

# Introduction to Parallel Computing

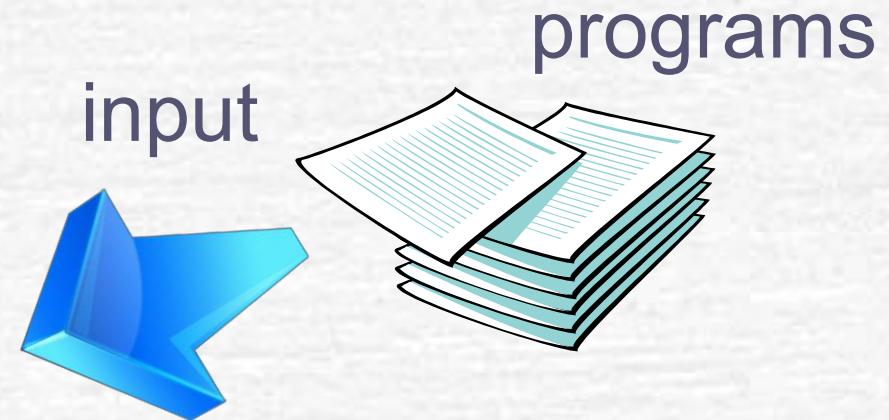
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# Serial hardware and software

~19 den 2019



output



Computer runs one  
program at a time.

# Parallelism

## Parallel Computing:

- is a fundamental technique by which computations can be accelerated.  
سرعه ایجاد
- is a form of computation in which many calculations are carried out simultaneously.  
متز من موسس فی نفس اوقات

## Parallel Programming:

- Decomposing a programming problem into tasks
- Deploy the tasks on multiple processors and run them simultaneously
- Coordinating work and communications of those processors

Lapri

ایجاد  
و بین  
لگ نیز  
کمینه  
اوقات

Cilk (کلک) یا آرچیتیوژن لپری

# Parallel Computers

- classified according to the level at which the hardware supports parallelism:

- Multi-core and multi-processor (Symmetric Multiprocessing) computers

بروسر فی اکٹو ویسٹر کوئے بالا رکھوں

- Multi-core computers have multiple processing elements (cores) within a single machine.

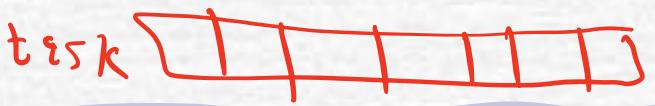
- Symmetric Multiprocessing (SMP) - multiple processors sharing a single address space, OS instance, storage, etc. All processors are treated equally by the OS

اکٹر میں سے جوں اسے لے تو اسے بدلے دے

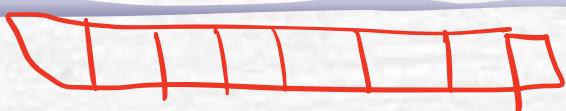
- Clusters and grids use multiple computers to work on the same task.

- Cluster: A parallel system consisting of a combination of commodity units (processors or SMPs).

- Grid: is a group of networked computers that work together, only when idle, as a virtual supercomputer to perform large tasks.



میں کسی نصیت اپنے  
on run time



Virtual  
پر

fixed  
9 group  
کامپیوٹر  
نیکیت

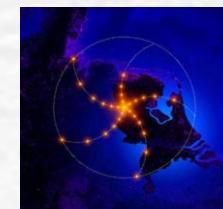
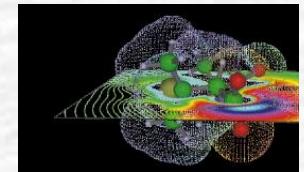
# Why do we need Parallel Processing?

- Many applications need much faster machines
- Sequential machines are reaching their speed limits.

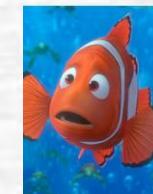
وحلو لهم في اسرعه (نشروا بني)  
الحل
- Use multiple processors to solve large problems faster.
- Microprocessors are getting cheaper and cheaper.
- Cheap multiprocessors and multi-core CPUs bring parallel processing to the desktop.

# Challenging Applications

- ☞ Modeling ozone layer, climate, ocean
- ☞ Quantum chemistry
- ☞ Protein folding
- ☞ General: *computational science*
- ☞ Aircraft modeling
- ☞ Using volumes of data from scientific instruments
  - ✿ astronomy
  - ✿ high-energy physics
- ☞ Computer chess
- ☞ Analyzing multimedia content



جذب  
البيانات  
الديناميكية  
التحليل  
المulti-processor



# History

فكرة مفهوم

- ➊ 1950s: first ideas (see Gill's quote)
- ➋ 1967 first parallel computer (ILLIAC IV)
- ➌ 1970s programming methods, experimental machines
- ➍ 1980s: parallel languages (SR, Linda, Orca), commercial supercomputers  
لقد بدأ الجميع في العمل على ذلك
- ➎ 1990s: software standardization (MPI), clusters, large-scale machines (Blue Gene)
- ➏ 2000s: grid computing: combining resources world-wide (Globus)

# Opportunities to use parallelism

## ☞ Instruction Level Parallelism

- Hidden Parallelism in computer programs

## ☞ Single computer level

- Multi-core computers: Chip multi-processors
  - Dual-core, Quad-core
- Multi-processor computers: Symmetric multi-processors
  - Super-computers

كيف نستفيد من  
parallel  
يا كمبيوتر واحد

## ☞ Multiple computers level

- Clusters, Servers, Grid computing

او اكثر من كمبيوتر

## ☞ Need for programs that have multiple instruction streams

# Parallelism in Computer Programs

الانستركشن تنفيذها  
سكونشل

- The main motivation for executing program instructions in parallel is to complete a computation faster.
- But programs are written assuming that:
  - Instructions are executed in **sequential**.
  - Most programming languages embed sequential execution.

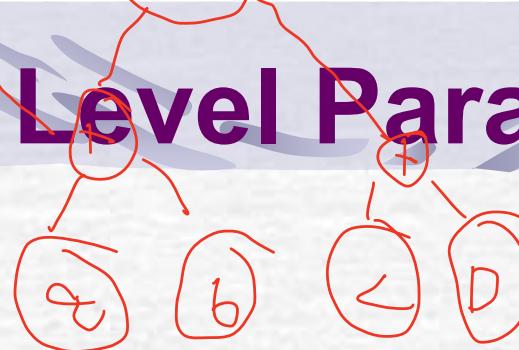
تنفذ لكن لحالها سكونشل

سكونشل يعني وحدة البارالل يعني تنفيذ اكثـر من شيء

# Instruction Level Parallelism (IPL)

$$(a+b) * (c+d)$$

- could be computed simultaneously.



كيف يتم تنفيذ العمليات الى parallel  
نسوبيا tree (بالغالب باينري تري)  
نضع المعلومات تحت  
ثم نضع العمليات

## Separation of instructions and data.

- Instructions and memory references execute in parallel without interfering.



ان عمليات الجمع  
مفصولة



## Instruction Execution is pipelined

ان عمليه جميع a+b في ماصورة  
و c+d في ماصورة

## Processors initiate more than one instruction at a time.

البروسس فيه اكثرب من كور  
حيث كل كور يتحمل عملية

# How do we write parallel programs?

كيف كتابة برامج البارالل

## Task parallelism

- Partition various tasks carried out solving the problem among the cores.

بنشرى بيعبرون 4 كفرات  
يعبرون كفرات واثنين صواميل 2 :  
task : data parallelism :  
كلن يمسك كفر

## Data parallelism

- Partition the data used in solving the problem among the cores.
- Each core carries out similar operations on it's part of the data.

لا يتم تقسيم التاسك لكن يتم تقسيم الداتا

# Professor P

task:

15 questions  
300 exam copies

الداتا هي الوراق



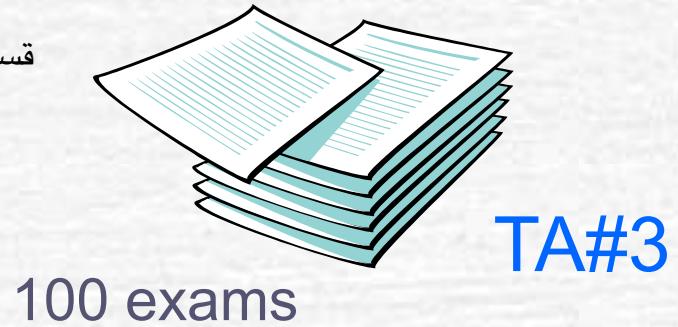
# Division of work – data parallelism

Teacher 1  
TA#1



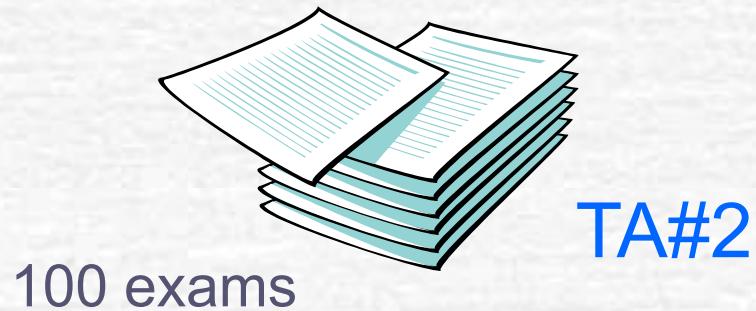
100 exams

قسمت الداتا وسوبيتها parallel



100 exams

TA#3



100 exams

TA#2

# Division of work – task parallelism

راح يصححون كل الاختبار لكن جزء من الاسئلة  
الاداتا هي نفسها  
لكن التاسك مختلف

TA#1



Questions 1 - 5

or Questions 1 - 7



Questions 6 - 10

or Questions 8 - 11



TA#3

Questions 11 - 15

or Questions 12 - 15

TA#2

Partitioning strategy:

- either by number
- Or by workload

# Parallel Computing vs. Distributed Computing

Latency : how much process take time to finish a task ( since from take input to finish it )

throughput ( وقت الانتاجي ) : how much work can finish in period of time

## Parallel computing

- Provides performance that a single processor can not give. Speed up (decrease latency)
- Interaction among processors is frequent
  - Fine grained with low overhead
  - Assumed to be reliable.

كم حجم البيانات الذي تقدر

تعالجها في جزء من الوقت

how much data can we process in per unit of time

الهدف من parallel

تقليل الالاتنجي ورفع البنداث

Increase bandwidth , increase throughput

distributed اما

To increase availability

يستعمل اكثر من بروسيس

no single point failed

ما فيه بروسيس : No Gloable state

يعرف جهاز او طافي

## Distributed Computing

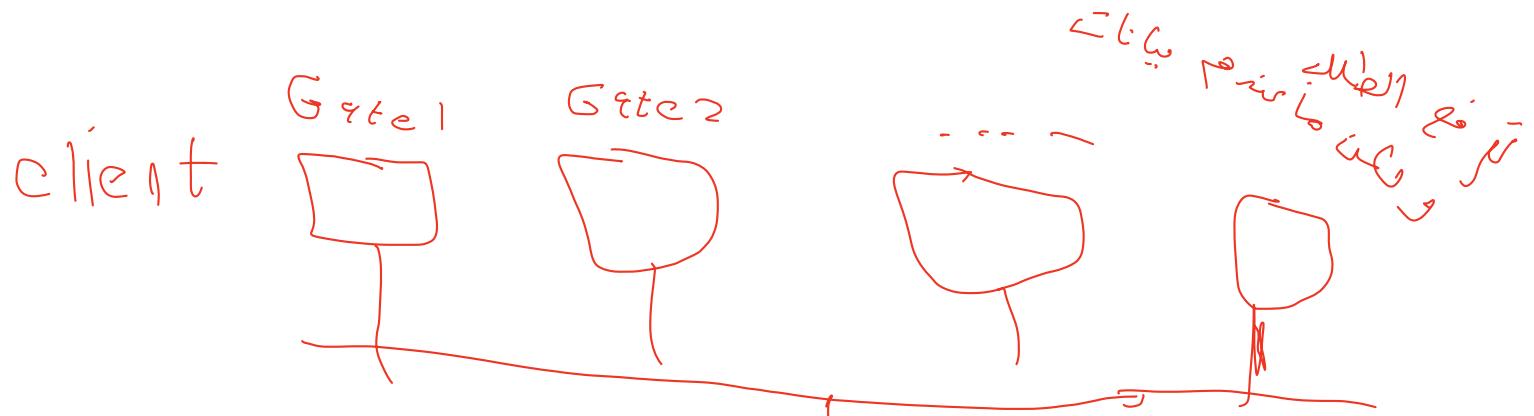
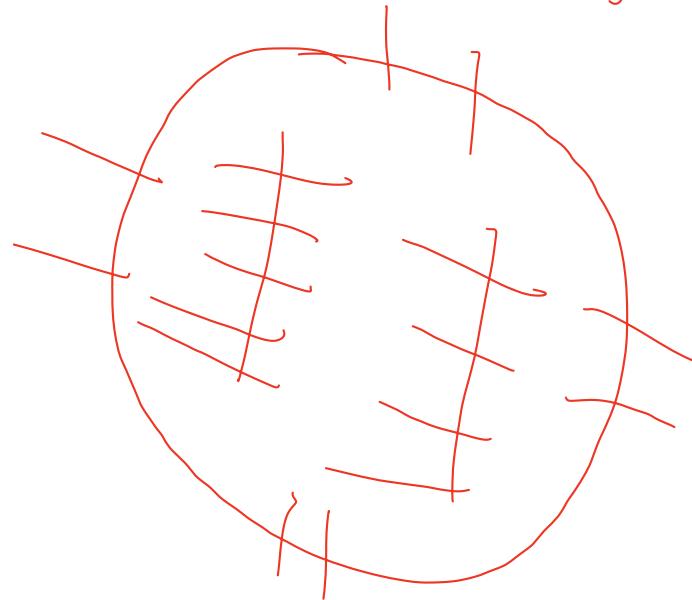
- Provides convenience:
  - Availability, Reliability
  - Physical distribution, Heterogeneity
- Interaction is infrequent, assumption اسمبشن  
  - Coarse grained - heavier weight
  - Assumed to be unreliable.

DC	reliability
not reliable	ليس عملي
infrequent	التواصل قليل بين السيرفرات ( عند الحاجة مثل التوكن بالموافق )
frequent	ال التواصل بينهم كثير
coarse grained	كل سيرفر يأخذ جزء صغير
fine grained	يعني وحدة من السيرفرات بينفذها

Norkload

مقدار الشغل

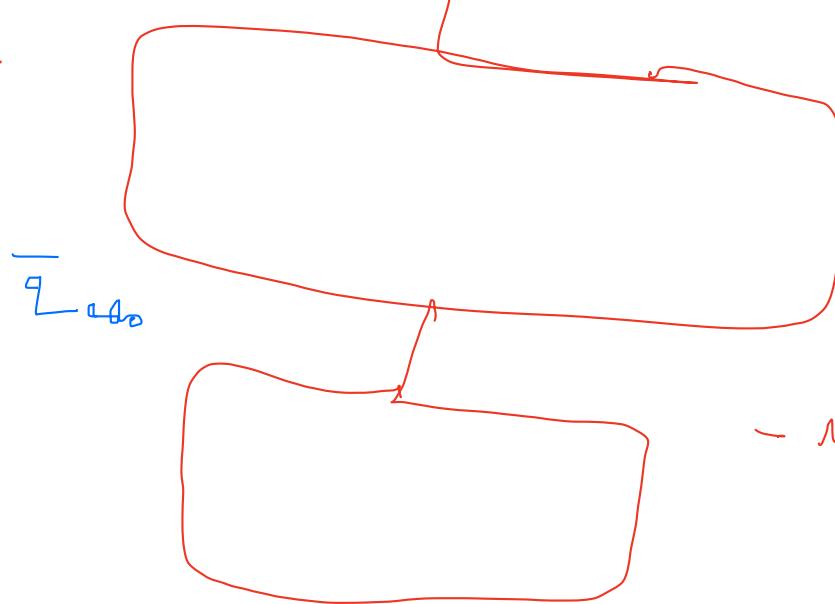
Parking : M park N gate



Single Server

- ما يسمى distribute server
- no single link of failure
- no global state
- يعني الكابينت ماعنده داتا
- no global clock
- ??

>> 1gate>> 1peer :

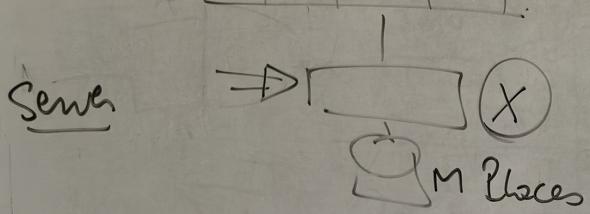


N peers ~ client, server

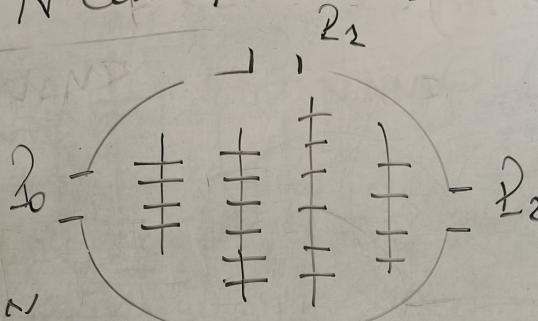
Parking: M Places, N Gates; Action: Enter, Exit

- N clients
- 1 Server
- Gates<sub>1</sub> ... Gates<sub>N</sub>

Client:



Server:



- No Single Point of Failure.
- No Global State.

- No Global

- N Peers [client / server] clock.

1 Gate  $\rightarrow$  1 Peer:  $\frac{M}{N}$  Tokens

Enter:  $\text{if } (M > 0) \text{ then } n--$   
Asymmetric Processing | return Yes  
 else return No

Exit:  $n++$   
 return Yes.

الى على اليسار يعتبر  
 non-distributed  
 وليس  
 parallel

=====  
 distributed

مثل سالفة البنوك

مادرسي انت اي سيرفر خاشه

# What is a Distributed System?

- ☞ A distributed system is one that looks to its users like an ordinary, centralized, system but runs on multiple independent CPUs

نظام يشغل على اكثر من جهاز

# Symptoms? Shroeder:

- **Multiple, independent processing units** اكثر من وحدة معالجة شغاله بنفس الوقت
  - Processors communicate via a hardware interconnect \*
  - **Processing unit failures are independent: No single point of failure**
  - No global clock مافيهم وقت معين  
يشتغلون فيه؟؟
  - State is shared among processors

## no-global state

## Parallel Computers Architecture

اختراع كمبيوتر

## Algorithms and applications

- Reasoning about performance
- Designing parallel algorithms.

تحسين الاداء

تصميم خوارزمية  
مثل-  
quick-  
sorting

## Parallel Programming

اهتمام بالبرامج

- Paradigms
- Programming Models
- Programming languages
- Frameworks يشتمل على parallel
- Dedicated environments

برمجه في parallel

	DC	PC
Objectives	Increase Availability → Reliability	Speed up → bandwidth → throughput → strength
Assumption	Not Reliable	Reliability
Instruction		
Work load	Coarse Grained	Fine Grained

المقصد هنا ان عند الاعتماديه مقيله

Architecture		
Performance		
decreasing latency is a goal in parallel computing		
Applications		
Objective	DC	PC
assumption	not reliable	reliable
work load	coarse grained	fine grained

