# Sensornets and Global Change

**Invited Talk**
**Greenovation Forum: Sensing and Sustainability**
**Calit2@UCSD**
**December 2, 2009**

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Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD

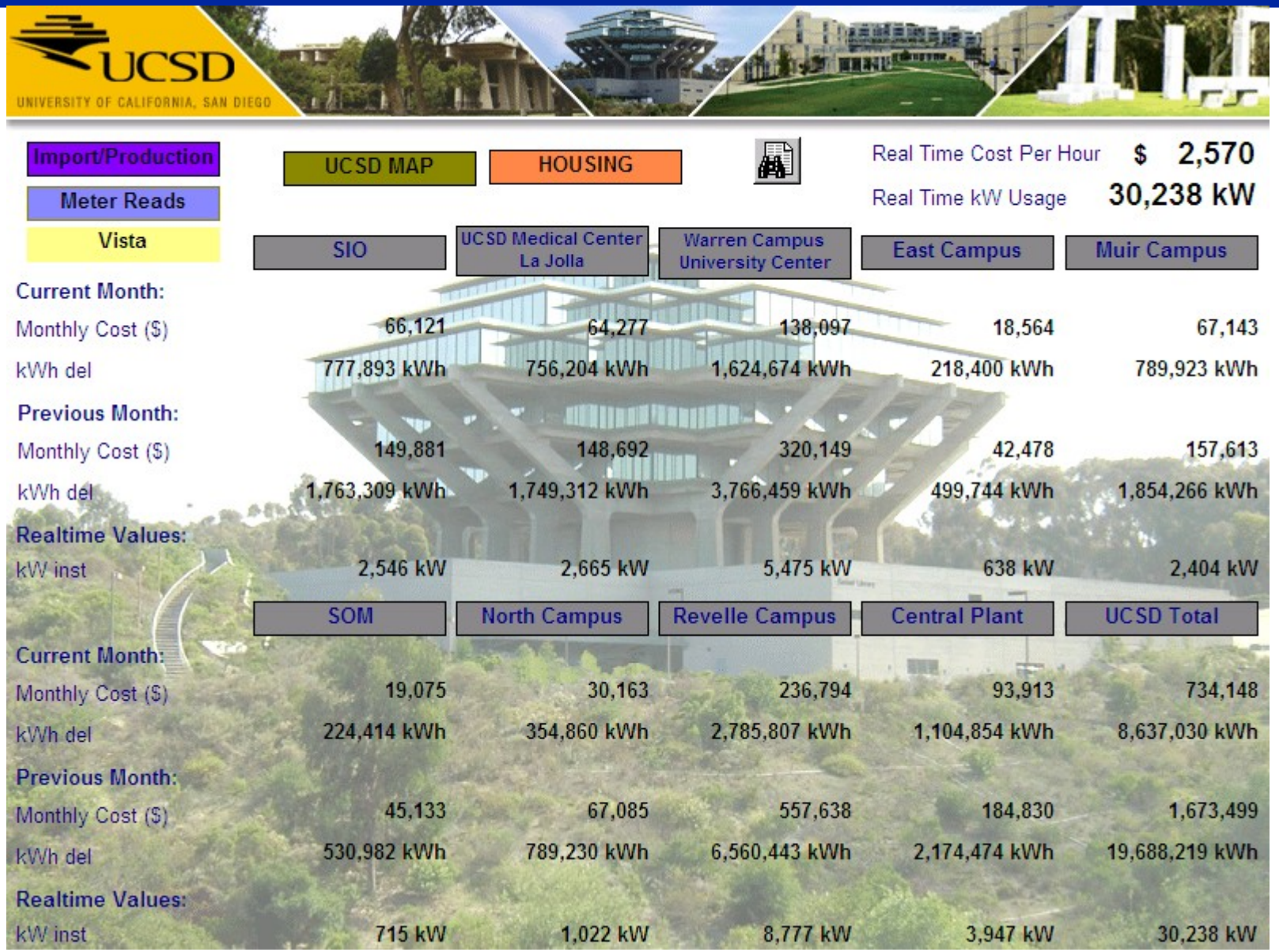
Follow me on Twitter: http://twitter.com/lsmarr

# San Diego Examples of Sensornets for Sustainability

- Building Sensing
- Wildfire Sensing
- What is a Sensornet?
- Coastal Sensing

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




| | 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 |

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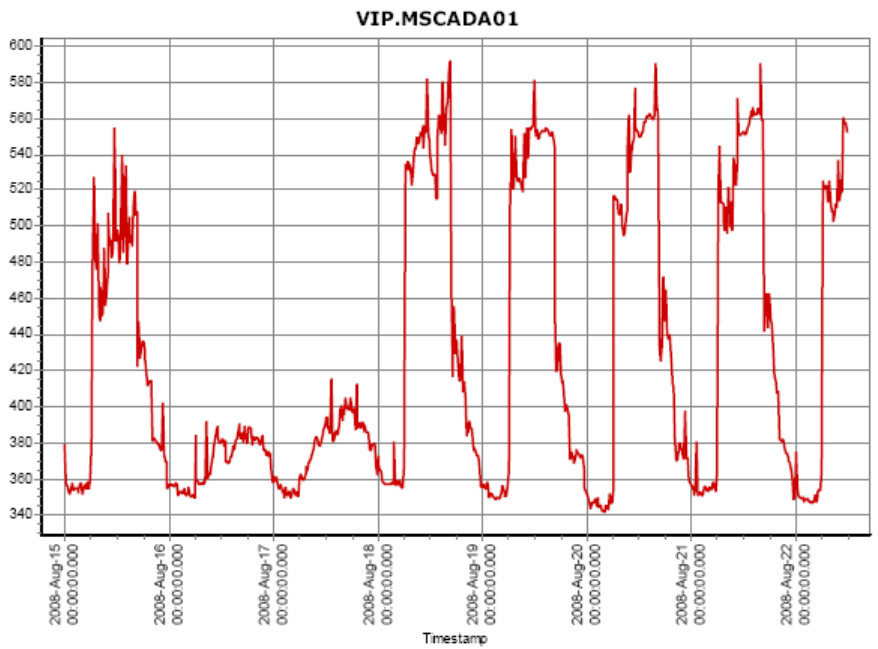
http://mscada01.ucsd.edu/ion/

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
- 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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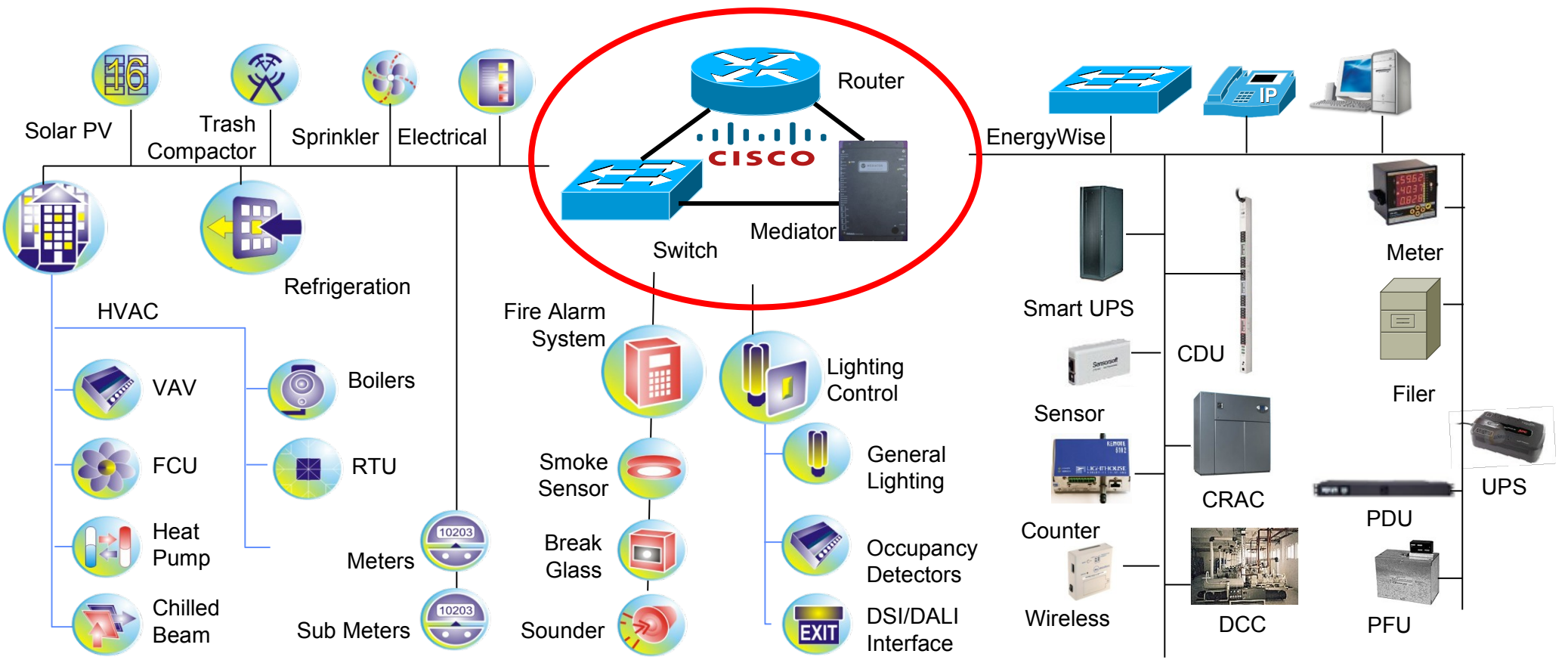
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# Cisco Vision: Mediating the Smart Building

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

## Open XML Interface

## Network as a Platform to Connect, Aggregate and Normalize

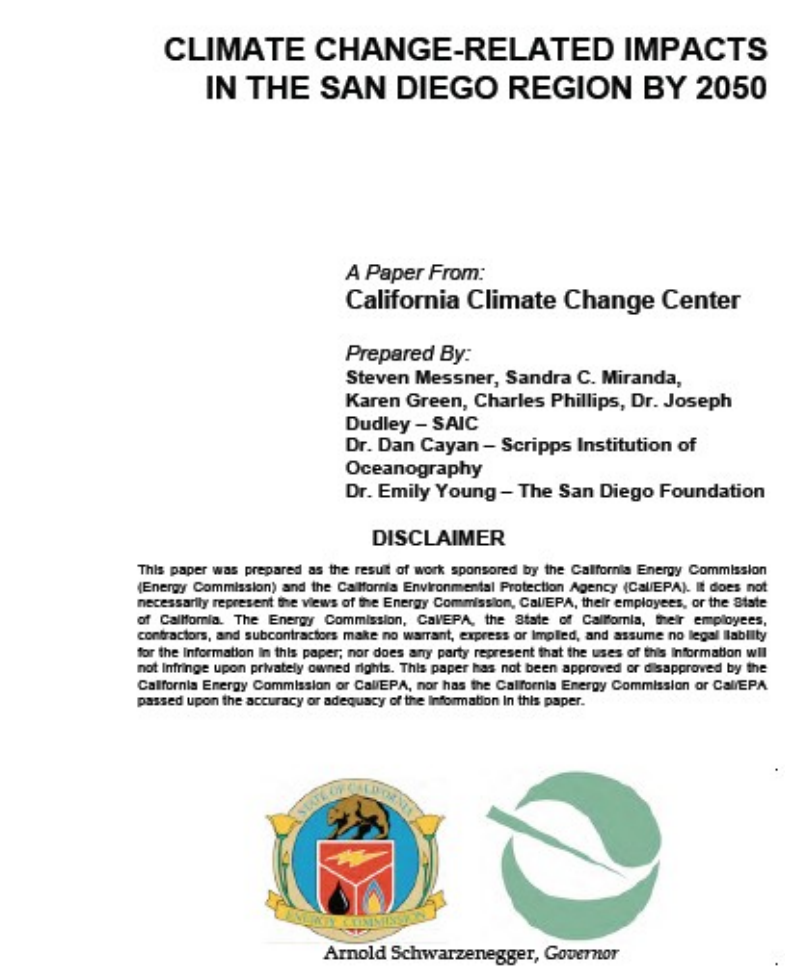



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Source: Dave Clute, Cisco Connected Real Estate

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# Climate Change Will Pose Major Challenges to California in Water and Wildfires



CLIMATE CHANGE-RELATED IMPACTS
IN THE SAN DIEGO REGION BY 2050

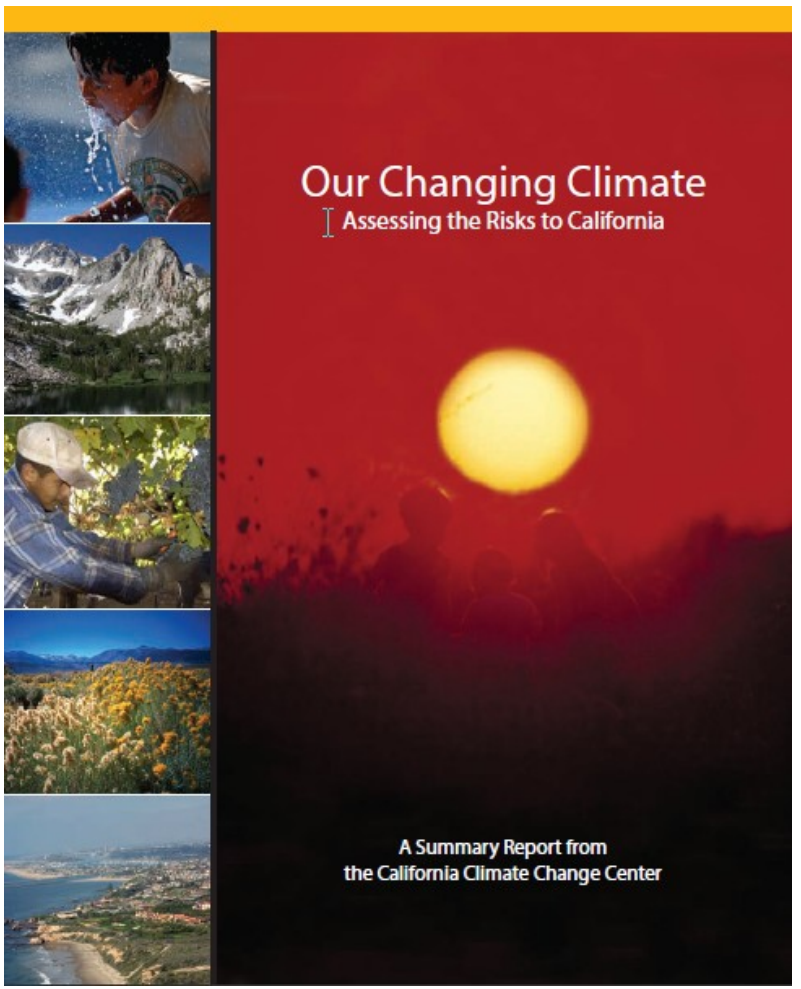
*A Paper From:*
**California Climate Change Center**

*Prepared By:*
**Steven Messner, Sandra C. Miranda, Karen Green, Charles Phillips, Dr. Joseph Dudley – SAIC**
**Dr. Dan Cayan – Scripps Institution of Oceanography**
**Dr. Emily Young – The San Diego Foundation**

**DISCLAIMER**

This paper was prepared as the result of work sponsored by the California Energy Commission (Energy Commission) and the California Environmental Protection Agency (Cal/EPA). It does not necessarily represent the views of the Energy Commission, Cal/EPA, their employees, or the State of California. The Energy Commission, Cal/EPA, the State of California, their employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this paper; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This paper has not been approved or disapproved by the California Energy Commission or Cal/EPA, nor has the California Energy Commission or Cal/EPA passed upon the accuracy or adequacy of the information in this paper.

Arnold Schwarzenegger, *Governor*




"It is likely that the changes in climate that San Diego is experiencing due to the warming of the region will increase the frequency and intensity of fires even more, making the region more vulnerable to devastating fires like the ones seen in 2003 and 2007."

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California Applications Program (CAP) & The California Climate Change Center (CCCC)
CAP/CCCC is directed from the Climate Research Division, Scripps Institution of Oceanography

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# Using Sensornets to Accelerate Response to Wildfires



Early on October 23, 2007, Harris Fire San Diego

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Photo by Bill Clayton, http://map.sdsu.edu/

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# NASA's Aqua Satellite's MODIS Instrument Provided "Situational Awareness" of the 14 SoCal Fires

Calit2, SDSU, and NASA Goddard Used NASA Prioritization and OptIPuter Links to Cut time to Receive Images from 24 to 3 Hours




Moderate Resolution Imaging Spectroradiometer (MODIS)

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*NASA/MODIS Rapid Response*
www.nasa.gov/vision/earth/lookingatearth/socal_wildfires_oct07.html

it²

# MODIS Images Provide Targeting Information to NASA's EO-1 Satellite Which Cuts Through Smoke

Composite of the
Red, Blue, and Green Channels



Three of the
Shortwave Infrared Channels



October 23, 2007 Witch Wildfire south of Escondido, California

EO-1's Hyperion Spectrometer Observes 220 Contiguous Wavelengths
From Visible Light To Shortwave Infrared

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*NASA/EO-1 Team*
www.nasa.gov/vision/earth/lookingatearth/socal_wildfires_oct07.html

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# 1/3 Billion Pixel OptIPortal Linked to NASA Goddard Earth Satellite Images of October 2007 Wildfires



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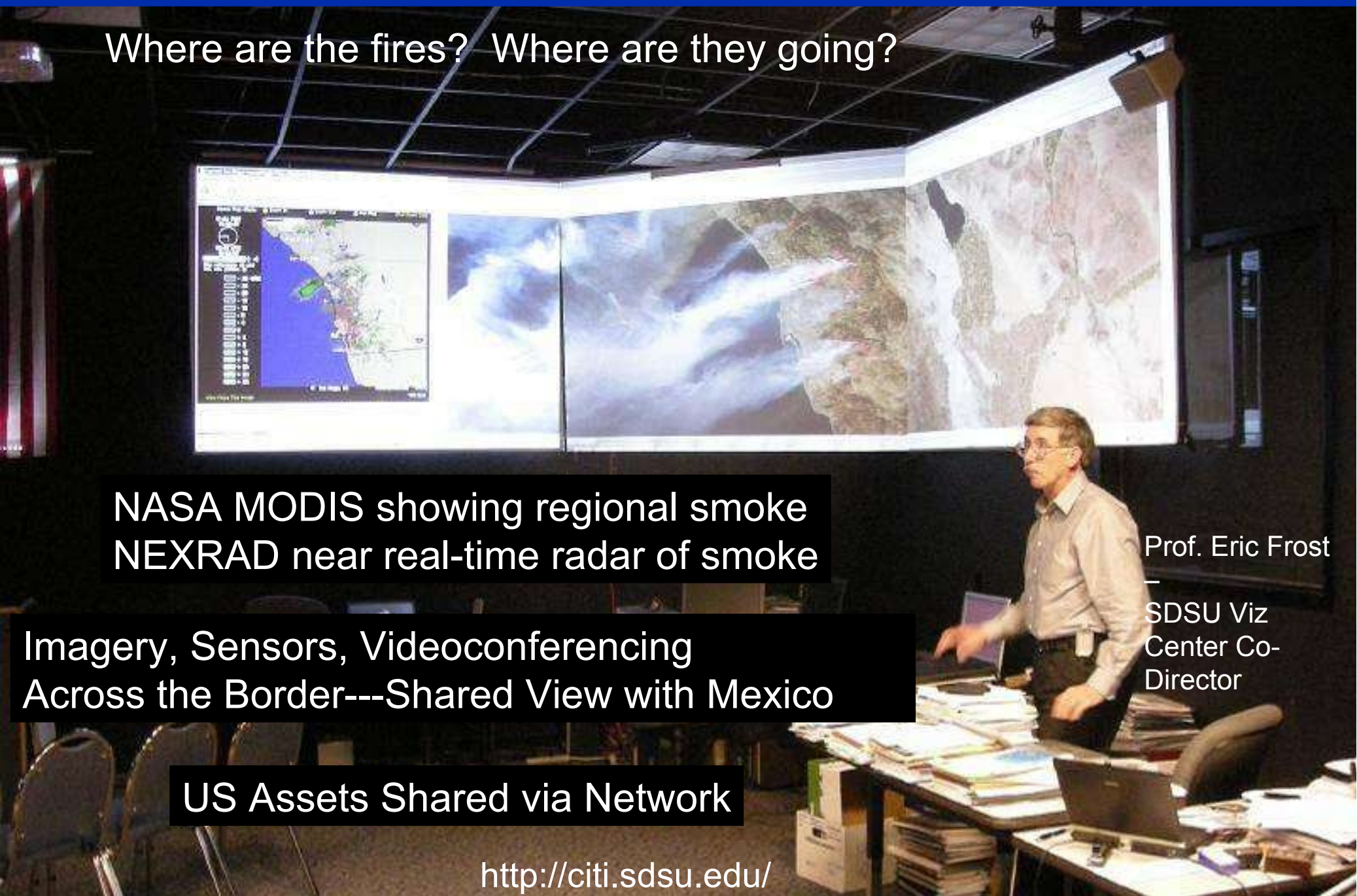
Powered by Rocks ROCKS

Source: Falko Kuester, Calit2@UCSD

CGLX

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# Prototyping Future Knowledge Integration Center for Emergency Response





High Performance Wireless Research and Education Network

http://hpwren.ucsd.edu/

National Science Foundation awards 0087344 and 0426879

HPWREN

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

UCSD

SAN DIEGO STATE UNIVERSITY

NSF

# HPWREN Topology, August 2008



Hans-Werner Braun,
HPWREN PI

PSAP
WIDC
KYVW
COTD
KNW
B08
1
BDC
PFO
GVDA
Santa
Rosa
WMC
RDM
AZRY
CRY
SND
BZN
FRD
KSW
SMER
P474
SO
DHL
SLMS
MPO
LVA2
SCS
BVDA
GLRS
P486
P478
MTGY
MVFD
P510
P483
CRRS
WLA
GMPK
DSME
RMNA
CWC
USGC
P506
P499
P480
P509
CE
MONP
UCSD
MLO
P497
DESC
P494
70+ miles
to SCI
IID2
P473
SDSU
P500
POTR
P066

155Mbps FDX 6 GHz FCC licensed
155Mbps FDX 11 GHz FCC licensed
45Mbps FDX 6 GHz FCC licensed
45Mbps FDX 11 GHz FCC licensed
45Mbps FDX 5.8 GHz unlicensed
45Mbps-class HDX 4.9GHz
45Mbps-class HDX 5.8GHz unlicensed
~8Mbps HDX 2.4/5.8 GHz unlicensed
~3Mbps HDX 2.4 GHz unlicensed
115kbps HDX 900 MHz unlicensed
56kbps via RCS network

dashed = planned

approximately 50 miles:

For Live Cameras See:
http://hpwren.ucsd.edu/cameras/

HPWREN
High Performance Wireless Research & Education Network

- Backbone/relay node
- Astronomy science site
- Biology science site
- Earth science site
- University site
- Researcher location
- Native American site
- First Responder site

# Calit2 Added Live Feeds From HPWREN Cameras to KPBS Google Map




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# What is a SensorNet?

- **Sensors**
  - Physical, Chemical, Biological, Imaging,…
- **Sensor Platform**
  - Computing, Power, Storage, Radios, …
- **Telecommunications Infrastructure**
  - Wired, Wireless, Internet, …
- **Sensor Arrays**
  - Homogeneous, Inhomogeneous, Ad Hoc, …
- **Backend Data Systems**
  - Storage, Compute, Analysis, Visualization

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# Creating Environmental Observatories – Combining OptIPortals with DataTurbine








- **Streaming Data Middleware System Satisfies Common Critical Infrastructure Requirements Across NSF-Sponsored Observing Systems:**
  - **Framework for Integration of Heterogeneous Instruments with Reliable Real-Time Data Transport**
  - **Sensors /Sensor Streams Become First-Class Objects**
  - **Comprehensive Suite Of Services For Data Management, Routing, Synchronization, Monitoring, and Visualization**
- **All-Software Solution (Java)**
  - **Open Source Software- Apache 2.0 License**
- **Used In NSF, NASA, NOAA, DOE Projects**
  - **NSF Support from SDCI program (Sept 07)**

OPEN SOURCE DATA TURBINE INITIATIVE

*Empowering the Scientific Community with Streaming Data Middleware*

Source: Tony Fountain, Sameer Tilak, Calit2

www.dataturbine.org

UCSD UCIrvine Gordon and Betty MOORE FOUNDATION CREON GLEON global lake ecological observatory network PRAGMA it2

# Streaming Underwater Video Sensors From Taiwan's Kenting Reef to Calit2

My next plan is to stream stable and quality underwater images to Calit2, hopefully by PRAGMA 14. -- Fang-Pang to LS Jan. 1, 2008



CREON

March 6, 2008 Plan Accomplished!

ROCKS

NSF

SAGE

OPEN SOURCE DATA TURBINE INITIATIVE

Empowering the Scientific Community with Streaming Data Middleware

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UCSD: Rajvikram Singh, Sameer Tilak, Jurgen Schulze, Tony Fountain, Peter Arzberger
NCHC : Ebbe Strandell, Sun-In Lin, Yao-Tsung Wang, Fang-Pang Lin

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# Towards a Total Knowledge Integration System for the Coastal Zone—SensorNets Linked to Fiber Cable

- Moorings
- Ships
- Autonomous Vehicles
- Satellite Remote Sensing
- Drifters
- Long Range HF Radar
- Near-Shore Waves/Currents
- COAMPS Wind Model
- Nested ROMS Models
- Data Assimilation and Modeling
- Data Systems

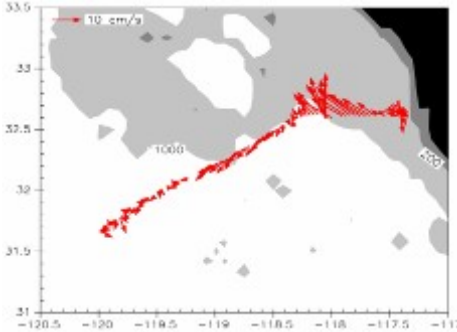



NOAA

NSF

ROADNet

COCMP
Coastal Ocean Currents Monitoring Program





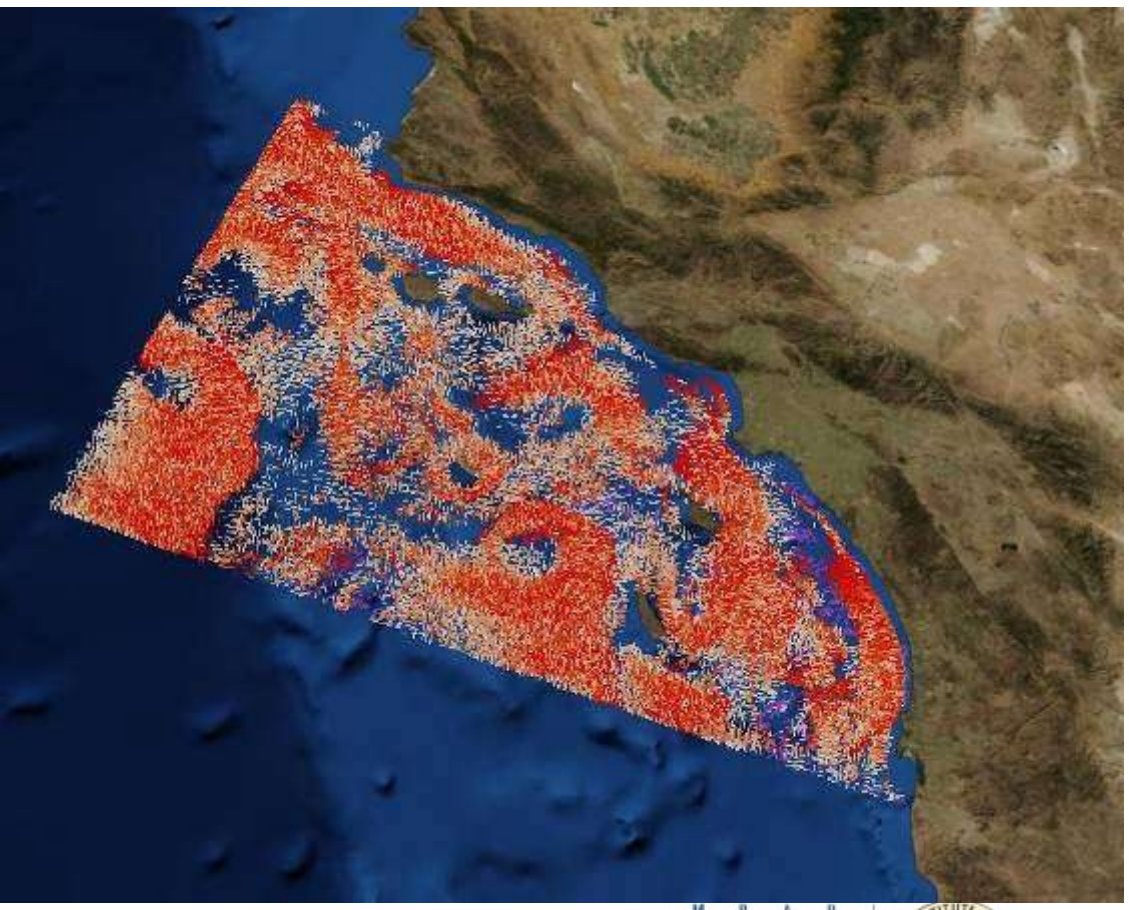
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www.sccoos.org/

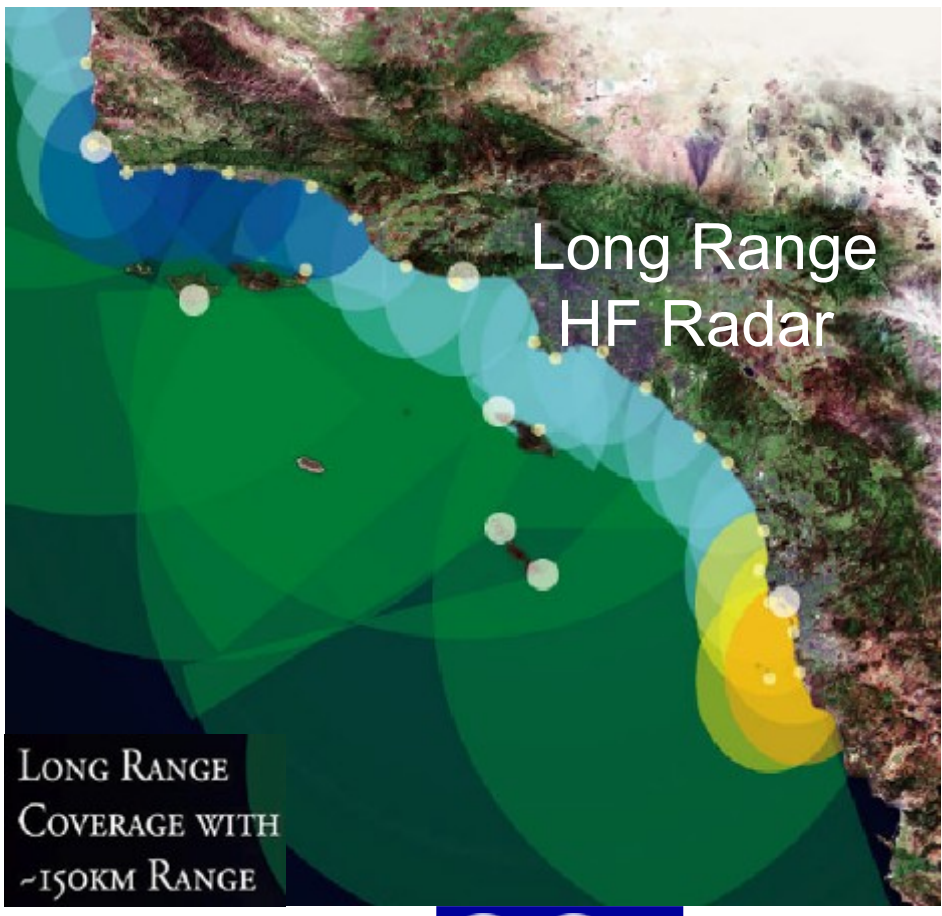
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# Coupling Data Assimilation Models to Remote Sensor Nets in Near Real Time

Visualization: Philip Weber, Matthew Arrott, Calit2



Source: SCCOOS




JPL ONR MBARI CALIFORNIA INSTITUTE OF TECHNOLOGY

OOI OCEAN OBSERVATORIES INITIATIVE

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Regional Ocean Modeling System (ROMS)

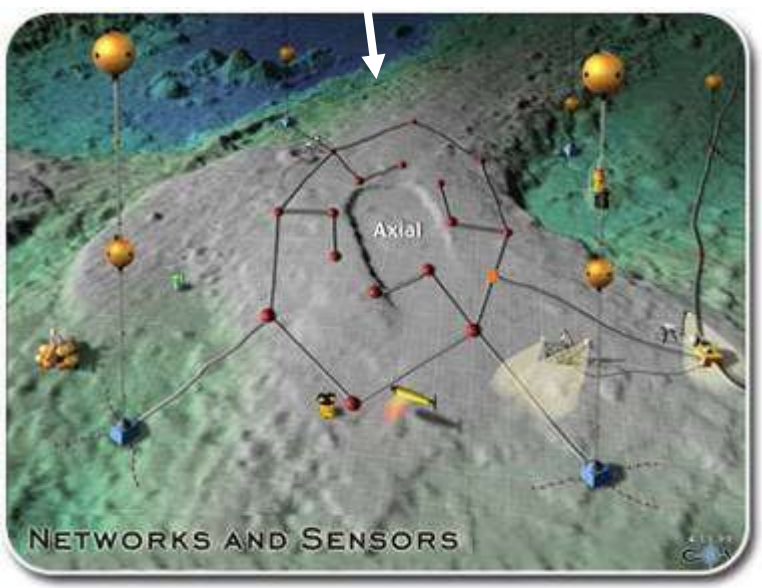
http://ourocean.jpl.nasa.gov/

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# The Ocean Observatories Initiative (OOI) -- a Networked Infrastructure Of Science-Driven Sensor Systems




CONSORTIUM FOR
Ocean Leadership
DISCOVERY • UNDERSTANDING • ACTION




The OOI Cyberinfrastructure
30-40 Software Engineers
Housed at Calit2@UCSD

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# Taking Sensornets to the Ocean Floor: Remote Interactive HD Imaging of Deep Sea Vent




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High Definition Still Frame
of Hydrothermal Vent Ecology 2.3 Km Deep

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