Cloud Computing

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Course Outcomes

- To describe the different cloud computing models and underlying technologies
- To develop real world applications using cloud computing platforms and containerization technologies
- To implement solutions to complex problems using distributed computing technologies
- To identify and analyze security issues in cloud computing

Tentative List of Topics

- **Introduction to Cloud Computing and its Enabling Technologies :** Evolution of Computing, Grid and Utility Computing, The vision of Cloud Computing, Characteristics and Benefits, Distributed Computing, Virtualization, Web 2.0, Service Oriented Architecture
- **Cloud Computing Architecture** : Introduction, Cloud Service Models, Cloud Deployment Models, Open Challenges
- **Virtualization:** Introduction, Characteristics of virtualized environments, Taxonomy of virtualization techniques, Virtualization and cloud computing, Pros and cons of virtualization, Technology examples, Containers and Applications
- **Cloud Platforms:** Amazon Web Services, Google Cloud Platform, Microsoft Azure, Aneka, OpenStack, Cloud Automation using CHEF/Ansible
- **Introduction to Bigdata:** Bigdata concepts, terminology, NoSQL; Distributed File Systems-Hadoop File System, GFS, Introduction to MapReduce and applications
- **Cloud Security:** Security Issues in Cloud Computing, Hypervisor and VM Security, Data Security in Cloud Environment, Identity and Access Management in Cloud

Tentative Evaluation Policy

- **Examinations: 55%**
  - Mid Semester Exam: 20%
  - End Semester Exam: 35%
- **Research Work / Assignments: 20%**
- **Project: 10%**
- **Scheduled Quizzes: 15%**

So, let us begin…

What is **Computing**?

Pascaline

Charles Babbage

Computing

- **Computing** consists of three things:
  - Managing,
  - Processing, and
  - Communicating information
- Over the years, computing has evolved – passing through a number of computational paradigms
  - More computational capacity
  - More efficiency
  - Less cost
  - Less size

Vacuum Tube

Transistors

Integrated Circuit

Microprocessor

Quantum Computer

1st Generation Computer

2nd Generation Computer

3rd Generation Computer

4th Generation Computer

5th Generation Computer

The Evolution of Commercial Computing

Centralized Era

first, large and expensive Computers

(since 1940s)

Microprocessors & Mass Production

Personal Computers

(since 1970s)

Miniaturization & Mobility needs

Notebook Computers

(since 1980s)

Timesharing Operating Systems & Local Area Networks

dedicated, on-premise Data Centers

(since 1980s)

Internet

Decentralized Era

Public Data Centers

(since late 1990s)

Service-oriented Architecture

Public Cloud Computing

(since early 2000s)

Blockchain

Distributed Computing (with limited use cases)

(in development since 2016)

Artificial Intelligence

Distributed Computing (with flexible use cases)

(in development since 2018)

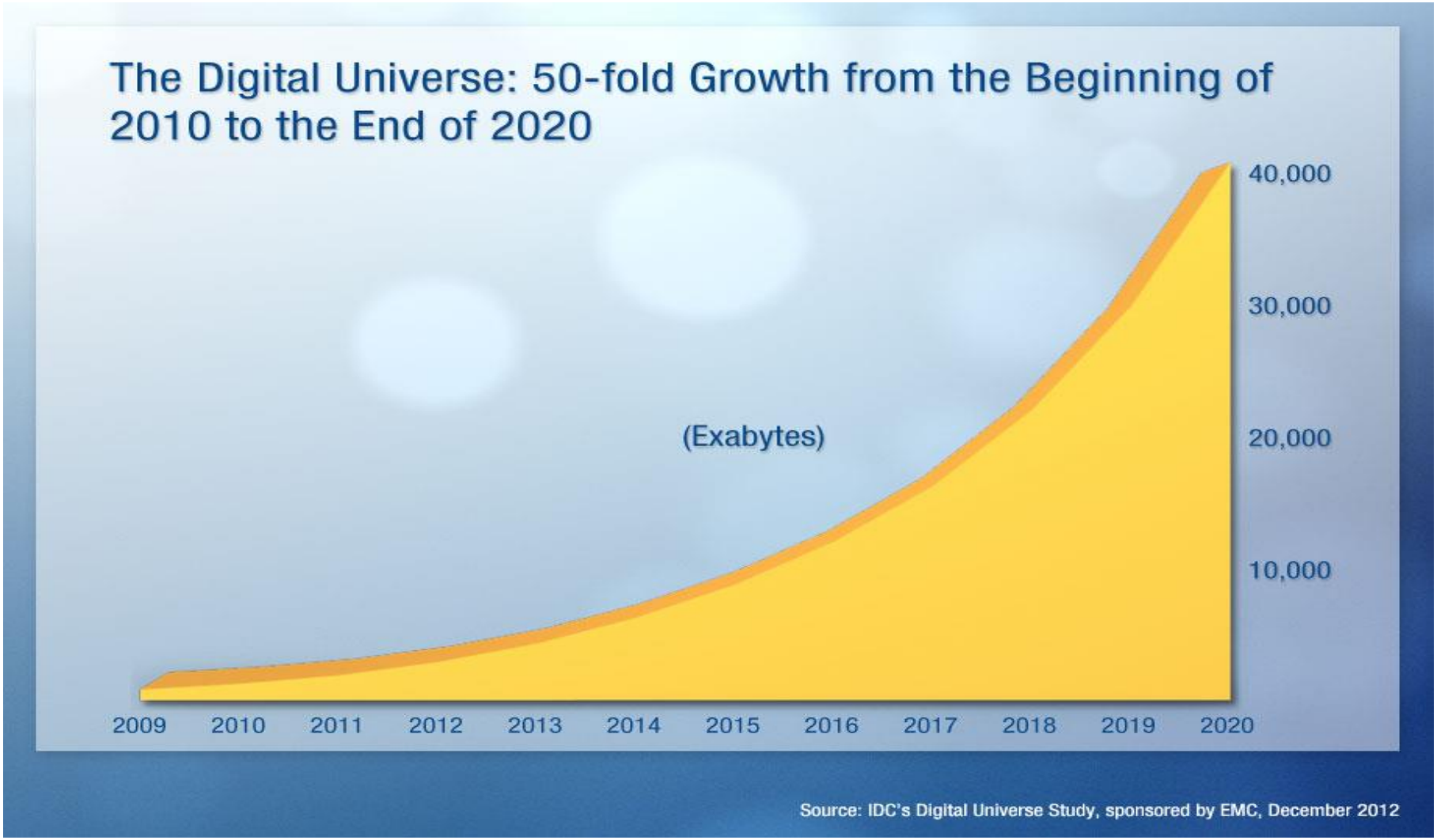
Distributed Era

HiveNet

Networked Computing

- Need for networked computing:
  - Better communication between systems
  - Resource sharing
- Systems and associated resources, such as printers, were interconnected to form local networks (LANs)
- These small networks evolved to form ARPANET, which finally evolved to the Internet

Information Explosion



Identifying Mersenne Primes

- **Mersenne Primes :** Prime numbers of the form 2^n-1
- Exponent *n* needs to be prime
- Used in Elliptic Curve Cryptography (ECC)
- Require enormous amount of computation

The GIMPS Project

- The Great Internet Mersenne Prime Search (**GIMPS**) was launched in 1996
- Allows users to contribute a portion of their unused CPU/GPU for computation
- By the end of 1996, the project could identify the 35th Mersenne Prime ($2^{1,398,269}$-1)
- In 2018, the project identified the 51st known Mersenne Prime ($2^{82,589,933}$-1)

SETI

- SETI – Search for Extra Terrestrial Intelligence
  - Analyzes radio waves in outer space for patterns
- Requires enormous amount of computation
- SETI@home allowed users to dedicate a part of their unused CPU for this purpose
- SETI@home and GIMPS were some of the first instances of volunteer computing projects

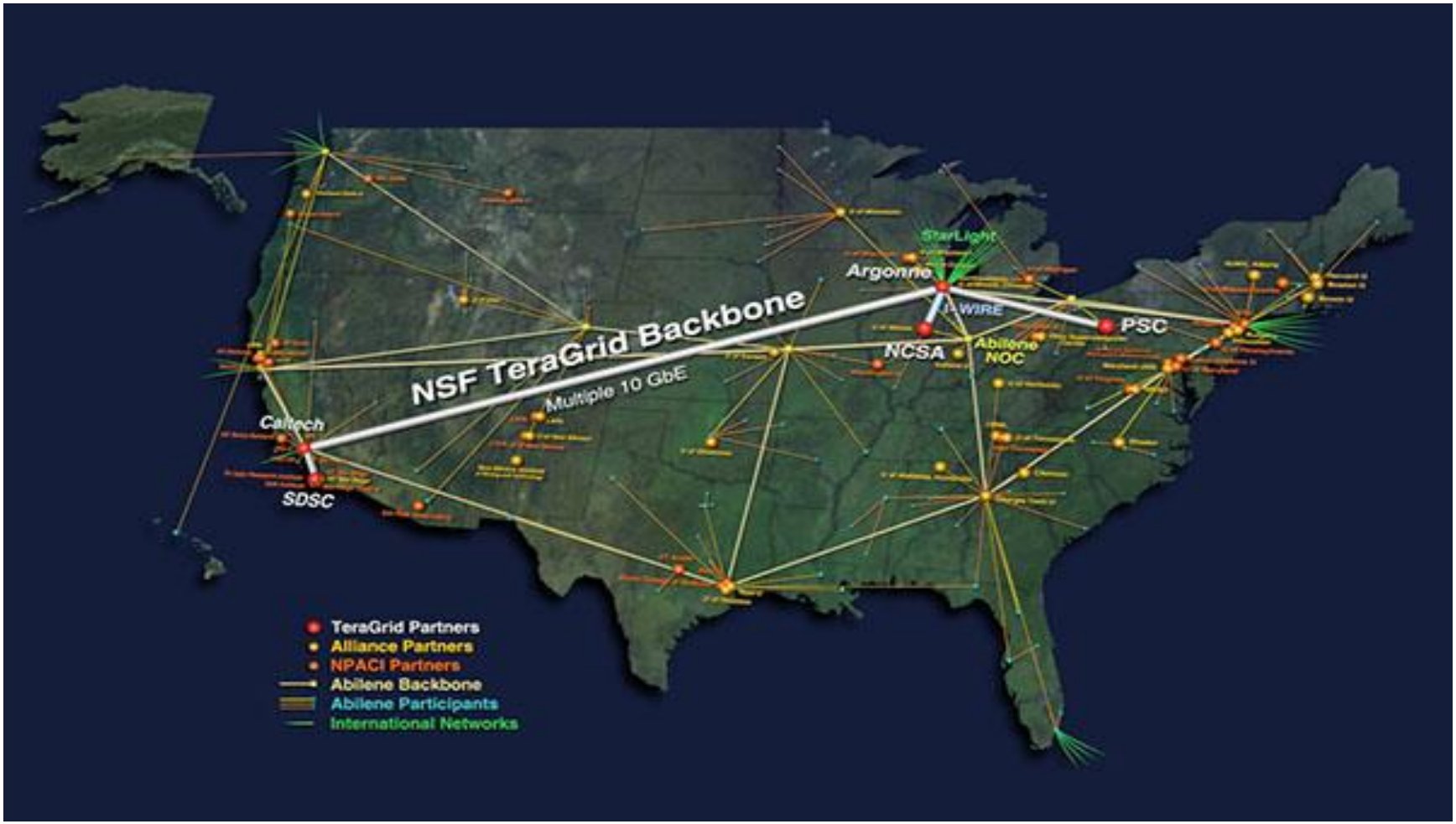
Grid Computing

- The volunteer computing projects are often compared to electric grids
  - Large number of connected nodes which act like a single entity
  - Users do not know which node serves their requests
- This comparison has led to the name “Grid Computing” being used to describe them

Grid Computing

- Multiple physically separated systems share data and resources for **performing a common task**
- Often, the original **task is split and distributed** among different systems or nodes
- Requires **special software** to be installed on the systems (“middleware”)

TERAGRID


StarLight
Argonne
I-WIRE
PSC
NCSA
Abilene NOC
NSF TeraGrid Backbone
Multiple 10 GbE
Caltech
SDSC
TeraGrid Partners
Alliance Partners
NPACI Partners
Abilene Backbone
Abilene Participants
International Networks

TERAGRID

- e-Science grid computing **spread over 11 sites** across USA
- **Petaflops of computing capability** and more than **30 petabytes of online and archival data storage** connected by **high speed optic fibre (10 Gbps)**
- Coordinated TeraGrid Software and Services (CTSS).
  - single-sign on
  - remote job submission
  - workflow support
  - distributed accounting and account management software
  - verification and validation software
  - set of compilers, programming tools etc

Advantages of Grid Computing

- Improved resource utilization
- General performance increase – parallel processing
- Easier collaboration
- Increased robustness