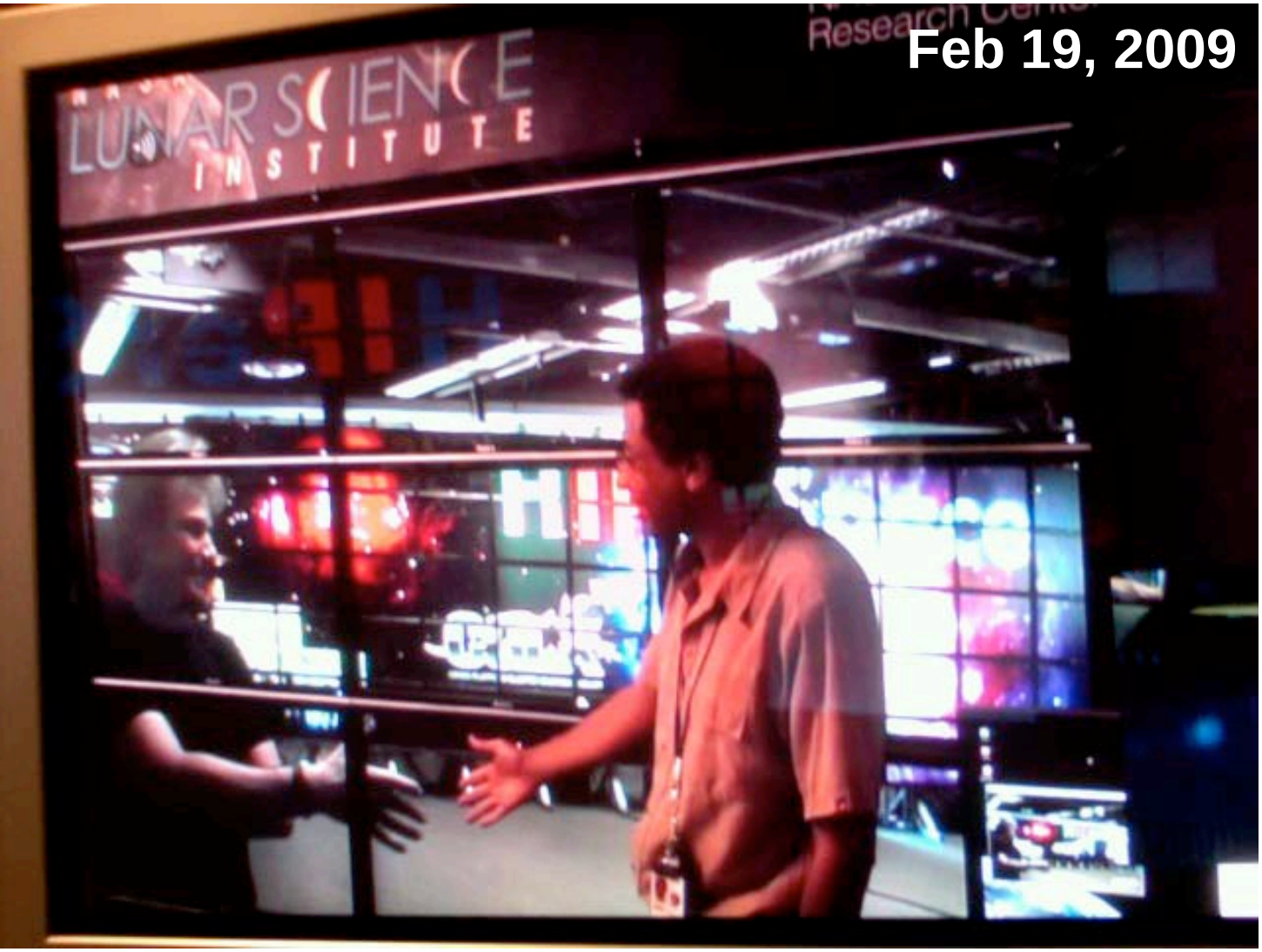


•Overall average utilization **49%**

•30K Multipoint mtgs
•Average 3,919 in past 30 days

Updated Aug 2,2009….145 weeks after launch
~~~

Just in Time OptIPlanet Collaboratory: Live Session Between NASA Ames and Calit2@UCSD



From Start to This Image in Less Than 2 Weeks!

View from NASA Ames Lunar Science Institute Mountain View, CA

Virtual Handshake

HD compressed 6:1

NASA Interest in Supporting Virtual Institutes

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Source: Falko Kuester, Calit2; Michael Sims, NASA

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



Qvidium Compressed HD ~140 mbps

Source: David Abramson, Monash Univ

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



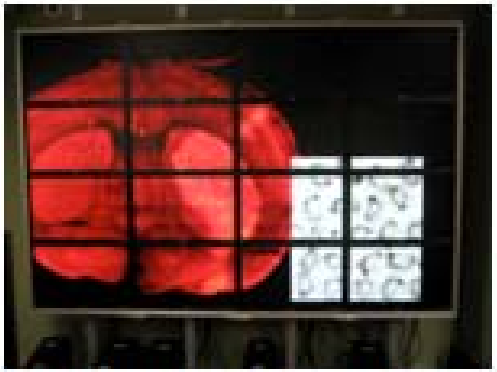
ANU



U Queensland



AARNet



Monash U-Caufield



CSIRO



Monash U-Clayton

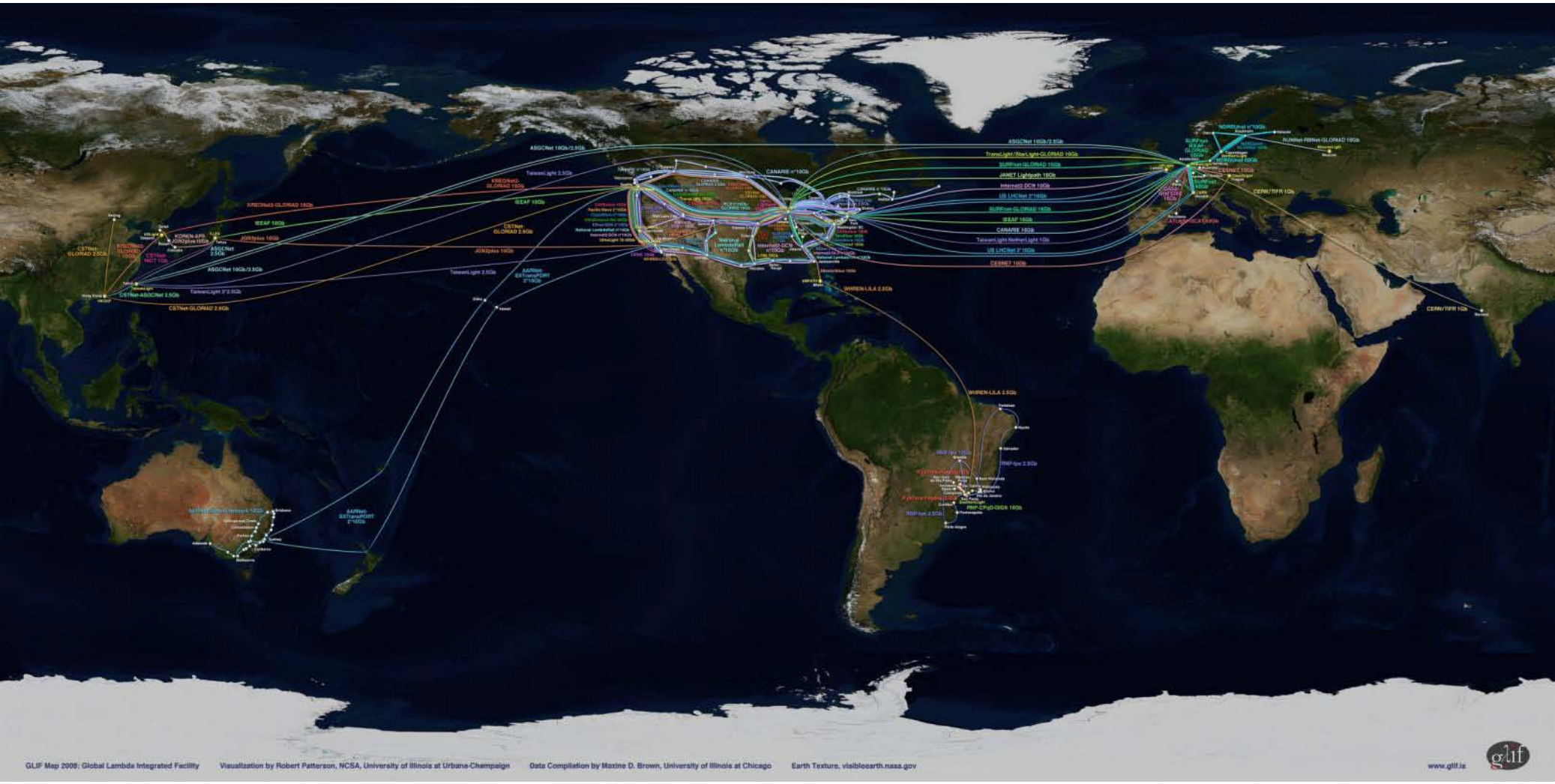


U Wellington, NZ

OptIPuter

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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

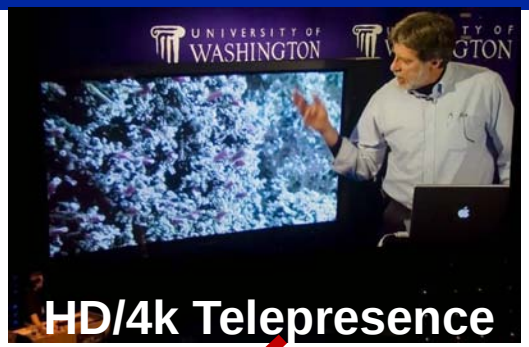
Academic Research "OptIPlatform" Cyberinfrastructure: A 10Gbps Lightpath Cloud



End User OptIPortal



Instruments



HD/4k Telepresence

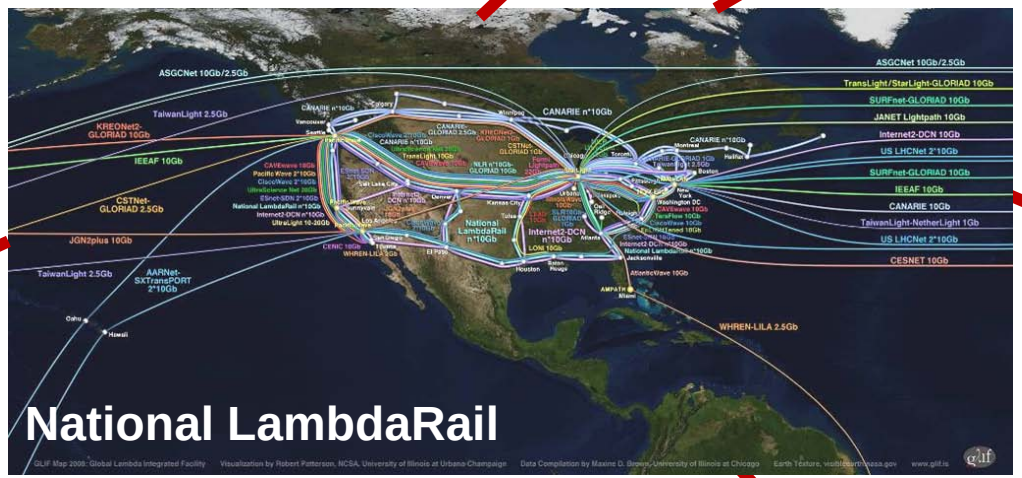


HD/4k Video Cams

HPC



10G Lightpaths



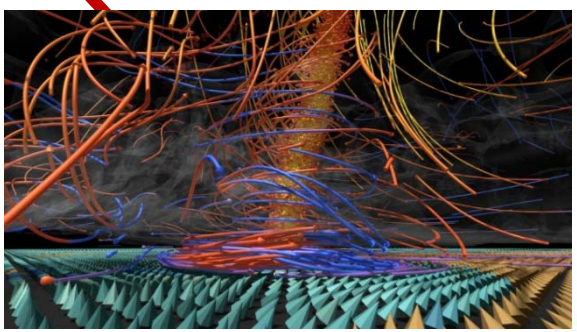
National LambdaRail

TeraGrid™

Campus Optical Switch



Data Repositories & Clusters



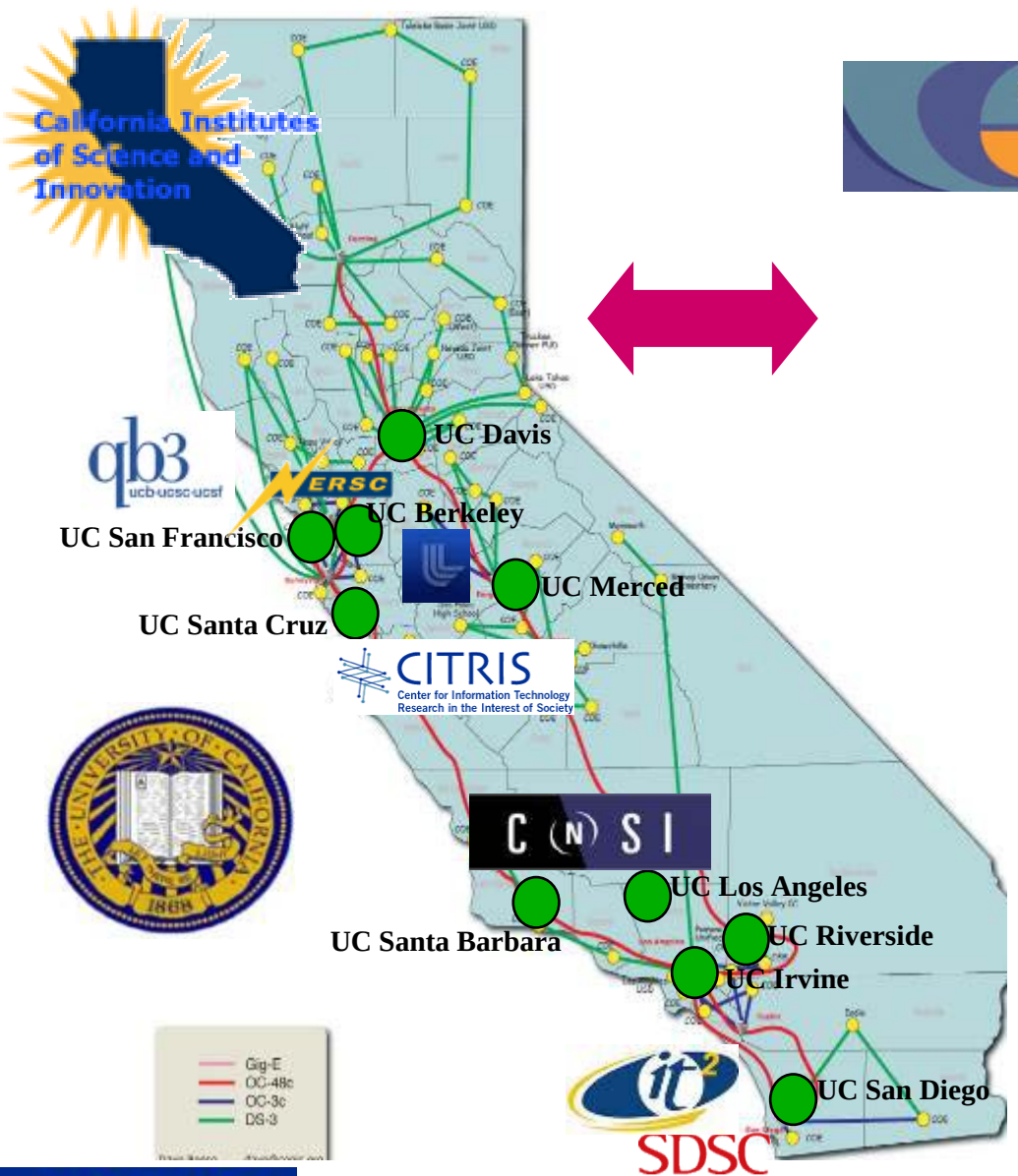
HD/4k Video Images

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Creating a California Cyberinfrastructure of OptIPuter "On-Ramps" to NLR, I2DC, & TeraGrid



NLR NATIONAL LAMBDARAIL

TeraGrid

Internet2 Network
Dynamic Circuit Network

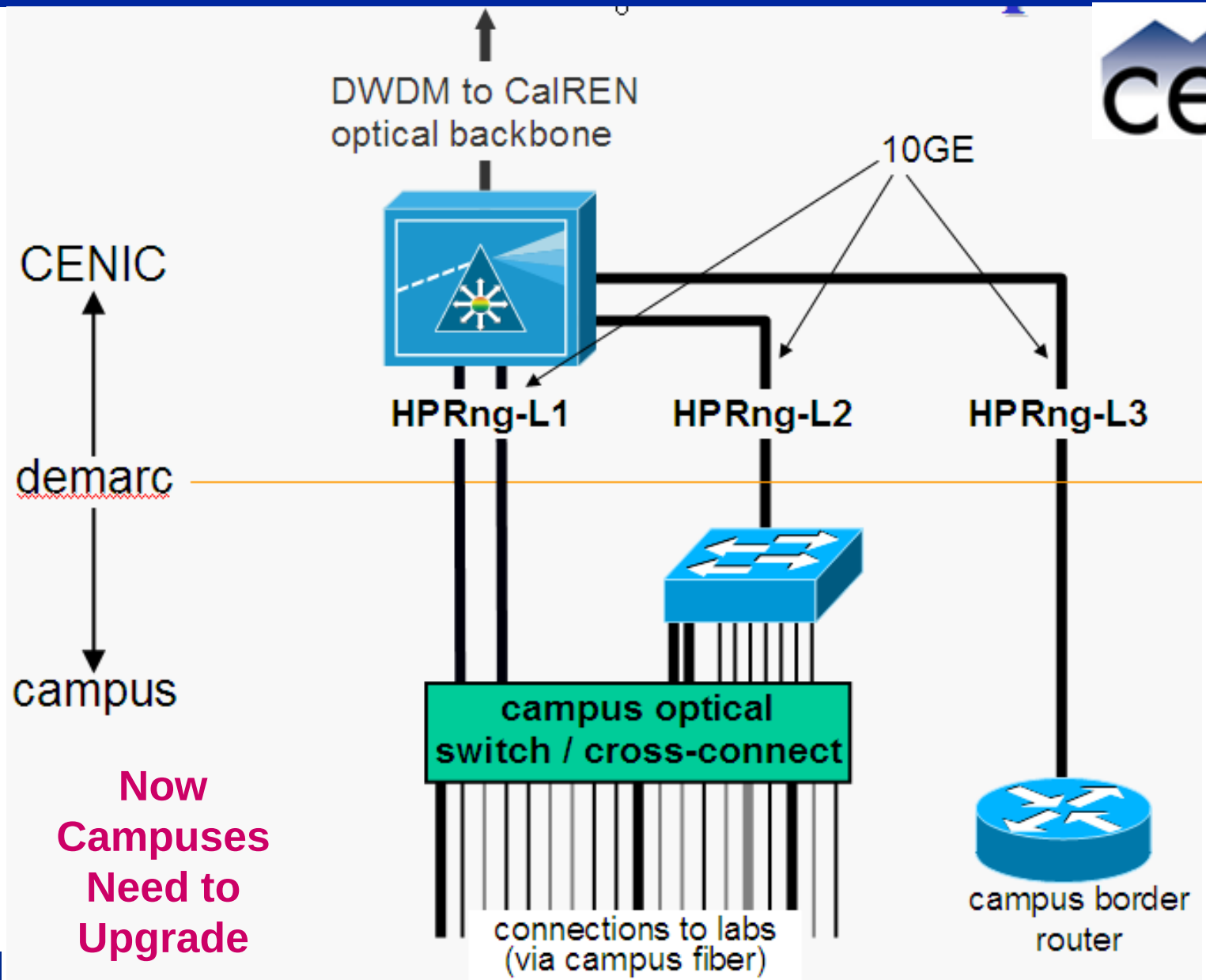
Creating a Critical Mass of OptIPuter End Users on a Secure LambdaGrid

CENIC Workshop at Calit2
Sept 15-16, 2008

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CENIC's New "Hybrid Network" - Traditional Routed IP and the New Switched Ethernet and Optical Services

CENIC Invested ~ $14M in Upgrade



Now Campuses Need to Upgrade

Source: Jim Dolgonas, CENIC

The "Golden Spike" UCSD Experimental Optical Core: Ready to Couple Users to CENIC L1, L2, L3 Services



Currently:

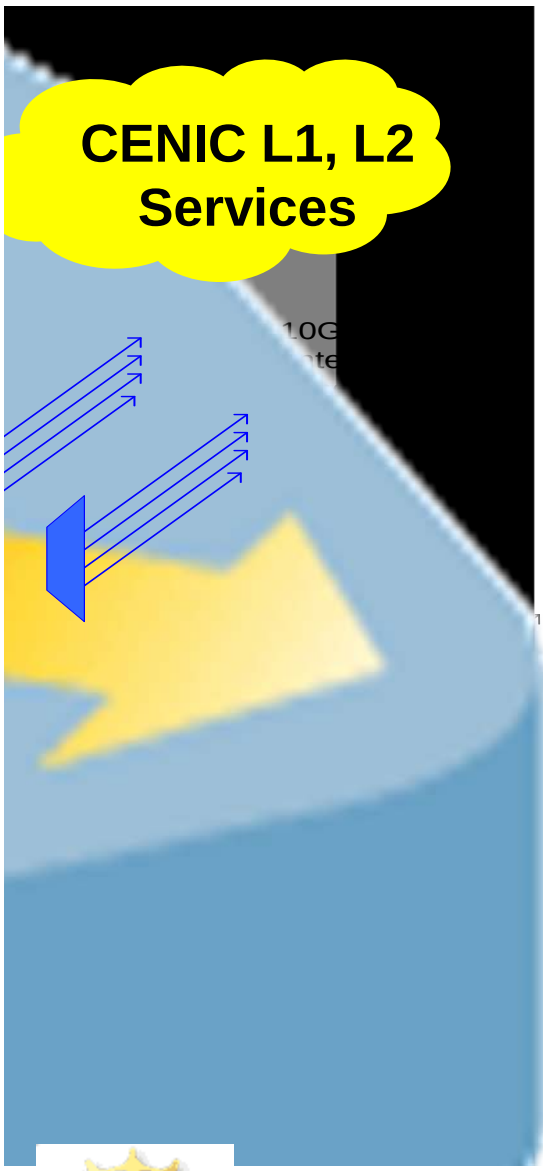
>= 60 endpoints at 10 GigE

>= 30 Packet switched

>= 30 Switched wavelengths

>= 400 Connected endpoints

Approximately 0.5 Tbps Arrive at the "Optical" Center of Hybrid Campus Switch



Funded by NSF MRI Grant

UCSD UCIrvine SDSC

Source: Phil Papadopoulos, SDSC/Calit2 (Quartzite MRI PI, OptIPuter co-PI)

NSF

it2

TritonResource:

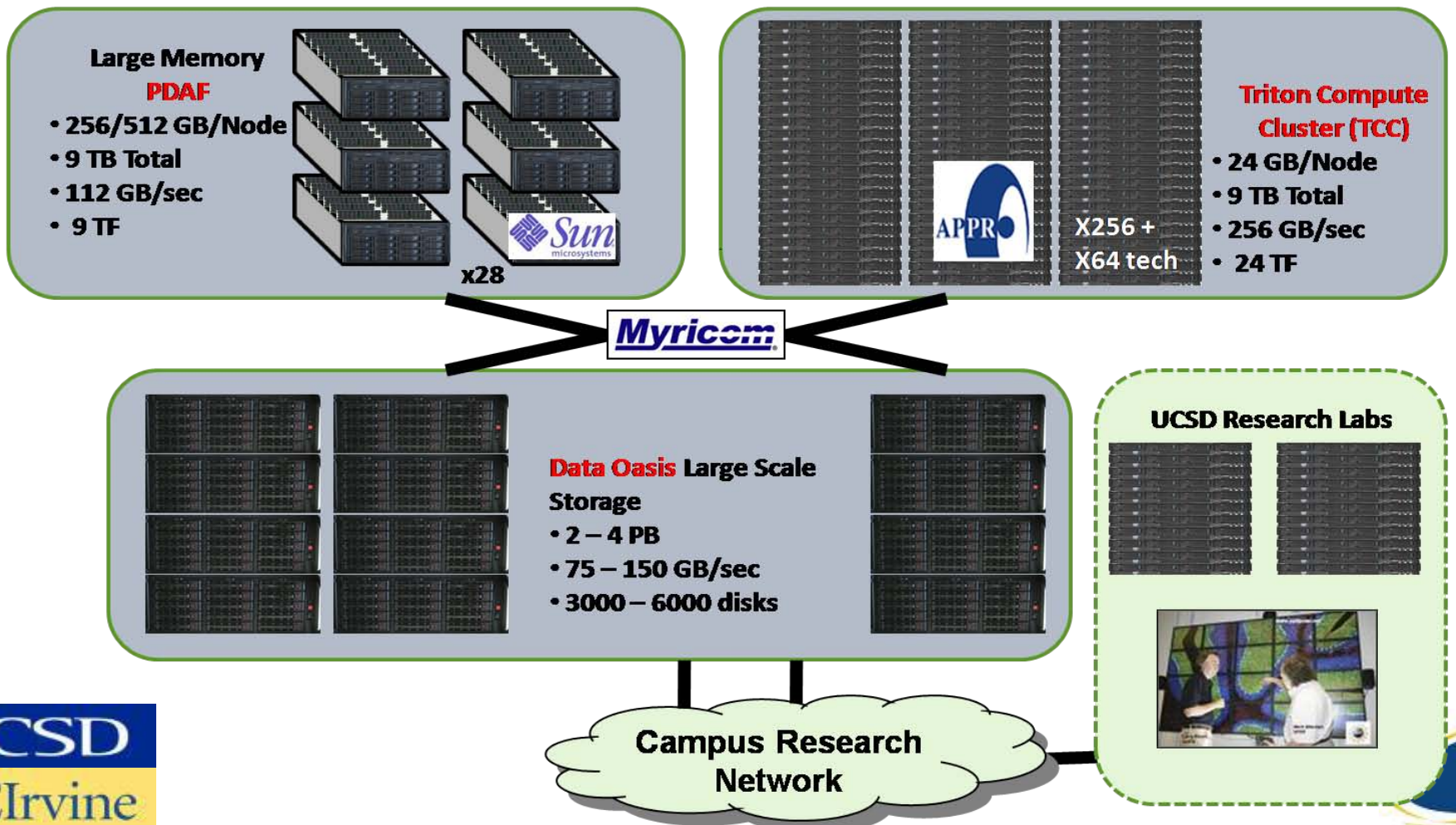
Expect initial production on compute systems ~June 2009
Data Oasis storage system expected fall 2009

SDSC

TRITON RESOURCE

Triton Resource Phase I Configuration

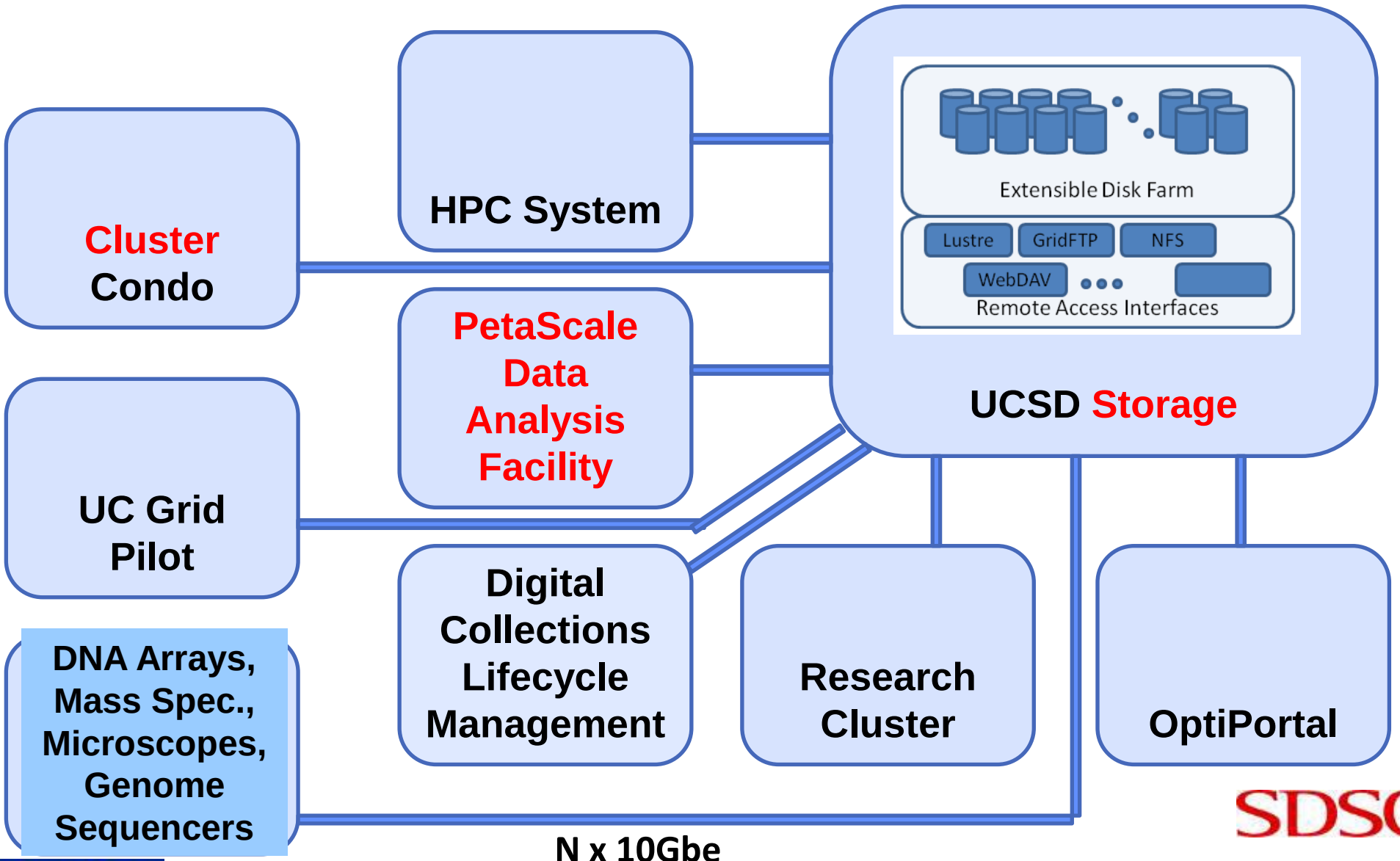
(Storage numbers subject to change)



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Campus Fiber Network Based on Quartzite Allowed UCSD CI Design Team to Architect Shared Resources



Source: Phil Papadopoulos, SDSC/Calit2