





• Los Alamos

NATIONAL LABORATORY

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Facilities Challenges for HPC

Space, power & cooling

Presented by CSCNSI



Agenda

- Facilities challenges for HPC
 - What does it take to run Trinity?
 - Some ways we handle facilities issues

HPC creates serious challenges for facilities

Trinity Supercomputer Facts

Nodes	19,208
Compute Cores	967,456
Peak Perf.	43.9 PFlops
Floor space	5200 sq.ft.
Power	9.4 MW
Weight	~ 250,000 lbs
Liquid Vol.	18,000 ga



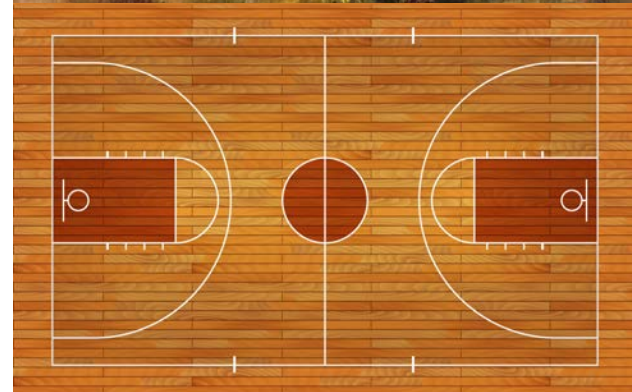
So, what does it take to run Trinity?

How do we put 20,000 computers in a room?

- ...and fit them all?
- ...and connect them all?
- ...and power them all?
- ...and cool them all?

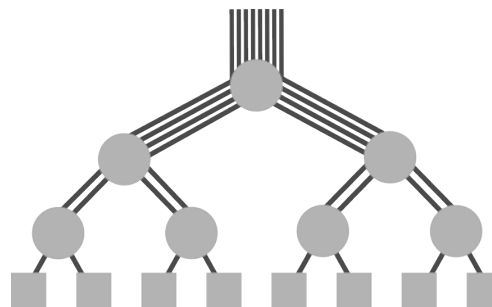
How do we put 20,000 computers in a room... ...and fit them all?

- Trinity's racks weigh > 3500 lbs each
 - That's more than an average car
- Trinity sits on roughly 5,200 sq. ft.
 - A bit bigger than a basketball court
- So... we have to fit about 80 cars on a basketball court
 - We'll have to stack them 2 deep!
- *We have to carefully engineer for weight and density, or we could literally fall through the floor!*



How do we put 20,000 computers in a room... ...and connect them all?

- Just naively connecting 20,000 nodes would take
- Using calculator at:
<https://clusterdesign.org/cgi-bin/network/network>
 - > 40,000 cables
 - 95 (very large) switches
- We're going to need to stay very, very organized!
- (this isn't actually how Trinity is connected)



How do we put 20,000 computers in a room... ...and power them all?

- Trinity has a peak draw of 9.4 MW
- That's as much power as the rest of the county uses, combined
- At draws like this, we have to be especially careful about powering on or off everything at once
 - Can even blow power substations!

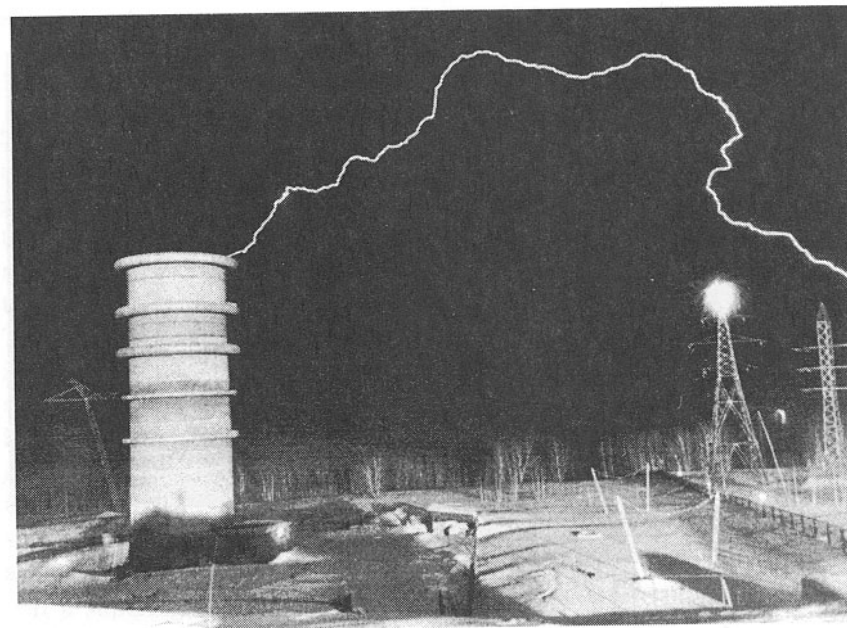


FIGURE 1.2

Superlong negative discharge to a 110 kV transmission line wire. Voltage pulse amplitude, 5 MV. Courtesy of A. Gaivoronsky and A. Ovsyannikov, the Siberian Institute for Power Engineering.

How do we put 20,000 computers in a room... ...and cool them all?

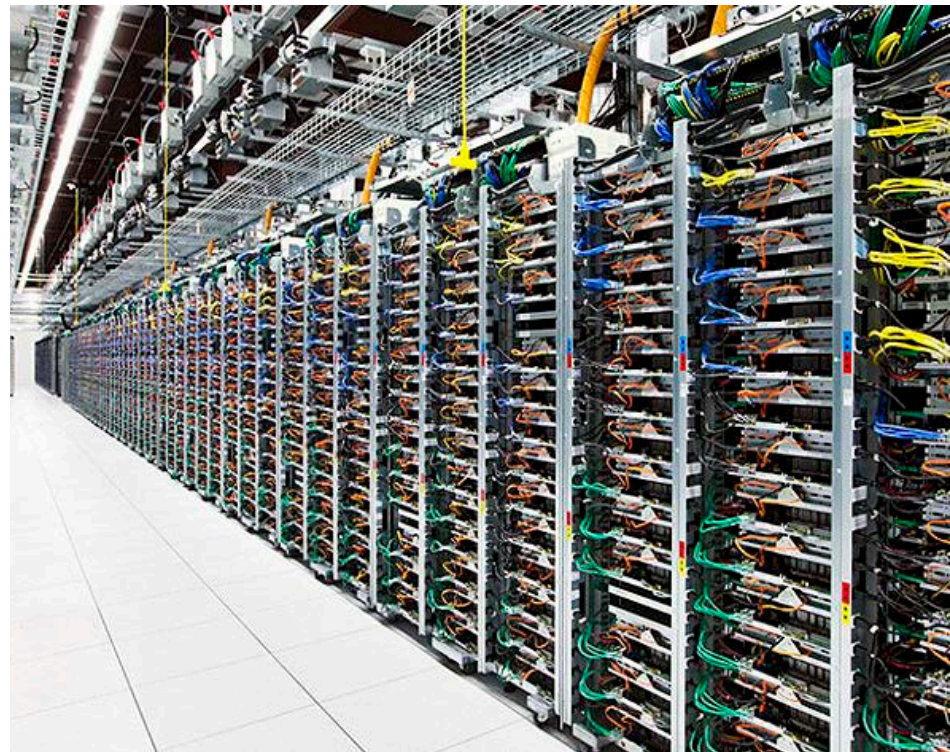
- For every bit of power we use, that is heat created
- 9.4 MW \approx 3000 tons of refrigeration
- There are 18,000 gallons of coolant in Trinity's main loop
 - ...and much more in the total loop.
- That's 150,000 lbs of coolant
- And an additional 300 tons of air cooling



Some ways we handle Facilities issues

What we mean by an HPC Facility

- Any physical environment that provides:
 - Power
 - Cooling
 - Physical space
 - Physical security
- For HPC equipment



Space planning

- Arrange rooms in well-ordered rows
- Use raised floor systems for things like cables, power, plumbing
- Carefully calculate weight distribution to avoid overloading floors



Cable management

- For smaller systems, organized & orderly cabling is good enough
- For larger systems, we usually build more than one system into a chassis/rack that don't have to use external cables
- We often put overhead trays and/or use a raised floor for cable management



Power management

- We use *a lot* of power
 - And typically
- We use smart startup/shutdown procedures to manage the ramp up/ramp down problem
- We often run equipment at high voltage (e.g. 480 V)
- We typically tree the power through different tiers
 - Building distribution -> Floor PDU -> Rack PDU



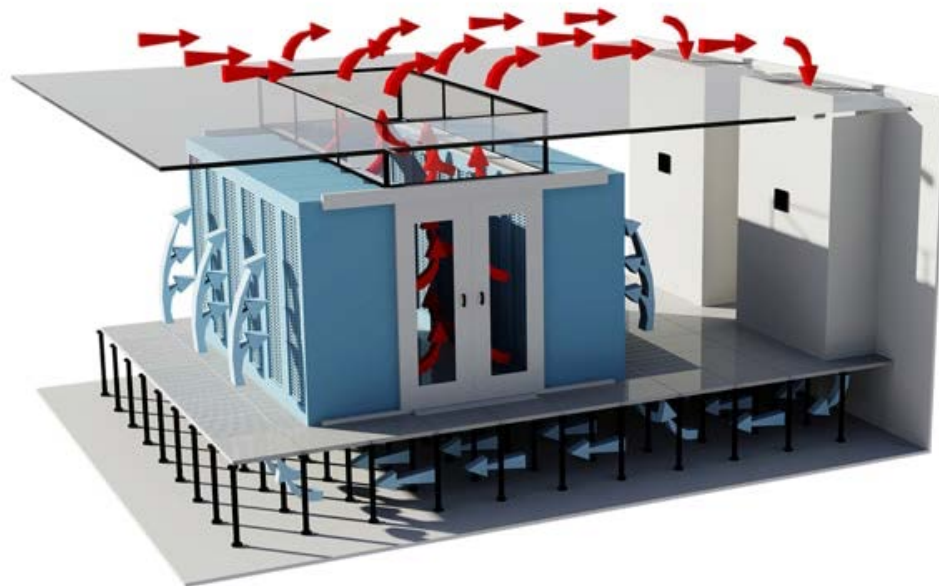
Floor PDU



Rack PDUs

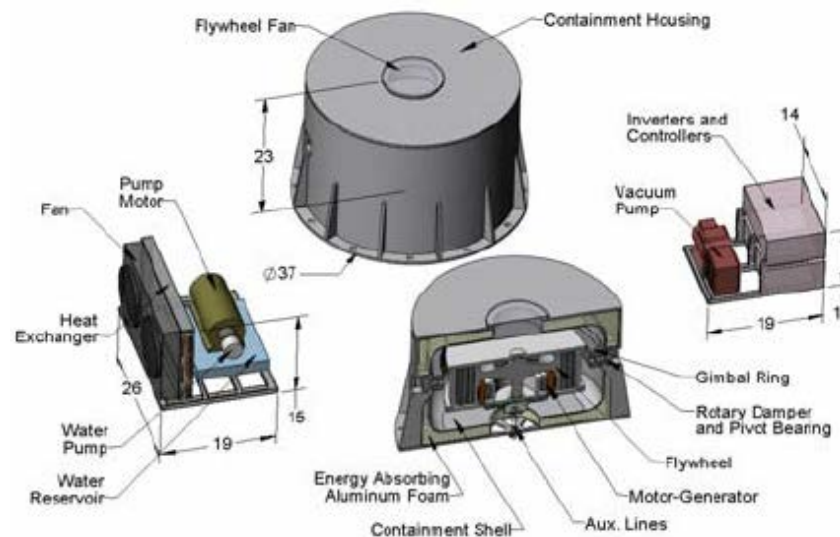
Cooling systems

- Air cooling can be managed with careful arrangement and planning
 - Keep hot air isolated
 - Inject cold air where needed
- Integrated high voltages racks are often liquid cooled
- The liquid can be kept cool through
 - Refrigeration
 - Evaporative cooling...



This is just a taste...

- We also have to think about things like:
 - Can the room withstand an earthquake?
 - ...a flood?
 - ...a fire?
 - ...a power outage?
 - ...



Questions?