Fascinating Insights to Supercomputing

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The Scientific Method

1. Identify question and literature review
2. Develop a testable hypothesis
3. Select a research method and collect data
4. Analyze the data and accept or reject the hypothesis
5. Publish, replicate and seek scientific review
6. Build a theory

Where does computing fit here?

- Understanding and validating a hypothesis deals with data collection and observation.
- When this data becomes large, both collection and observation needs tools.
- Many scientific phenomenon are expressed using a mathematical model.
- Complex mathematical models use computational models for simulating the scientific phenomenon under study both to gather and observe data!

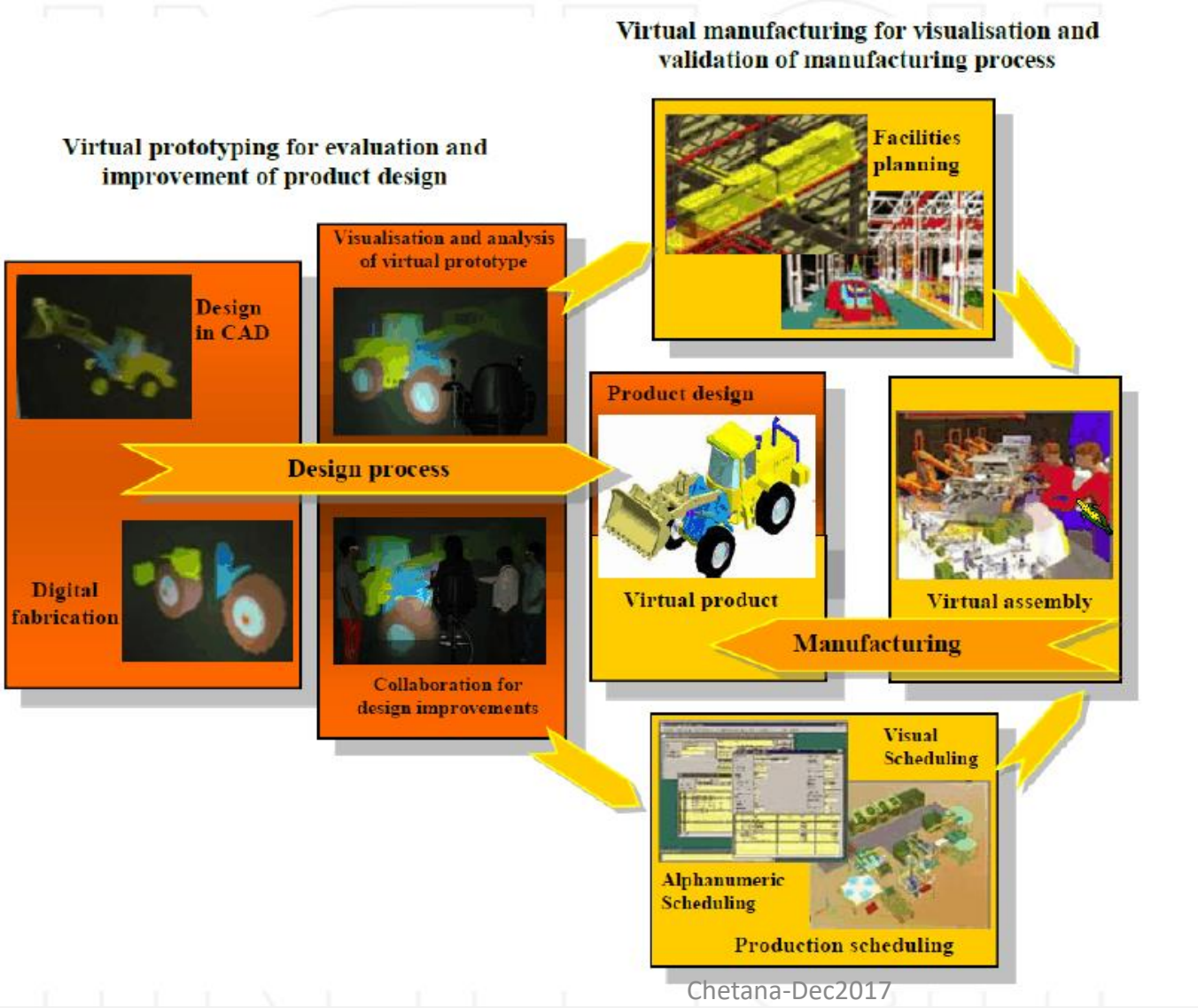
Why Supercomputers?

- Complex models have multiple dimensions that lead to data explosion.
- Large data need higher computational capability to sieve through and analyze for meaningful scientific insights.
- Supercomputers aid solving of problems that would take too long using traditional methods.

Human Genome Project

- Human Genome Project (HGP) was the international, collaborative research program whose goal was the complete mapping and understanding of all the genes of human beings. All our genes together are known as our "genome."
- Knowing our genome map helps in disease diagnosis and cure!
- The first gene map (*Drosophila – fruit fly*) was created in 1911 and a complete human genome map was arrived at in 2003!
- There are 3.2 billion letters in the human genome and it would take 100 years to recite, if we stated one letter per second, 24 hours a day!
- The HGP is considered to be the biological equivalent of the Wright Brothers' first flight or the Apollo Project bringing man to the moon!
- Explaining human genome: https://www.youtube.com/watch?v=PwdDa6QCDWw
- How HGP was realized: https://www.youtube.com/watch?v=5CaaXJTAOZA
- Computational tools used in the HGP:
  - databases and data management tools to integrate large amounts of heterogeneous biological data,
  - presentation tools that help users comprehend large datasets, and
  - algorithms to extract meaning and useful information from large amounts of data

Virtual Prototyping of Complex Engineering Designs



An interesting video explaining how virtual prototyping helps in engineering applications:

https://www.youtube.com/watch?v=F-zeuqEtv9o

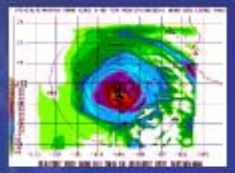
Immersive virtual engineering, an insight:

https://www.youtube.com/watch?v=IcmX_XtmZHg

Weather Prediction and Disaster Management

Disaster Management Support Project India

- Primary CFS Activities - Tropical Cyclone Forecast and Warning
  - Goals
    - Improve tropical cyclone prediction (predictive models)
    - Improve communications and understanding of tropical cyclone warnings (forecast operations)



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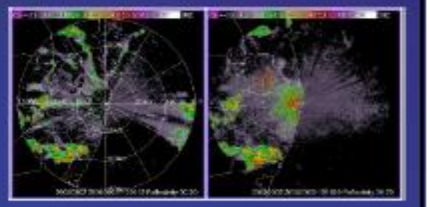
Disaster Management Support Project India

- Primary CFS Activities - Local Severe Storms (incl. Flash Floods)
  - Goal
    - Enhance capability for forecasting severe storms (predictive models for extreme events, weather radar operations)



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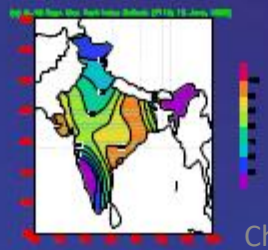
Disaster Management Support Project India

- Primary CFS Activities - Extreme Temperatures
  - Goals
    - Improve capacity for analyzing and forecasting heat waves and cold waves (long range temperature forecasting, climatological data analyses techniques)



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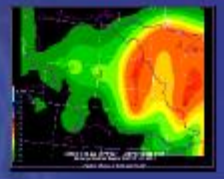
Disaster Management Support Project India

- Primary CFS Activities - Flood Forecasting
  - Goals
    - Improve capacity for high resolution rainfall forecasts (for hydrologic modeling applications)
    - Develop a river level forecast capability (predictive models)

Mahanadi River basin is the pilot for both goals
(implementation of NWS River Forecast System)



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in-Situ Tele-Medicine and Healthcare

- Telemedicine offers real and practical opportunities to share expertise over distances.
- For a country like India with pockets of medical excellence surrounded by a vast number of badly equipped hospitals with limited specialists, telemedicine could revolutionize health care.
- Understanding Tele-medicine: https://www.youtube.com/watch?v=ZBwyqtKDZMw
- A cartoonist view on Tele-medicine: https://www.youtube.com/watch?v=c6AT1FLM8yk

Contemporary Supercomputing Use-cases – SC 17

- Ocean Mapping: https://www.youtube.com/watch?v=aLdNDFuLazw
- Smart Cities: https://www.youtube.com/watch?v=H7hYDwgc6WQ

SERC: Supercomputing Education and Research Center

- Centers like SERC cater to the computing needs of researchers in IISc.
- The center was established in 1970 as the Computer Center and later named as SERC in 1990.
- Country's leading supercomputing center with State-of-art computing facility hosting currently the fastest supercomputer of the country.
- The facility is available on the desktop of every researcher through campus-wide high speed network and dedicated data center infrastructure 24/7, 365 days!

What is a Supercomputer?

- Any computing system that provides close to the maximum performance than can currently be achieved.
- What was a supercomputer a few (5) years ago, is probably an order of magnitude slower system compared to today's supercomputer system!

The term "High Performance Computing" also refers to Supercomputing!

Beginning of Supercomputing

- Introduction of Cray 1 in 1976 ushered era of Supercomputing
  - –Shared memory, vector processing
  - –Good software environment
  - –A few 100 MFLOPS peak

Cray – 1 of 1976 @ US$ 5 Million

How to know if a machine is a Supercomputer?

- A computer's capability is measured in terms of the number of floating point operations (FLOPs) it can perform per second.
- Today's fastest system is in China and is called Sunway TaihuLight with a computing capacity of 93 Pflops.
- A supercomputer's capability is measured using the High Performance Linpack (HPL) program which is a program to solve a set of linear algebraic equations.

Supercomputing List – Nov 2017 (Top500.org)

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	National Supercomputing Center in Wuxi China	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway NRCPC	10,649,600	93,014.6	125,435.9	15,371
2	National Super Computer Center in Guangzhou China	**Tianhe-2 (MilkyWay-2)** - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P NUDT	3,120,000	33,862.7	54,902.4	17,808
3	Swiss National Supercomputing Centre (CSCS) Switzerland	**Piz Daint** - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 Cray Inc.	361,760	19,590.0	25,326.3	2,272
4	DOE/SC/Oak Ridge National Laboratory United States	**Titan** - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x Cray Inc.	560,640	17,590.0	27,112.5	8,209
5	DOE/NNSA/LLNL United States	**Sequoia** - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom IBM	1,572,864	17,173.2	20,132.7	7,890

India's Fastest

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
228	**SERC** - Cray XC40, Xeon E5-2680v3 12C 2.5GHz, Aries interconnect , Cray Inc. Supercomputer Education and Research Centre (SERC), Indian Institute of Science India	31,104	901.5	1,244.2	607.5
368	iDataPlex DX360M4, Xeon E5-2670 8C 2.600GHz, Infiniband FDR , IBM Indian Institute of Tropical Meteorology India	38,016	719.2	790.7	789.7
441	Cluster Platform 3000 BL460c Gen9, Xeon E5-2697v4 18C 2.3GHz, 10G Ethernet , HPE Geoscience (G) India	27,000	615.2	993.6	
487	**TIFR** - Cray XC30, Intel Xeon E5-2680v2 10C 2.8GHz, Aries interconnect , NVIDIA K20x , Cray Inc. Indian Lattice Gauge Theory Initiative (ILGTI), Tata Institute of Fundamental Research (TIFR) India	11,424	558.8	730.7	319.9

What is a Supercomputer made of?

- Processors: The computing machinery
- Interconnection network: The data transfer path and fabric
- Storage: Data repository
- Software: Glue to enable computing
- Supercomputers are expensive machines that require dedicated infrastructure and skilled manpower to maintain and manage.

What is India doing to enhance use of Supercomputing?

- In April 2015, our Prime Minister, Mr. Modi, announced the National Supercomputing Mission or NSM.
- NSM objectives are:
  - Multi-tiered HPC Infrastructure
  - Development of HPC applications
  - HPC-aware Manpower Development
  - Next generation R & D on HPC Systems
- IISc and CDAC are the organisations that are working to realize NSM goals.

Questions?

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THANKYOU!