Introduction to Cloud Computing

Overview and Introduction

15-319, spring 2010
1st Lecture, Jan 12th

Majd F. Sakr

Carnegie Mellon Qatar

Why take 15-319?

- **Because you're cool!**
- **Because we're cool!**
- **Gain real world experience and learn new tools**
  - Emerging technology
  - New programming model
  - Could be the future of computing?
  - Running application on very large data-sets

Syllabus: Course Purpose

- **Introduce you to the basics of the emerging cloud computing paradigm**
  - learn how this paradigm came about
  - understand its enabling technologies
  - understand the computer systems constraints, tradeoffs and techniques in setting up and using the cloud
- **Teach you how to implement algorithms in the cloud**
  - gain competence in Hadoop/MapReduce as a programming model for distributed processing of large datasets.
  - understand how different algorithms can be implemented and executed in the Hadoop framework.
  - gain competence in evaluating the performance and identifying bottlenecks when mapping applications to the cloud.

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Syllabus: Target Audience

- **Juniors & Seniors**

- **Pre-requisites:**
  - 15-213
  - 15-251
  - 15-212
  - Other equivalent courses

Syllabus: Instructor

- **Majd F. Sakr**
- **Office Hours:**
  - Tuesday 3-5pm
  - Welcome when my office door is open
  - By appointment

- **TA: Suhail Rehman**
- **Office Hours:**
  - To be decided NOW
  - By appointment

Syllabus: Course Components

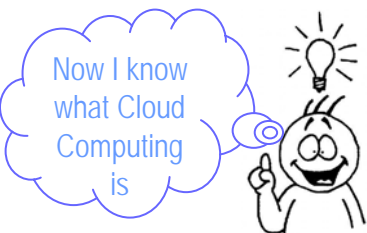## What are we trying to answer?

What is Cloud Computing?

Why Cloud Computing?

What are its challenges and opportunities?
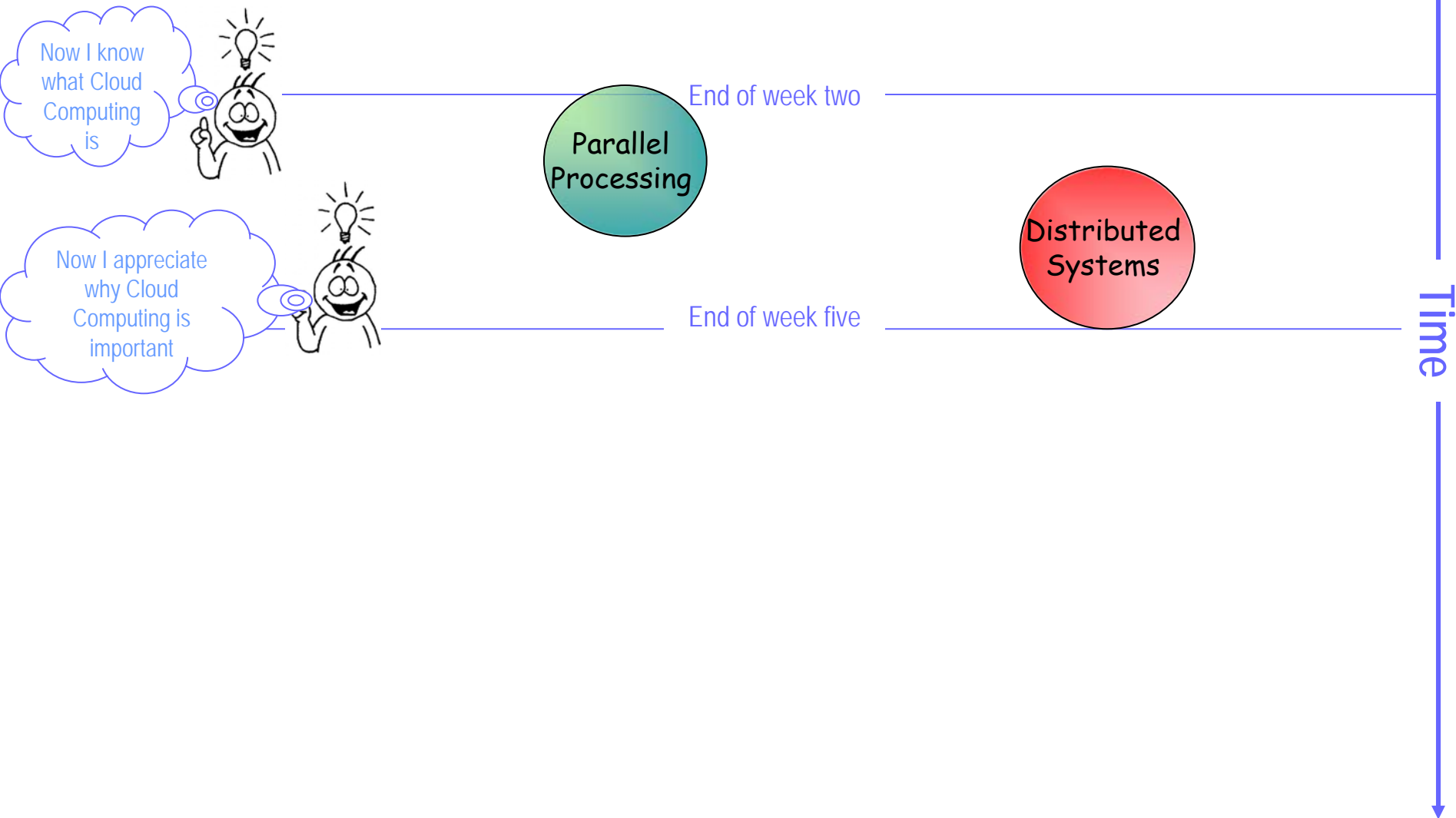
How does Cloud Computing work?
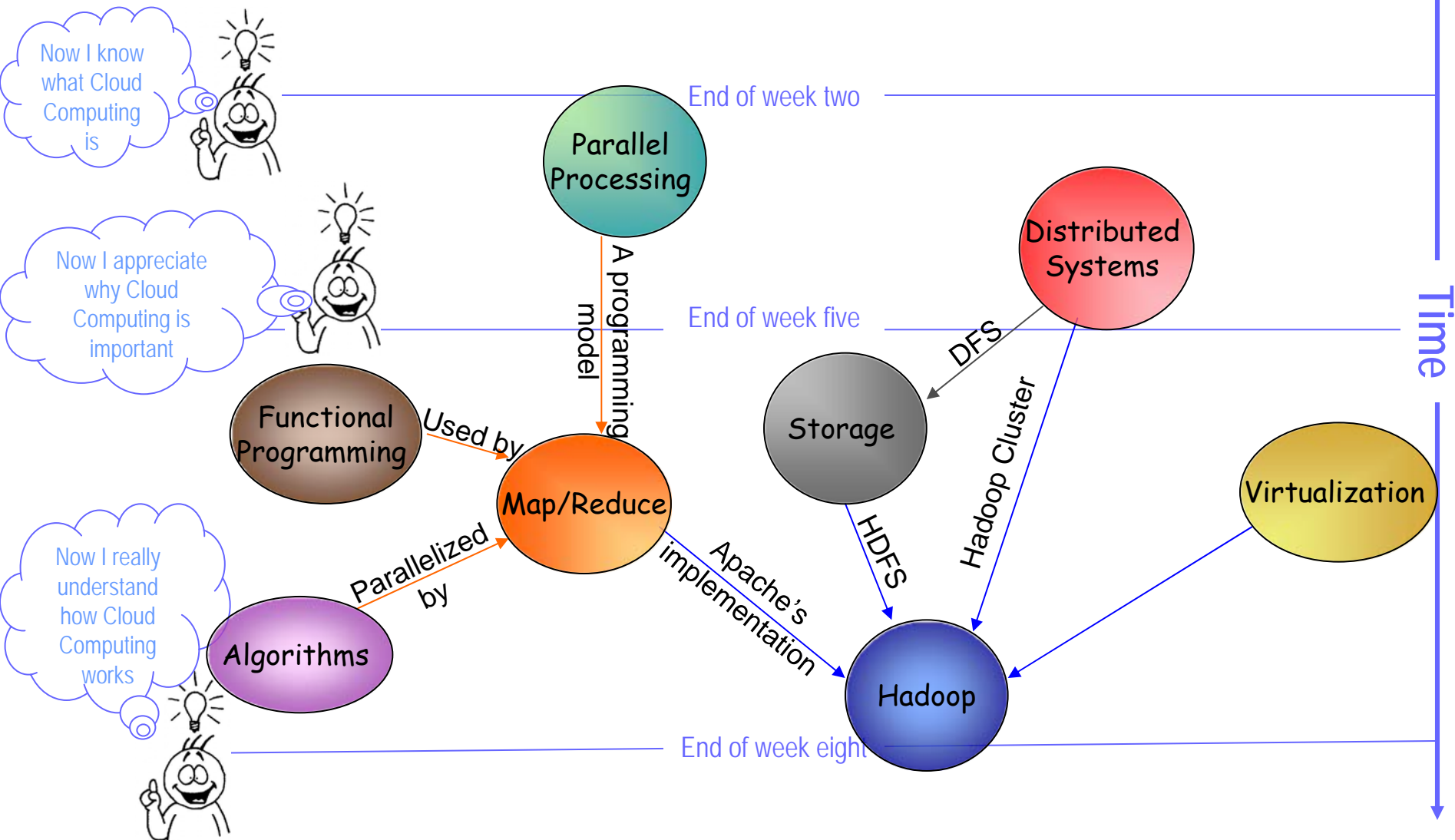
Syllabus: Course Components

Now I know what Cloud Computing is

End of week two

Time

Syllabus: Course Components

Syllabus: Course Components

Syllabus: Course Components

Cloud Computing

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Syllabus: Course Components
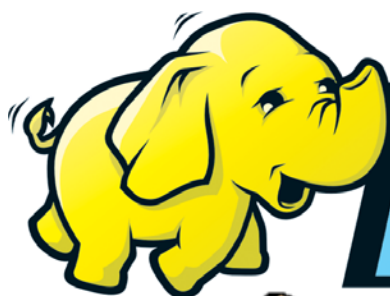
Syllabus: Text Books

- **Primary Book:**
  - Tom White,

    Hadoop: The Definitive Guide, O'Reilly Media, 2009.

- **Reference Books**
  - Tanenbaum and van Steen, *Distributed Systems: Principles and Paradigms*, Pearson, 2007.
  - Jean Dollimore, Tim Kindberg, George Coulouris, *Distributed Systems: Concepts and Design*, *Fourth Edition,* Addison Wesley, 2005.
  - Randal E. Bryant and David R. O'Hallaron,
    Computer Systems: A Programmer's Perspective, Prentice Hall, 2003.
  - Patterson and Hennessy, *Computer Organization and Design: The Hardware/Software Interface, Fourth Edition*, Morgan Kaufmann/Elsvier.
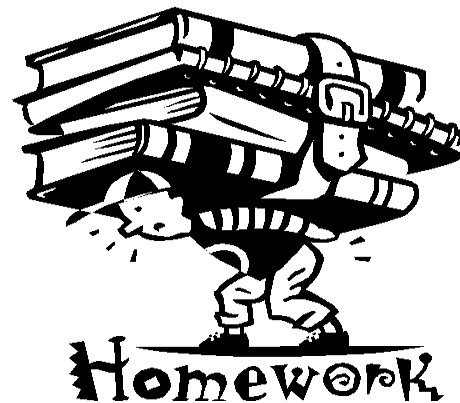 - Jason Venner, *Pro Hadoop,* Apress, 2009.

Syllabus: Projects

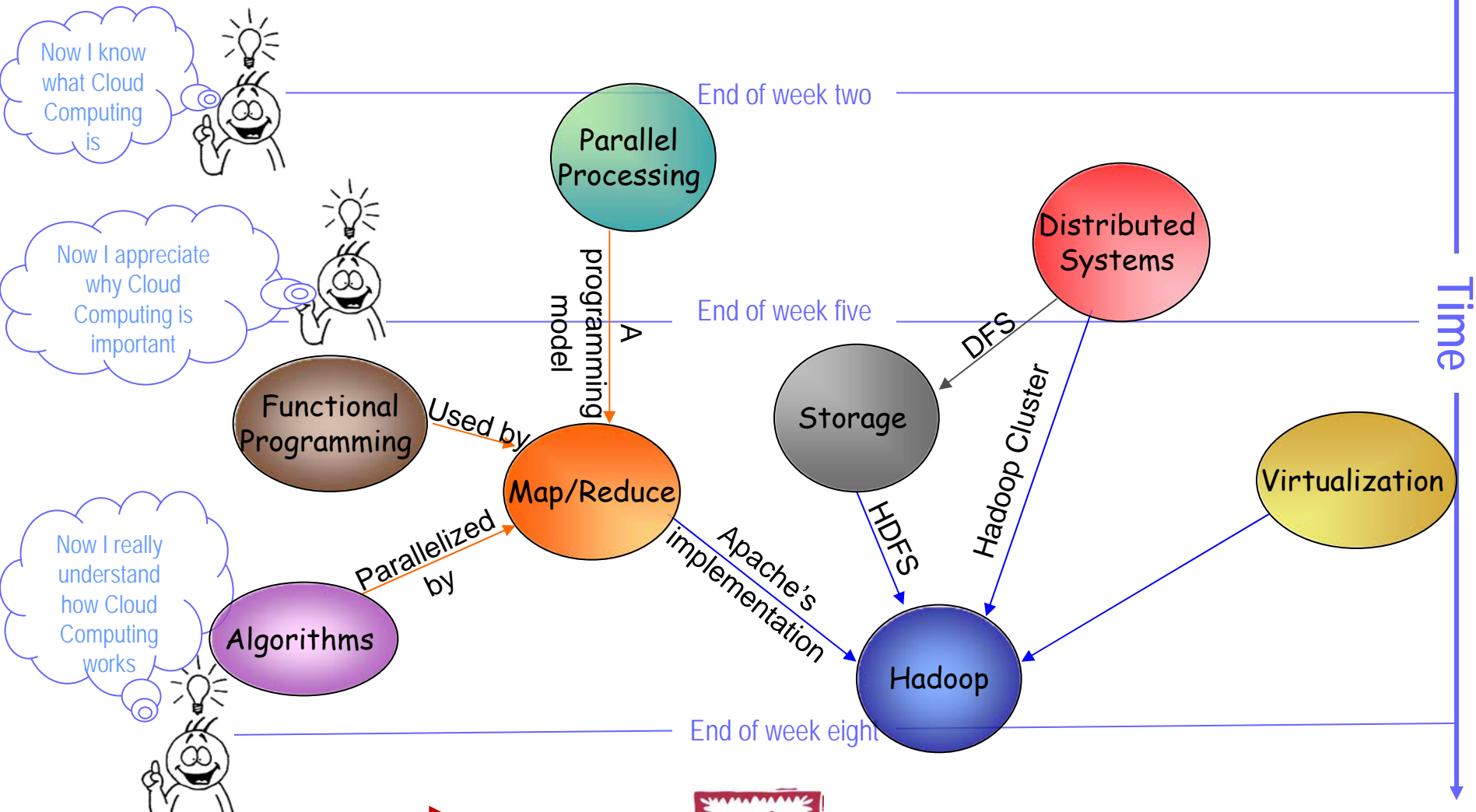- **Five assignments**
  - 2 weeks per assignment
  - Technical papers and case studies
  - Short write-up
  - In-class presentations and discussions

- **Four Projects:**
  - 4-5 weeks per project
  - Final project includes a paper and presentation

Syllabus: Exam

End of week two

End of week five

End of week eight

Now I know what Cloud Computing is

Now I appreciate why Cloud Computing is important

Now I really understand how Cloud Computing works

Parallel Processing

Distributed Systems

Functional Programming

Storage

Virtualization

Map/Reduce

Algorithms

Hadoop

A programming model

Used by

Parallelized by

Apache's implementation

DFS

HDFS

Hadoop Cluster

Time

End of week NINE ➡ ONLY **1** EXAM

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Syllabus: Grading

- **Attendance/Participation 10%**

- **Assignments 15%**

- **Projects   60%**
  - Project 1: 10%
  - Project 2: 10%
  - Project 3: 15%
  - Project 4:   25%

- **Exam   15%**

Final Thoughts

What Computing Paradigms Are There?

Existing Computing Paradigms

Personal Computing

Reconfigurable Computing

Parallel Computing

Distributed Computing

Ubiquitous Computing

Autonomic Computing

Super Computing

Grid Computing

Cluster Computing

Utility Computing

Cloud Computing

Pervasive Computing

Mobile Computing

Existing Computing Paradigms

Personal Computing

Reconfigurable Computing

Parallel Computing

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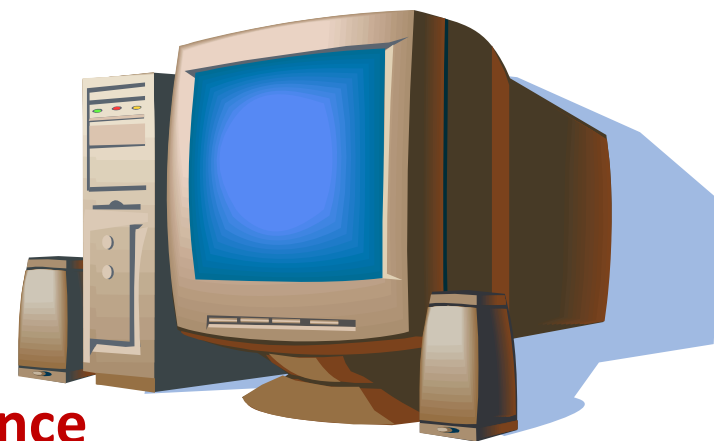Cluster Computing

Utility Computing

Cloud Computing

Pervasive Computing

Mobile Computing

Personal Computing

- **Personal computing system**
- **Local software installation, maintenance**
- **Local system maintenance**
- **Customizable to user needs**
- **Very low utilization**
- **High up-front cost**

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Reconfigurable Computing

- **Field Programmable Gate Arrays (FPGAs)**
  - Reprogrammable Hardware
  - Can exploit embarrassingly parallel code
  - Slow programming time (ms)
  - Power hungry

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Autonomic Computing

- Motivation: rapidly growing complexity of integrating, managing and operating computer systems

- introduced by IBM in 2001

- Inspired by Human ANS

- Self-management includes: self-

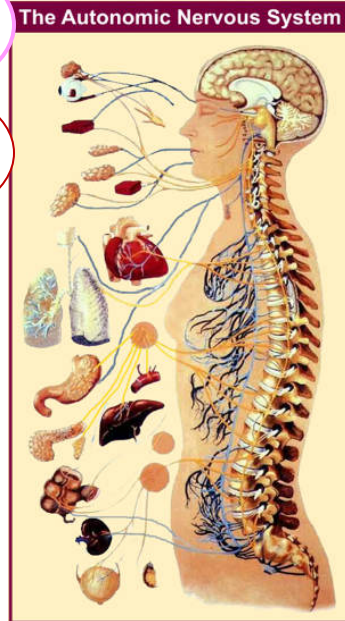configuration

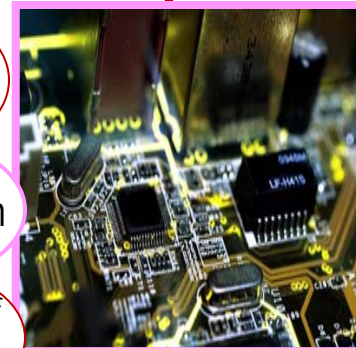organization

protection

governing

recovery

healing

autonomy

adaptation

optimization

diagnosis of faults

The Autonomic Nervous System

Complex yet self-managing

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Mobile Computing

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Mobile Computing

- **You can use computing technology on the move**
- **Since 1990s**
- **Intermittent connectivity**
- **Limited Bandwidth**
- **Mobile device maturity**

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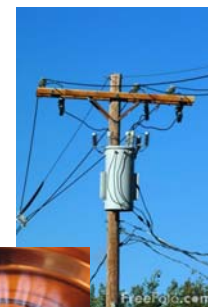
Cloud Computing

Pervasive Computing

Mobile Computing

Utility Computing

- Water, gas, and electricity are provided to every home and business as commodity services
    - You get connected to the utility companies' "public" infrastructure
    - You get these utility services on-demand
    - And you pay-as-you use

- Utility Computing is doing same for computing resources (processing power, bandwidth, data storage, and enterprise software services)

- Thought of by 1960s but re-surfaced late 90s
    - "If computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility... The computer utility could become the basis of a new and important industry.„
        —John McCarthy, MIT Centennial in 1961

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Existing Computing Paradigms - Blue Group

Super Computing
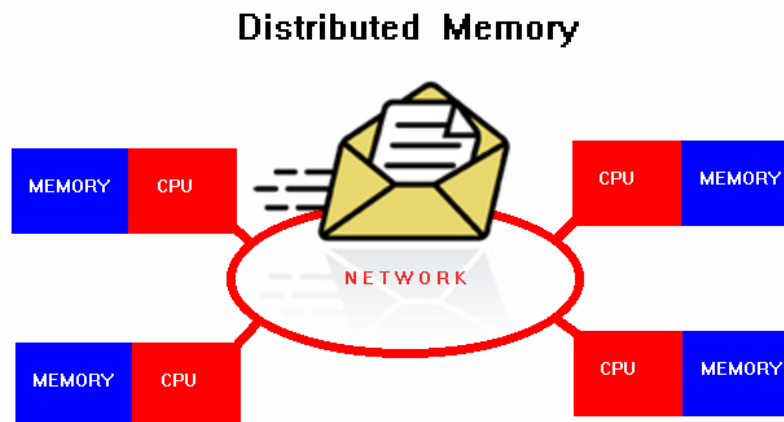
Grid Computing

Cluster Computing

Parallel Computing

Distributed Computing

Blue Group

- **Distributed Computing**
  - Using **distributed system**s to solve large problems.
  - **Distributed System:** multiple autonomous computers connected through a communication network
  - The system has a **distributed memory** where each processor has its private memory.
  - Information exchanged using communication models, ex: **MPI**

Distributed Memory

# Blue Group

Distributed Computing

- **Cluster Computing:**
    - Characteristics:
        - tightly coupled computers
        - single system image
        - Centralized Job management & scheduling system
    - Better performance and availability and more cost-effectiveness over single computer with same capabilities
   - Since 1987

- **Grid Computing:**
    - According to Gartner, "a grid is a collection of resources owned by multiple organizations that is coordinated to allow them to solve a common problem."
    - Characteristics:
        - loosely coupled
        - no Single System Image
        - distributed Job Management & scheduling
    - Originated early 1990s
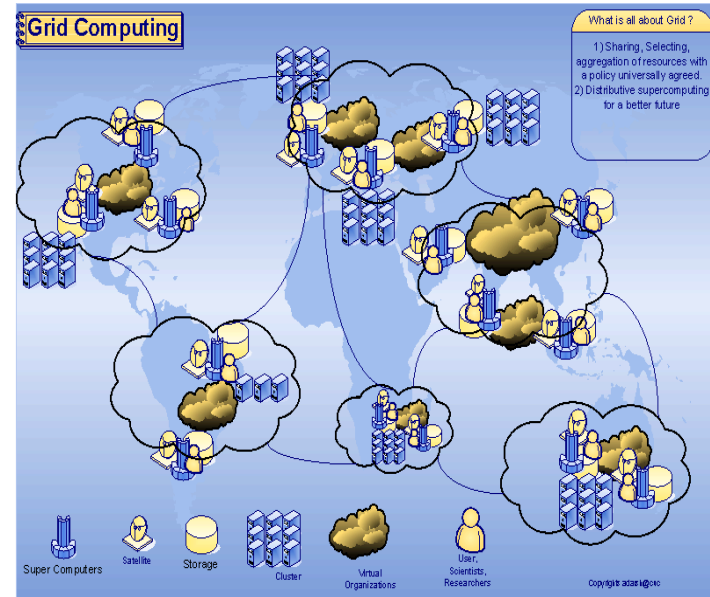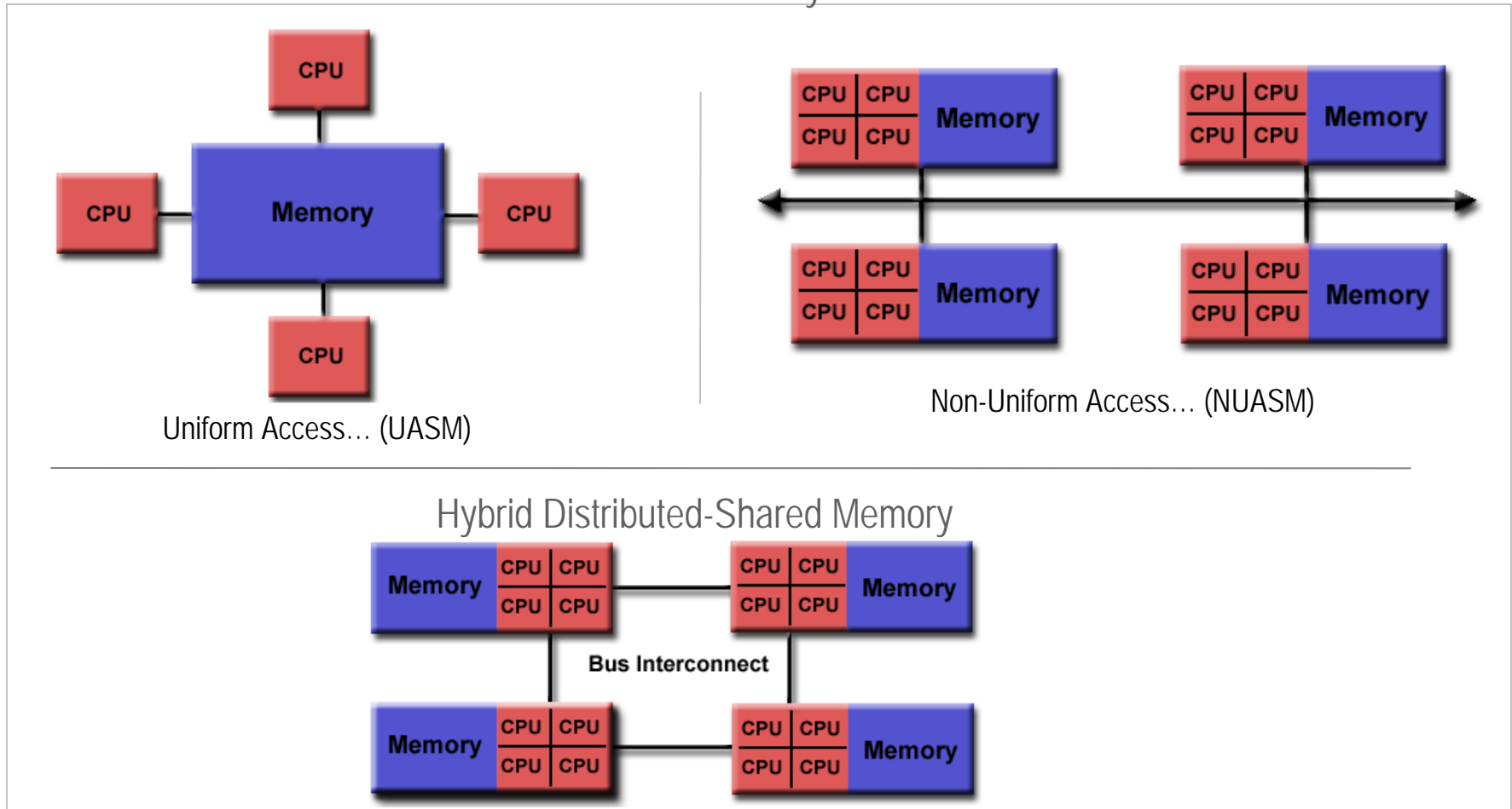
What is Parallel Computing

- Calculations of large problems are divided into smaller parts and carried out simultaneously/concurrently on different processors.
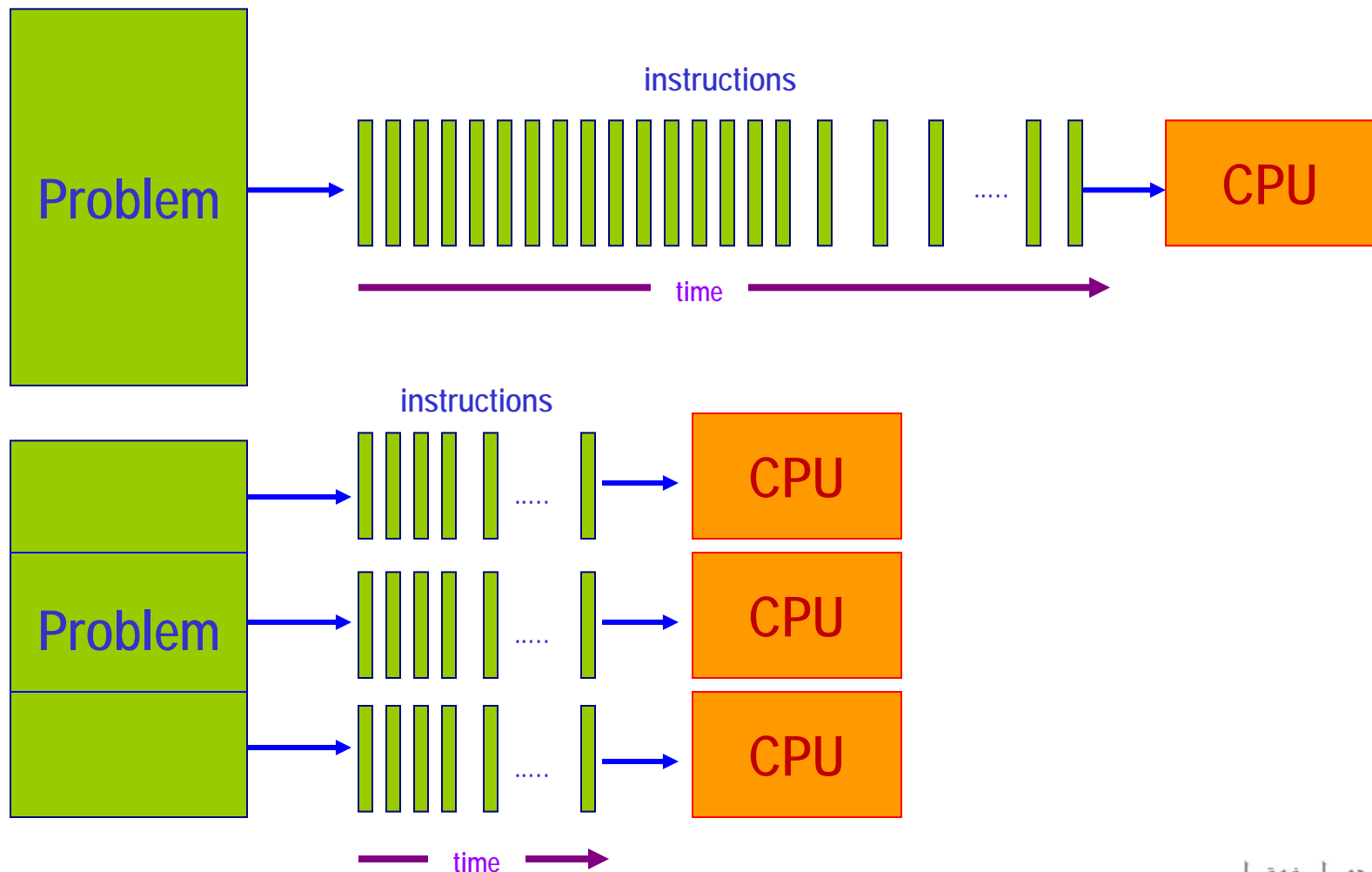
Parallel Computing

- All have access to a **shared memory** that is used to exchange information between processors

Shared Memory

Uniform Access… (UASM)

Non-Uniform Access… (NUASM)

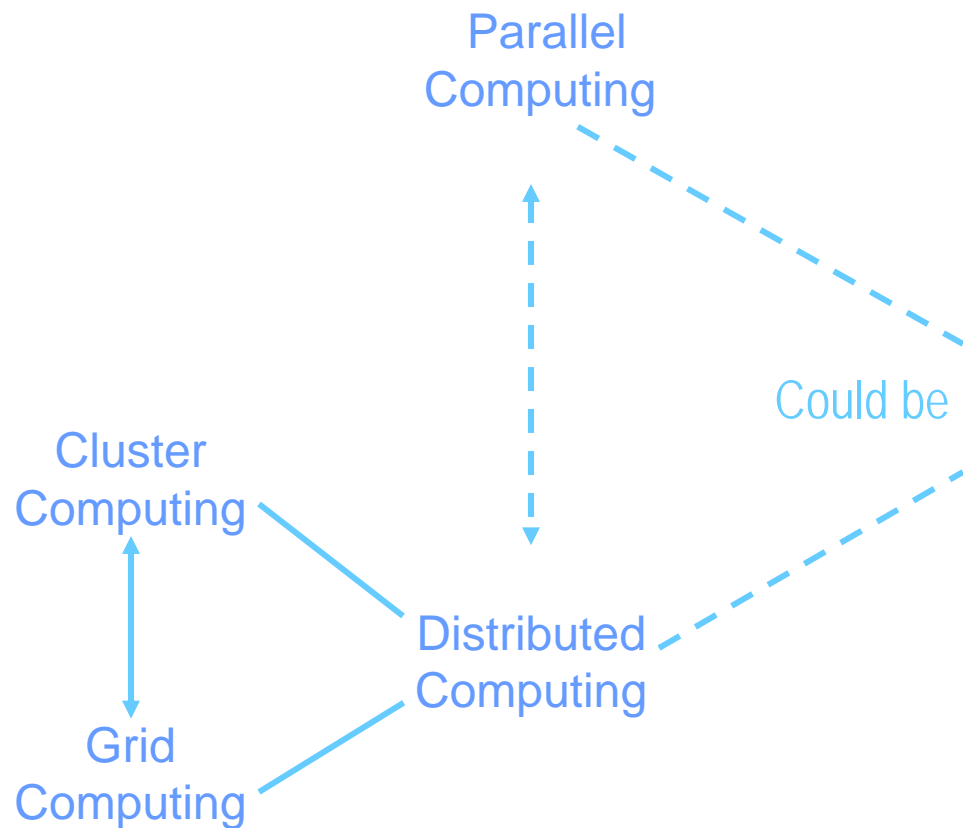Hybrid Distributed-Shared Memory

Bus Interconnect

Blue Group

- **Super Computing**
  - Thousands of processors
  - Used for compute-intensive problems
    - Days instead of Years!!!
  - introduced in the 1960s

Blue Group

Parallel
Computing

Super Computing

Could be

Cluster
Computing

Distributed
Computing

Grid
Computing

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Existing Computing Paradigms - Green Group

Ubiquitous Computing

Pervasive Computing

Green Group

- **Ubiquitous= "seeming to be in all places"**
- **Pervasive= "present or noticeable in every part of a thing or place"**
- **Information processing engaged in everyday's activities and objects.**
- **Term used since 1980s**
- **Different models but same vision:**
  - Small, inexpensive, robust devices distributed throughout everyday's life

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How about cloud computing?

Cloud Computing

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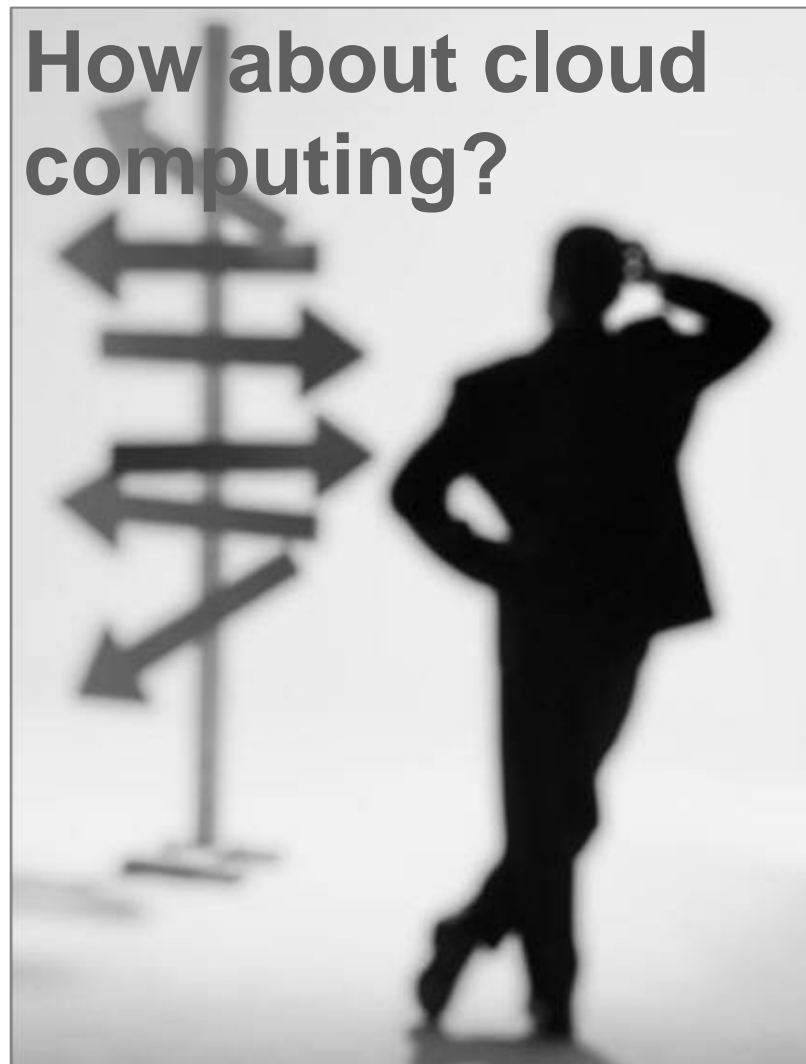
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Think of it this way …

■ **Banking**

Think of it this way …

■ **Power/ heat/electricity/water supply to your home**
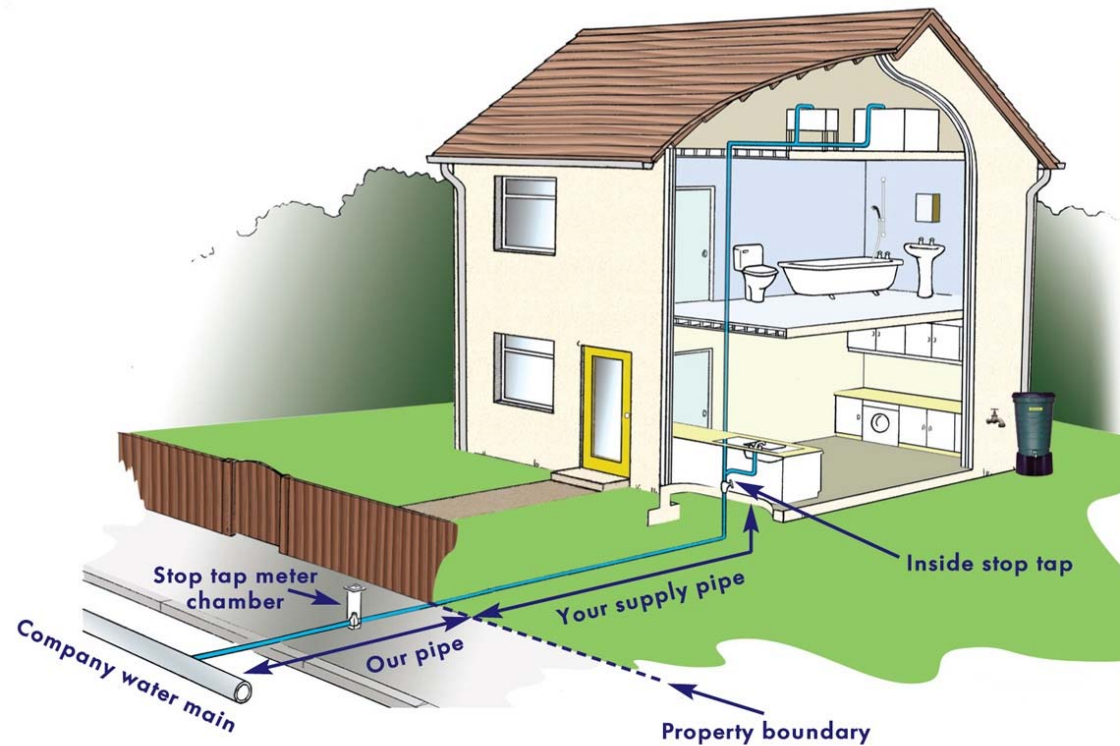
Before   Now

Think of it this way …

- **Transformation**
  - Which one should you pick?
  - Should you buy/rent?

Cloud Computing

Think of it as Internet Computing

- Computation done over the internet

■ Enabled through:

- High Bandwidth and High Speed Internet
- Utility Computing
- Virtualization
- …

Cloud Computing Services

Three basic services:

- **Software as a Service (SAAS) model**
  - Apps through browser

- **Platform as a Service (PAAS) model**
  - Delivery of a computing platform for custom software development as a service

- **Infrastructure as a Service (IAAS) model**
  - Deliver of computer infrastructure as a service

- **XAAS, the list continues to grow...**

Interesting Videos

- **SaaS: http://www.youtube.com/watch?v=kGUPSvswmY0&feature=related**

- **Virtualization: http://www.youtube.com/watch?v=p11lJOnALS4&feature=related**

- **Cloud Computing:**

  http://www.youtube.com/watch?v=XdBd14rjcs0&NR=1