

The (Light) Path is NOT the Goal; The GOLE is the Goal!

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International Center for Advanced Internet Research, Northwestern University

IRNC:ProNet: TransLight/StarLight20 years of
NSF-Funded High-Performance International
Networking for Advanced Applications
(1995-2014)

IRNC TL/SL 3-Year Deliverables

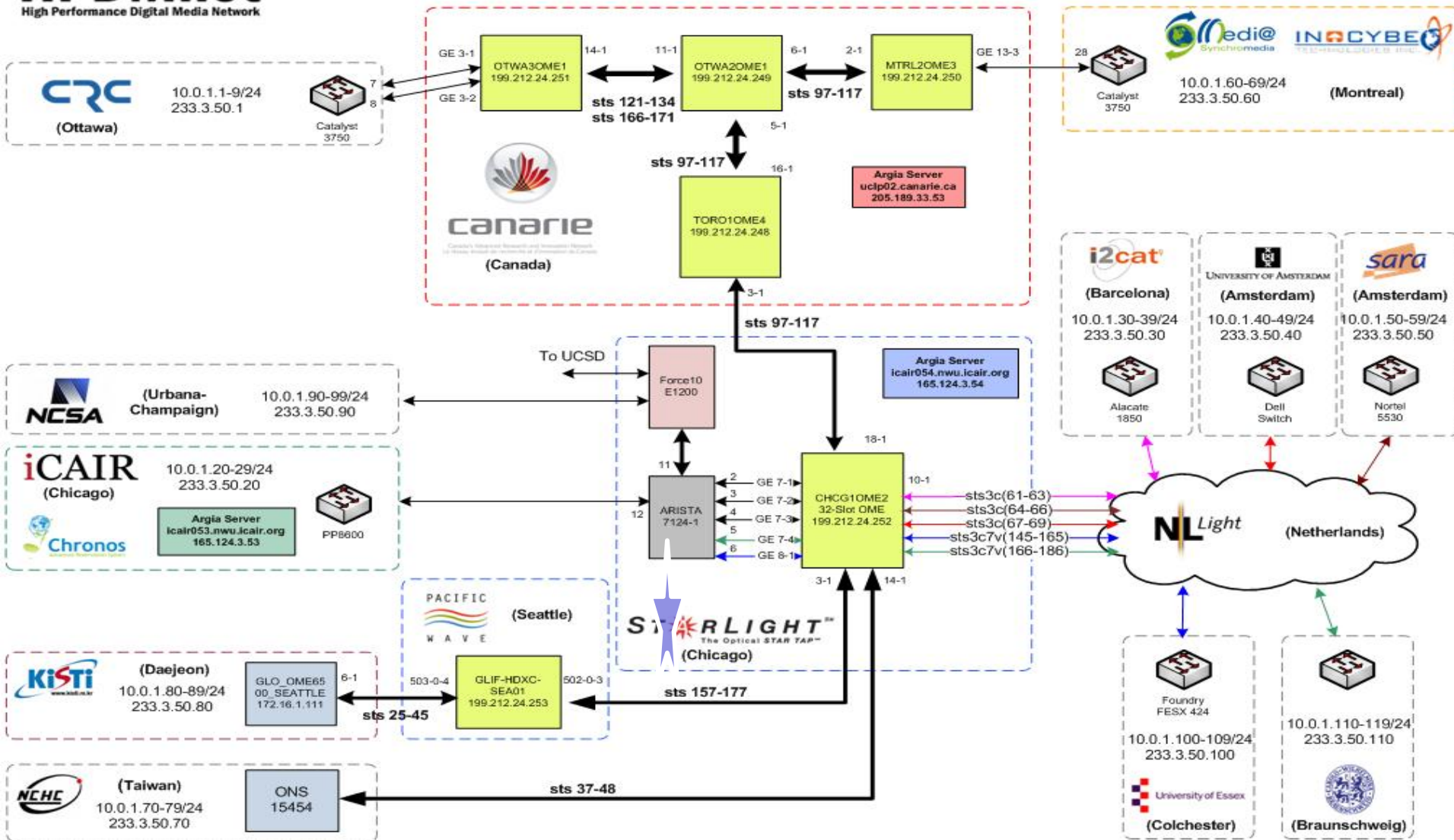
- Continue enabling multi-national application and middleware experiments on international networks
 - High-Performance Digital Media Network (HPDMnet)
 - iGENI: the GENI-funded international GENI project*
 - SAGE: connecting people and their data at high-res*
 - CineGrid: it's all about visual communications
 - GreenLight International: less watts/terabyte*
 - Science Cloud Communication Services Network (SCCSnet)*: the impending disruption
- Build cooperative partnerships (e.g. MSC-CIEC*)
- Serve GLIF, NLR, and I2 as senior leaders, reviewers
- New services, including many with industrial partners
- Create opportunities for all the students we support*

*Currently also funded by various NSF awards to UCSD/UIC/NU



High Performance Digital Media Network

HPDMnet
High Performance Digital Media Network



53 SAGE Collaborators Connect around the World

KISTI
Korea

GIST
Korea

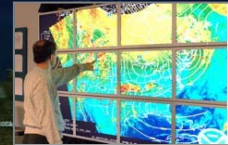
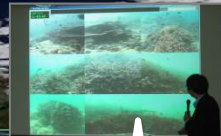
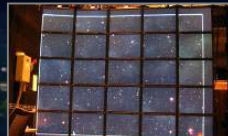
CNIC
China

NCHC
Taiwan

USGS
Sioux Falls

NCSA &
TRECC
Urbana

University
Michigan
Ann Arbor



Osaka
University
Osaka

AIST
Tokyo

Calit2
UCSD

EVL
Chicago

SARA
Amsterdam

Masaryk
University
Brno

Russian
Academy
Sciences
Moscow



DLF Map 2008: Global Lambda Integrated Facility

Visualization by Robert Patterson, NCSA, University of Illinois at Urbana-Champaign

Data Compilation by Maxine D. Brown, University of Illinois at Chicago

Earth Texture, via/leearth.nasa.gov

www.glif.is



Maxine Brown and Alan Verlo support SAGE for TL/SL



Science Cloud Communication Services Network (SCCSnet)

- The Science Cloud Communication Services Network assists projects that are developing high-performance communication services tailored for computational clouds used by data-intensive scientific applications.
- These projects are addressing the high-volume, high-performance national and international communication requirements of scientific computational clouds versus general consumer and enterprise clouds, which use the commodity Internet.

CineGrid Network Partners—Worldwide



AMPATH



CANARIE



CENIC



CESNET



CzechLight



Internet2



JANET (UK)



Japan Gigabit Network 2



National LambdaRail



NetherLight



NORDUnet



PacificWave



Pacific North West GigaPOP



RNP



SOL



StarLight



SURFnet



WIDE

CineGrid Network Partners provide bandwidth and open exchanges for computer science and engineering pre-commercial trials and experiments in labs, at conferences, and large-scale, multi-national demonstrations

CineGrid Founding Members Worldwide

CineGrid Founding Members



Cisco Systems



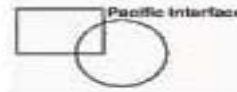
Keio University DMC



Lucasfilm Ltd.



NTT Network Innovation
Laboratories



Pacific Interface Inc.



Ryerson University/Rogers
Communications Centre



San Francisco State
University/INGI



Sony Electronics Inc.



University of Amsterdam



University of California
San Diego - Calit2/CRCA



University of Illinois at Urbana -
Champaign/NCSA



University of Illinois Chicago
EVL

More CineGrid Members—Worldwide

CineGrid at Calit2 December 12-15, 2010



University of Southern California
School of Cinematic Arts



University of Washington
Research Channel

CineGrid Exchange Global Archiving **with** iRods



Academy of Motion Picture



California Academy of Sciences



CPQD



CINEPOST, ACE Prague



Dark Strand



i2CAT Foundation



JVC America



KAIST Graduate School of Culture Technology



Louisiana State University/Center for Computation & Technology



Universidade Presbiteriana Mackenzie



Mechdyne Corporation



Meyer Sound Laboratories



Nortel Networks



Northwestern University



NPS



Poznan



Renaissance Center North Carolina



KTH - Royal Institute of Technology



SARA



Sharp Corporation Japan



Sharp Labs USA



Tulane University



Tohoku University



University of Manitoba



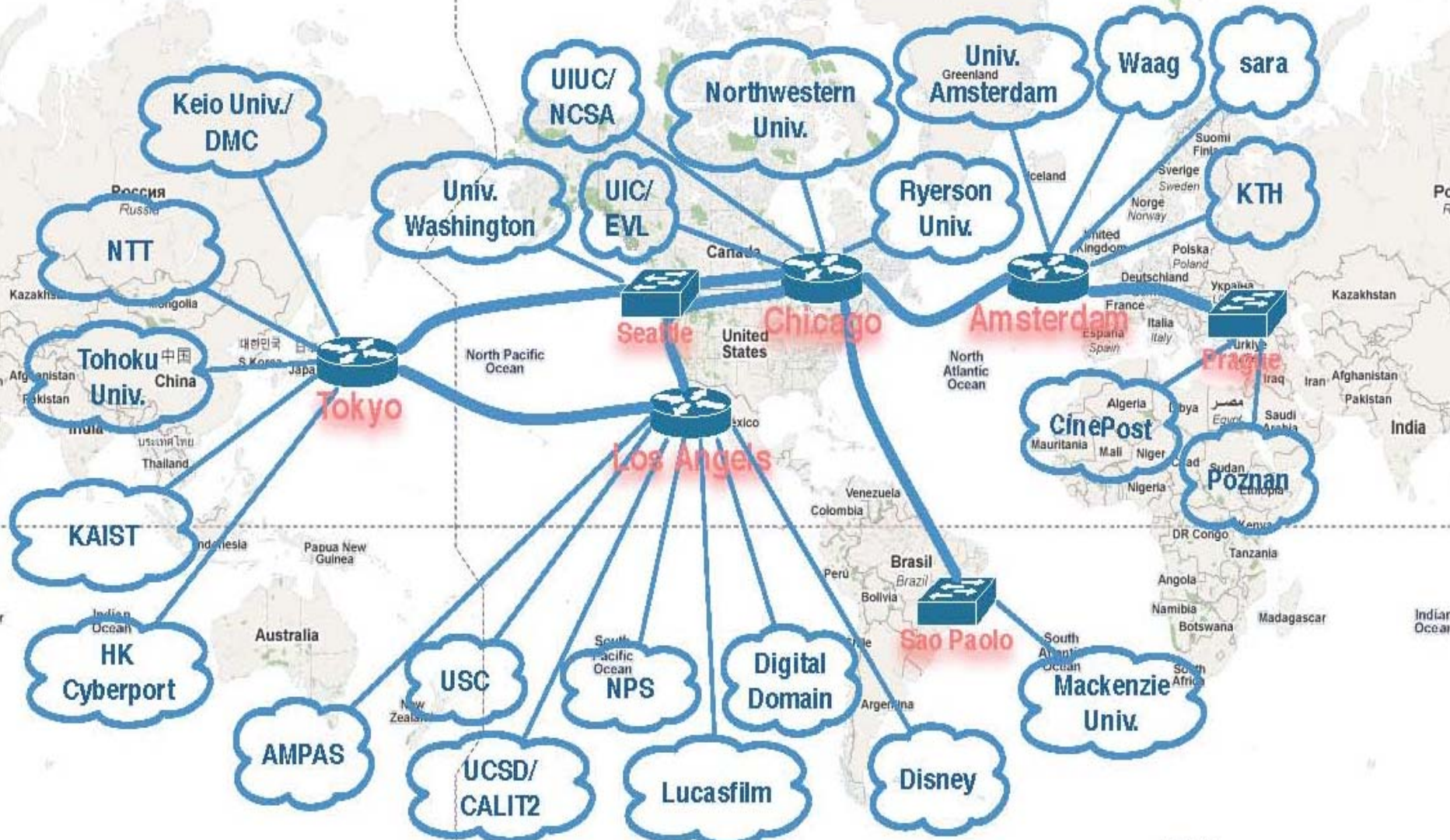
Waag Society

Digital media needs High Bandwidth: 30 fps UDP Pixel Streams with Known Latency

Streaming Video Type	Format	Bandwidth @30FPS
HDV uncompressed 4K JPEG compressed	720p RGB16 JPEG2000	~700 Mbps
HD video	1080p RGB16	~1 Gbps
HD animation	1080p RGB24	~1.5 Gbps
HD animation stereo	1080p RGB24	~3.0 Gbps
4K video & animation 4K with full meta data	2160p RGB24	~6.0 Gbps ~13-15Gbps

Can't prototype these trials with carriers; need short-term VLANs

CineGrid Network 2010



Network Resources are kindly provided by:

AMPATH, C-Wave, CANARIE, CaveWave, CENIC, CESNET, CzechLight, GEMNET, Internet2, JANET, JGN2plus, NetherLight, NLR, NORDUnet, PacificWave, PNWGP, RNP, StarLight, SOL, SURFnet, TransLight/StarLight, T-LEX, WIDE

UCSD Prof. Amin Vahdat Says:

- Computing and storage will be delivered by a relatively small number of international mega-scale data centers
- Much of the activity will be around networking within and between data centers
- Storage will be redesigned from the ground up
- Network fabric must keep up with end hosts *and* reduce energy consumption
 - Scheduling algorithms to leverage path diversity
 - Dynamic energy management; optics for energy-efficient networks
- How do we get a glimpse at what we need to know, as scientists and citizens, about IT energy consumption?

GLIMPSE





COVER

- o move world
- o move world trans
- o rot
- ing

- Live Stats
- o Systems Up/Down
 - o Power Consumption
 - o Temperature

- Selection
- Select All
 - All Servers (1)
 - All Switches (10)
 - All PCs (44)
 - All Unknown (1)
 - All Towers (1)

BlackBox Menu

- o R... Viewports Info
- o R... Information
- o R... Viewpoint
- o T... Flyby Tour
- o D... Stable Tour Mode
- o L... Stats
- o S... Deselect
- o S... any default
- o S... tourAround
- o T... selectorAround_i
- o T... amp... Grabif
- o T... amp... Around...
- o T... ish... tourAround_
- o C... awn... Chain Bor
- o c... am_aisle
- o
- o c... am_lastUserPositi

The GLIMPSE Dashboard

Dashboard interface

"Tap" for details

Power utilization

Enterprise reach

Multiple perspectives



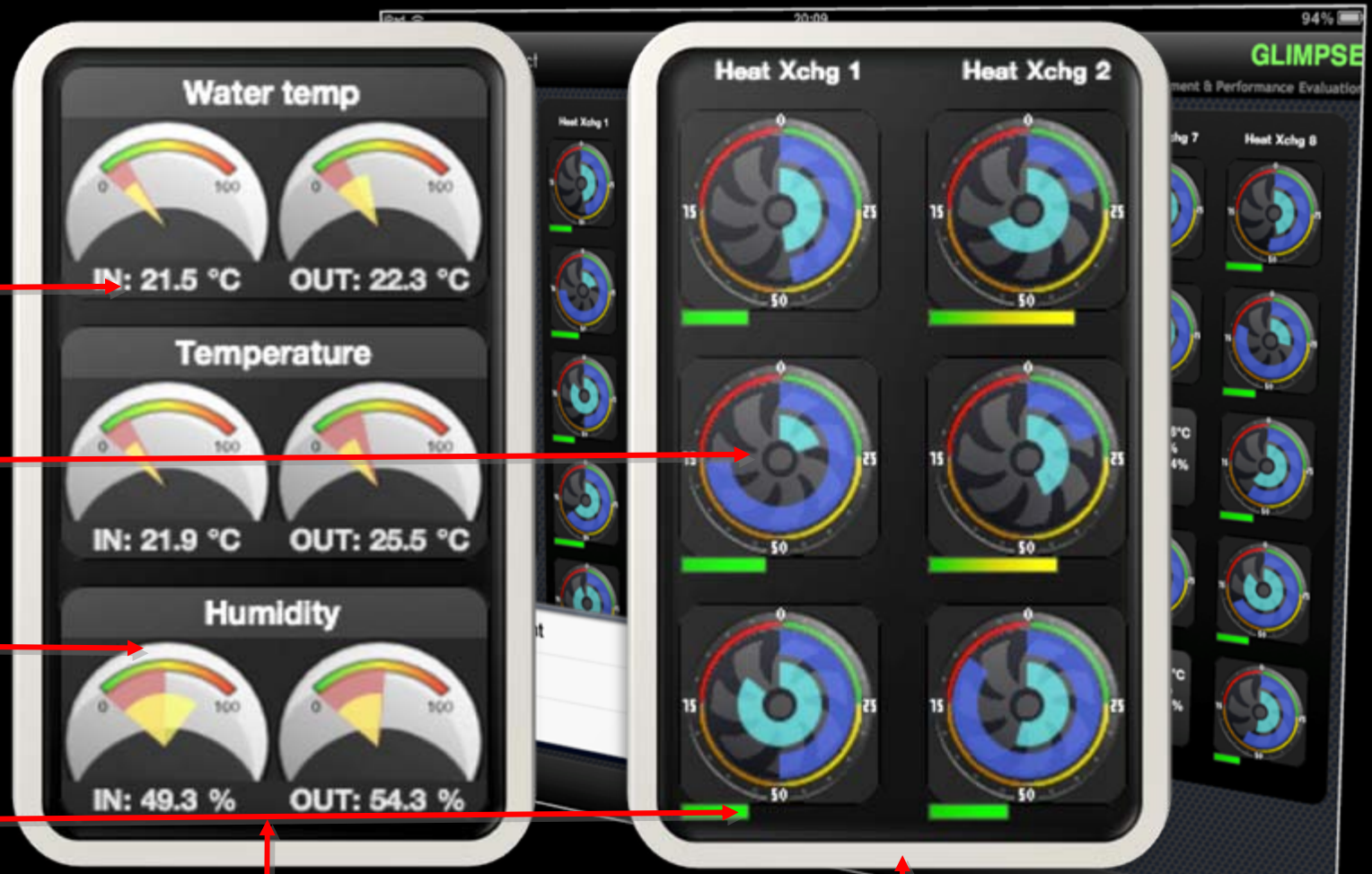
Datacenter vitals

Input/Output
sampling

Live/average
Fan speeds

Live/Average
data

Live
Temperature



Environmentals

Heat Exchangers

Domain specific views

iPad

20:08

94%

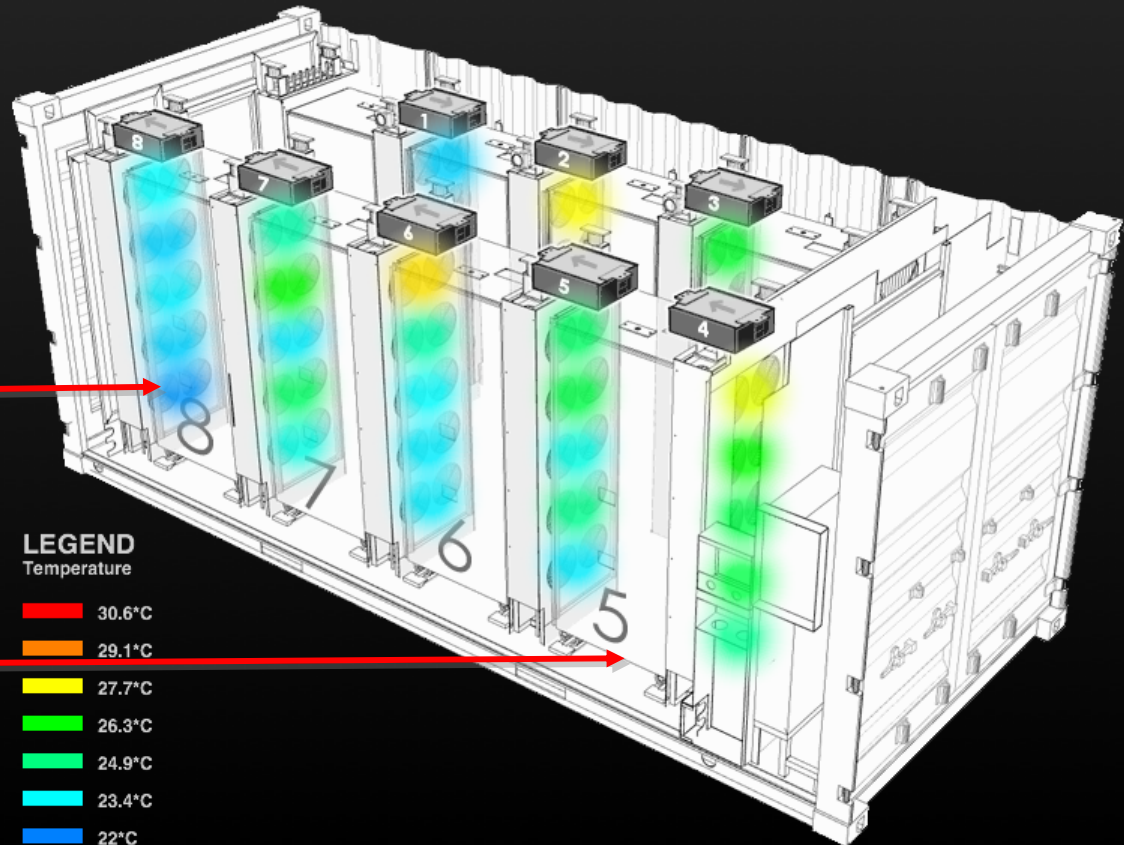


GreenLight Project

Heatmap

GLIMPSE

GreenLight Infrastructure Management & Performance Evaluation



Control elements



Real-time heatmap



Realistic models

UCSD/GreenLight



TRANS LIGHT



Airflow dynamics

iPad

20:08

94%



GreenLight Project

Heatmap

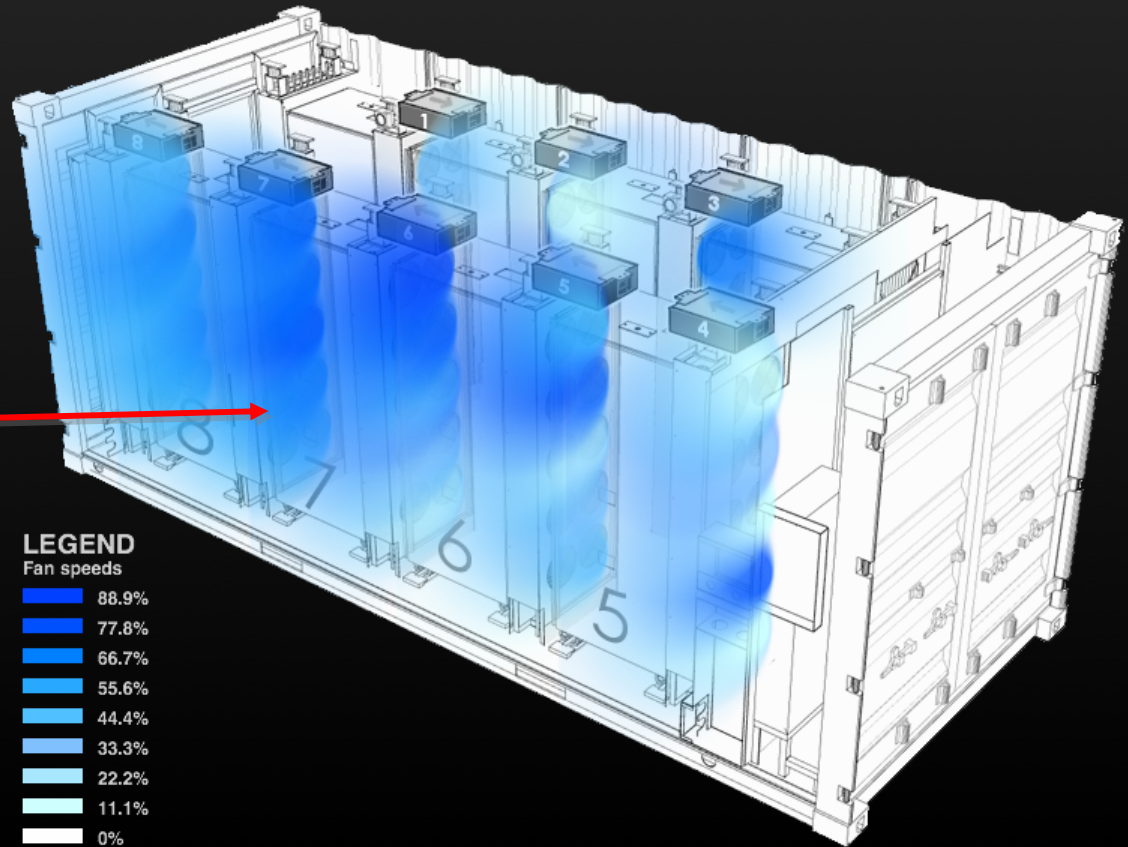
GLIMPSE

GreenLight Infrastructure Management & Performance Evaluation

Live fan speeds



Airflow dynamics



LEGEND

Fan speeds

- 88.9%
- 77.8%
- 66.7%
- 55.6%
- 44.4%
- 33.3%
- 22.2%
- 11.1%
- 0%

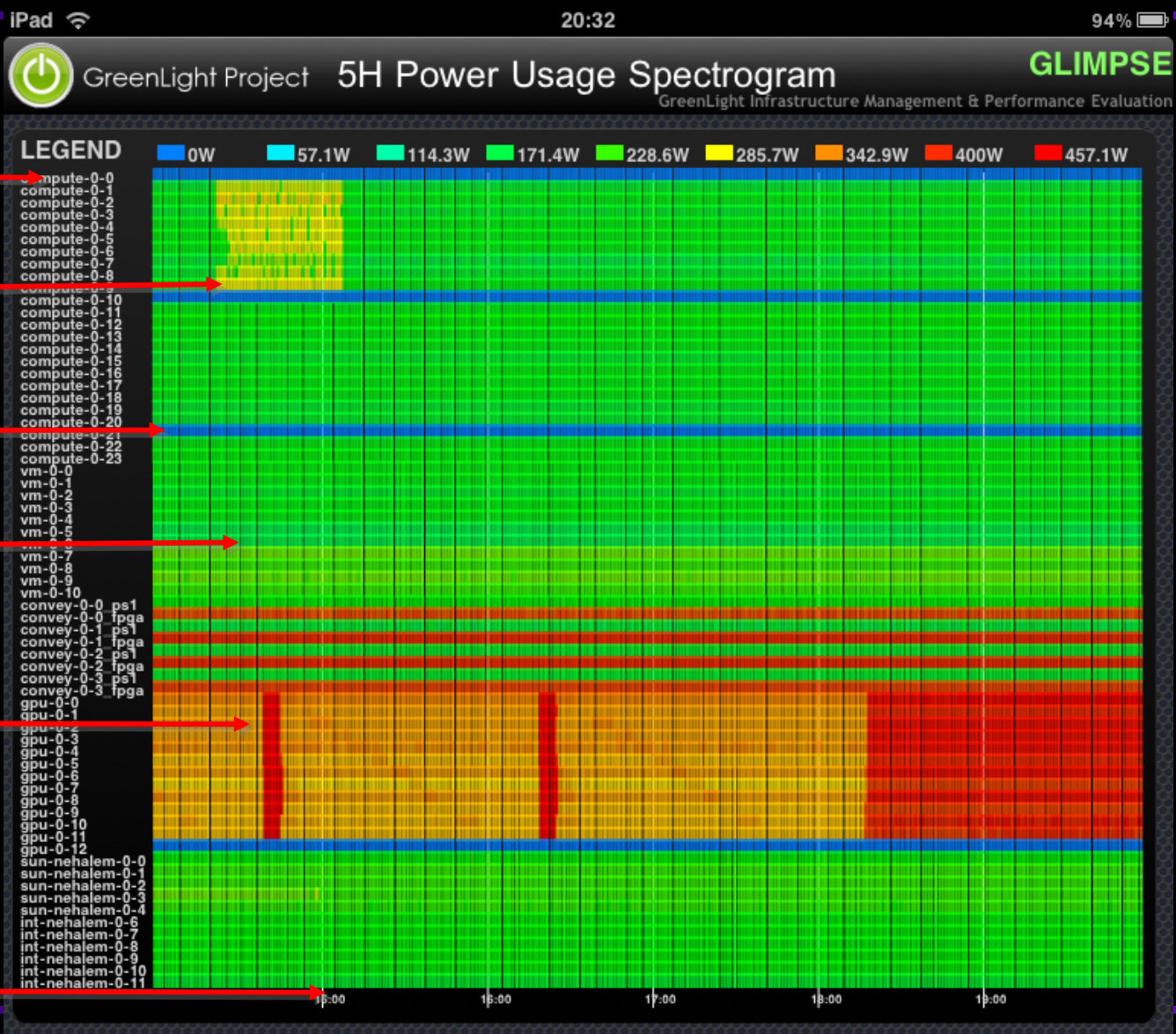
UCSD/GreenLight



TRANS LIGHT



Power spikes



Zoom-in Analysis



History over several days.

Zoom on desired time range.

Hint on each sample point.

Automatic average area.

Multiple sensors per asset with up to 1 min sampling resolution.

The Gospel According to St. Arnaud

As I have often said the problem facing this planet is not energy consumption but the type of energy we consume. So while a more energy efficient data center or lower PUE will be of interest to data center operators, it does absolutely nothing in reducing GHG gases.

The Canadian Standards Association is developing standards for reducing carbon impact of data centers (as opposed to energy consumption). Fortunately many of the measurements and techniques are the same as measuring energy efficiency and so GreenLight and your IRNC project can play a critical role in helping address the bigger challenge of saving the planet.

For example in the UK because of carbon taxes (CRC) many datacenter operators including those at universities are looking to relocate their data centers off shore. This of course means high speed optical networks.

--Bill St. Arnaud, September 26, 2010

GreenLight Extended to Networks: Watts/TB

- Current GreenLight/SDSC/Calit2 switches: accurate measurement of energy cost of networks between servers
 - Ethernet PDUs supply energy measurements
 - Combine with bandwidth statistics on per link basis
 - 100G switches will be instrumented with installation
- WAN terrestrial/undersea costs in long-distance watts/TB
 - More complex: measuring off-campus involves access to production equipment administered by many entities
 - For undersea circuits, the NSF/UCSD OOI initiative will calibrate and measure the energy costs for underwater equipment in our labs
- GreenGLIF members have software and hardware access to long-distance transmission equipment

Networks Will Reduce Green House Gases

- TL/SL's green and transformative initiatives use high-definition and 4K videoconferencing, reducing air travel*
- Cloud computing may offer 10-20x work/watt efficiency
 - Virtualization and software optimizations
 - Much better total life-cycle cost management than universities
 - Powering of servers in more carbon-neutral facilities
 - Amazon EC2 data & compute (now in service for OOI, connected to CENIC/PNWGP and beyond)
 - Enhances University ICR; reduces carbon offset payments
 - See Jayant Baliga, et al. "Green Cloud Computing: Balancing Energy in Processing, Storage and Transport." *Proceedings of the IEEE*. To be published. [DOI:10.1109/JPROC2010.2060451](https://doi.org/10.1109/JPROC2010.2060451)
- Of course, the best GHG-reducing applications are yet to be conceived and tested! Stay tuned!
- We would like to discuss ideas with people here at GLIF

*Tom's air travel here: ~1.5 kW for a year

TL/SL Needs Help from GLIF GOLEs

- Connect between GOLEs with colocation space
- Make space available for power measurement
- Support persistent bandwidth at all layers to reach our global partners
- Focus on end-to-end performance and advanced services at leading-edge sites and facilities
- Train the next generation of network engineers and application scientists
- Paths are transient; GOLEs are the Goal!

Thanks, GLIF, for 10 Years of GOLEs!

- TL/SL and its loyal constituency look forward to years of collaboration and cooperation GLIF
- The future's so bright we'll have to wear shades!



Thank You Very Much!

- Our R&E efforts are made possible, in major part, by funding from:
 - US National Science Foundation (NSF) awards OCI-0962997, SCI-0441094, and CNS 0821155
 - State of California, Calit2 UCSD Division
 - State of Illinois I-WIRE Program, and major UIC and NU cost sharing
 - KAUST
- University of Illinois at Chicago, Argonne National Laboratory, and Northwestern University for StarLight networking and management
- National Lambda Rail, Pacific Wave and CENIC
- NTT Network Innovations Lab
- Pacific Interface, Inc.
- Cisco Systems, Inc.
- Darkstrand, Inc.
- Sharp Labs of America