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The UCSD NSFGreenLight Project

UCSD NSF GreenLight Project: Focus First on University Closet Clusters

- Compute energy/rack : 2 kW (2000) to 30kW (in 2010)
- Cooling and power issues now a major factor in campus clusters
- But academic clusters are often small: departmental closets
- **Energy use of departmental computers is increasing fast creating crises of space, power, and cooling**
- **Energy caps are coming!**
- **Unfortunately, almost nothing is known about how to make these shared virtual clusters energy efficient, since there has been no financial motivation to do so**

The NSF-Funded GreenLight Project
Giving Users Energy-Known Compute and Storage Options

7 Racks plus Network

Takes up 2 Parking Spaces

Data Power Cooling

- **UCSD installed two Sun MDCs in 2008**
- **GreenLight one is FULLY populated with PCs, FPGAs, GPGPUs, 250TB 10Gb/s disk, 5x10Gb/s networking to campus and GLIF via CENIC and NLR**

$2M NSF-Funded GreenLight Project

The GreenLight Project: Instrumenting the Energy Cost of Cluster Computing

- **Focus on 5 Communities with At-Scale Computing Needs:**
  - **Metagenomics**
  - **Ocean Observing**
  - **Microscopy**
  - **Bioinformatics**
  - **Digital Media**

- **Goal: Measure, Monitor, & Web Publish Real-Time Sensor Outputs**
  - **Via Service-oriented Architectures**
  - **Allow Researchers Anywhere To Study Computing Energy Cost**
  - **Enable Scientists To Explore Tactics For Maximizing Work/Watt**
- **Develop Middleware that Automates Optimal Choice of Compute/RAM Power Strategies for Desired Greenness**

Example: Improve Mass Spectrometry's Green Efficiency By Matching Algorithms to Specialized Processors

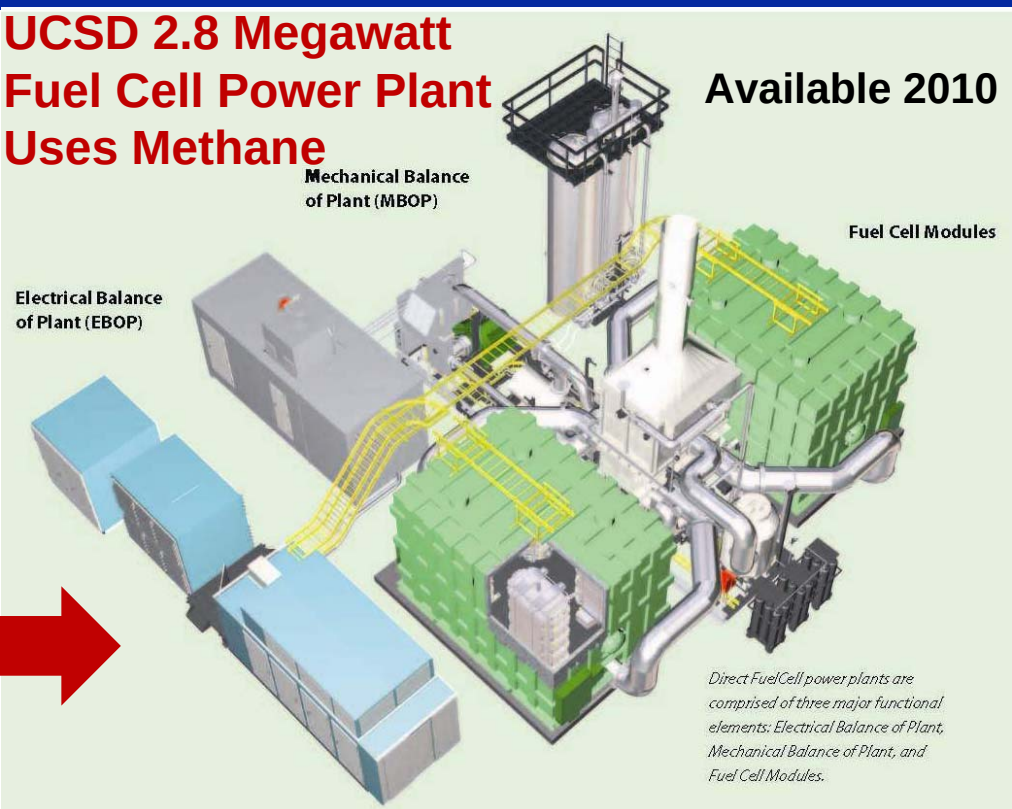
- **Inspect application implements the very computationally intense MS-Alignment algorithm for discovery of unanticipated rare or uncharacterized Post-Translational Modifications**
- **Solution: Hardware acceleration with a FPGA-based co-Processor (Convey Architecture)**
- **Results:**
  - **300x Speedup with hand FPGA coding**
  - **Increase in work/watt?**
  - **Increase in work/$ (purchase, life-cycle)?**

DC Power--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 2010



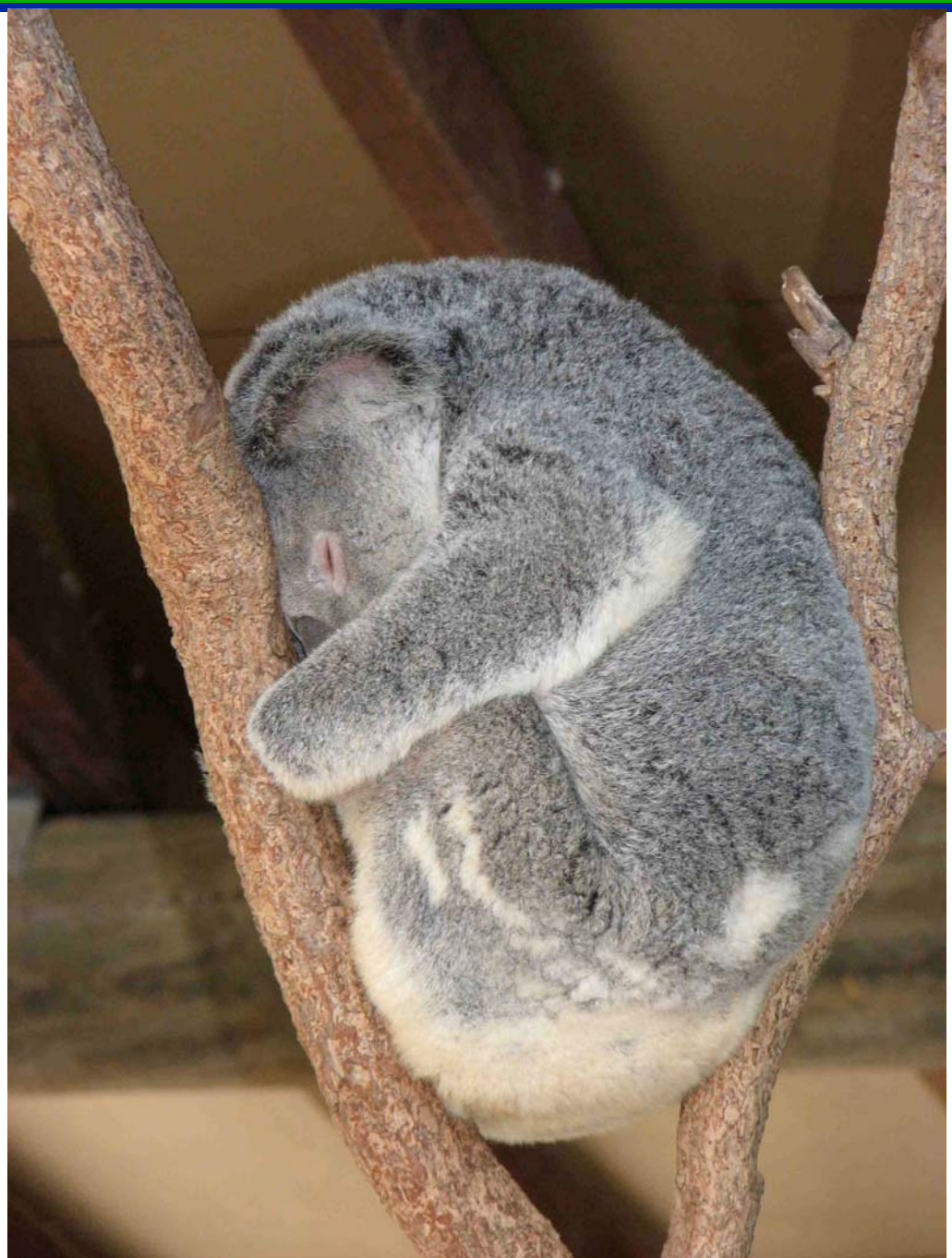
2 Megawatts of Solar Power Cells Being Installed

GreenLight Experiment: Direct 400v 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?
  - Scalable/Distributable?
- **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
  - Can switch to AC as backup

UCSD DC Fuel Cell 2800kW
Sun MDC <100-200kW

To be Energy Efficient, We Must Think about Koala-Style Computing and other "Smart" Ways



Size Your Brain Power, Visualization, Storage, Sleep Cycles, and Communications to Your Problem

Next Step:

Get more terabytes/watt!

GLIF: Thank You Very Much!

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