



Introduction to High Performance Computing (HPC)



What is HPC?

High Performance Computing encompasses a collection of :

- powerful hardware systems and faster networks
- high/low level libraries and languages
- software tools
- programming paradigms

which make previously unfeasible calculations possible.

- it's all about **SIZE** and **SPEED**!
- HPC=Parallel Computing

Why HPC?

- HPC can benefit those who wish to
 - carry out huge amounts of repetitive calculations on large amounts of data
 - obtain valid results in a reasonable time
- HPC supplements traditional scientific and engineering methods by carrying out numerical calculations on real phenomena and/or experiments that are expensive or too dangerous to perform in lab

Why HPC?

- ... too **EXPENSIVE**
 - building a throw-away passenger jet, F1 car
 - Wind tunnel
- ... too **SLOW**
 - waiting for climate or galactic evolution
 - earthquake prediction
- ... too **DANGEROUS** or **CONTROVERSIAL**
 - testing nuclear weapons
 - construction of atom bombs

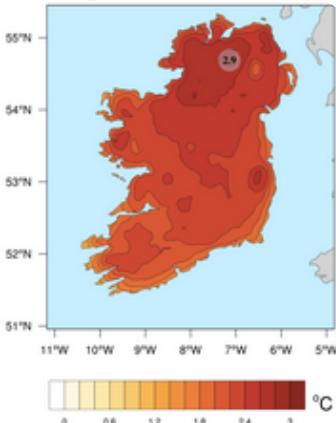
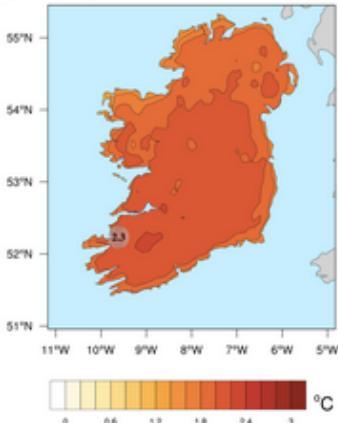
Motivation

- We continually demand greater computational power
- We want to reduce the execution time of our important applications
- We want to overcome the limitations of desktop computing architectures

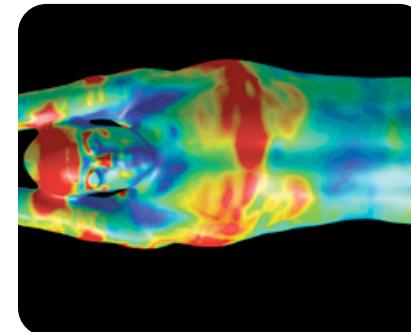
HPC Today

- HPC-capable architectures are becoming more accessible, user-friendly and affordable
 - From small inexpensive clusters with commodity hardware and Unix/Linux OS
 - To the fastest supercomputers
- HPC is being used around the world from large groups to individuals, from research labs to traffic management
- Growing demand for computational power
 - Engineering, physics, chemistry, biology, finance, social sciences

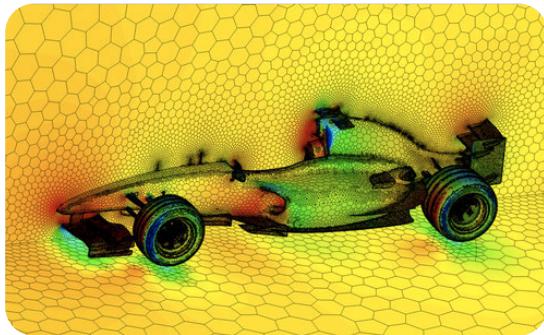
Where is used?



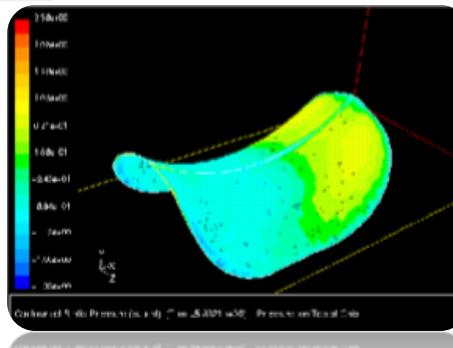
Simulation showing temperatures of top 5% of summer highest daytime and the lowest 5% of winter nighttime



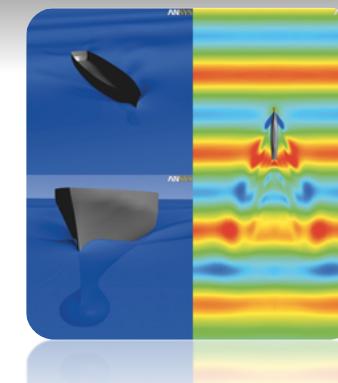
Swimsuit design to reduce drag based on fluid flow analysis



Polyhedral mesh and pressure distribution on an F1 car



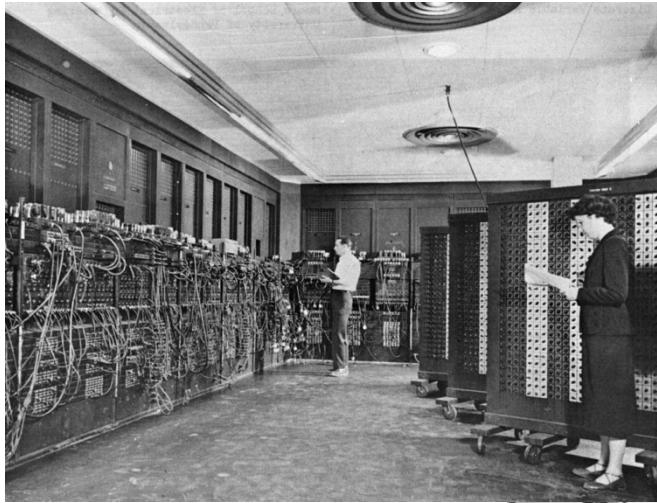
Model of the production and assembly of Pringles and Pampers Nappies



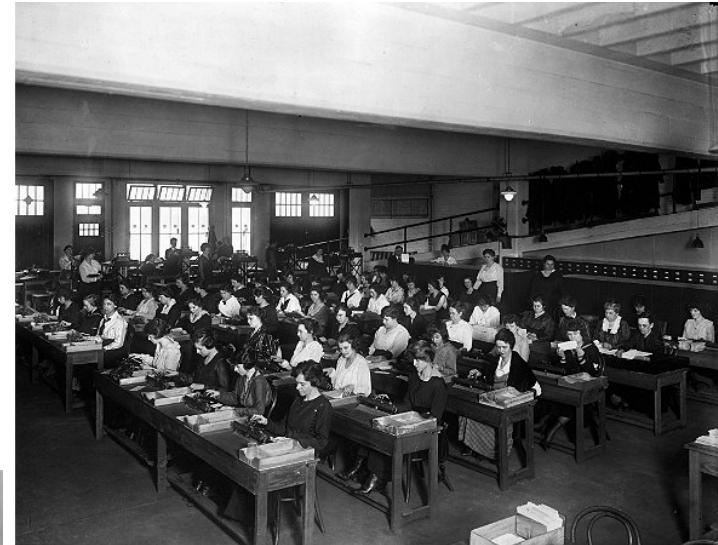
Model of the wave formulation around a seafaring vessel

History of HPC

- ENIAC... computing ballistic tables (July 1946 – Oct 1955)



ENIAC



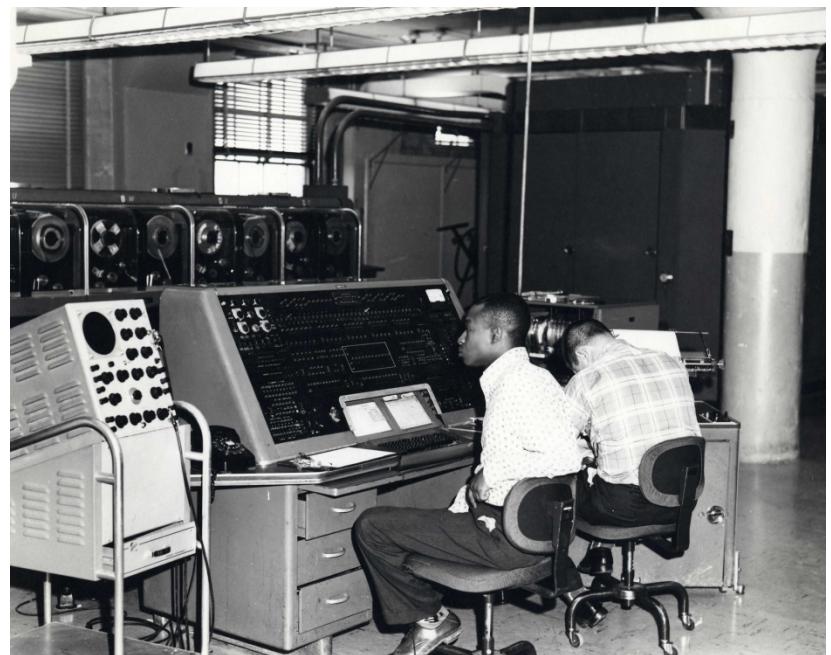
Computers



Meccano

History of HPC

- UNIVAC 1950s; less than 50 made



- US Census processing
- Army usage
- Use to predict 1952 US elections results
- Corporations

History of HPC

- 1960s: Scalar processor
 - Process one data item at a time
- 1970s: Vector (Array) processor
 - Can process an array of data items at a time
- Later 1980s: Massively Parallel Processing (MPP)
 - Up to thousands of processors, each with its own memory
- Later 1990s: Cluster
 - computers connected together with a network and centrally coordinated by some special software; physically close
- Later 1990s: Grid
 - collaboration among geographically distributed organisations
- Later 2000s: Accelerators
 - GPUs, FPGAs, Xeon Phis

Getting into HPC

- Understanding of:
 - Hardware/architectures
 - CPU, memory, interconnect, I/O
 - Software
 - Programming paradigms, performance considerations
 - Numerical libraries, I/O libraries
 - Applications and Tools