Design Project 2: Virtual Machine Placement in a Data Center Network

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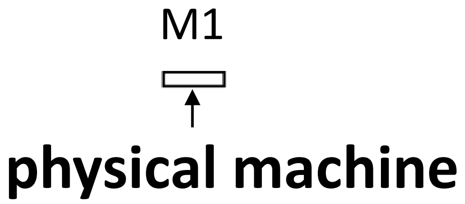
Data Center Network

The network you are using in your DP2

Data Center (DC) Networks

- DC networks are organized in a hierarchical way

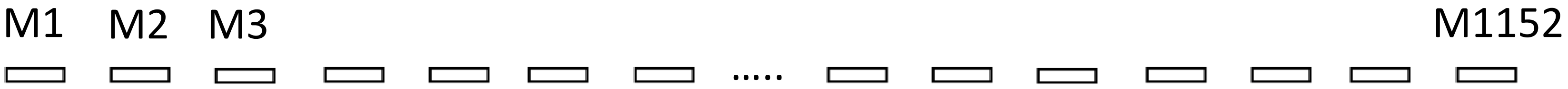


M1

physical machine

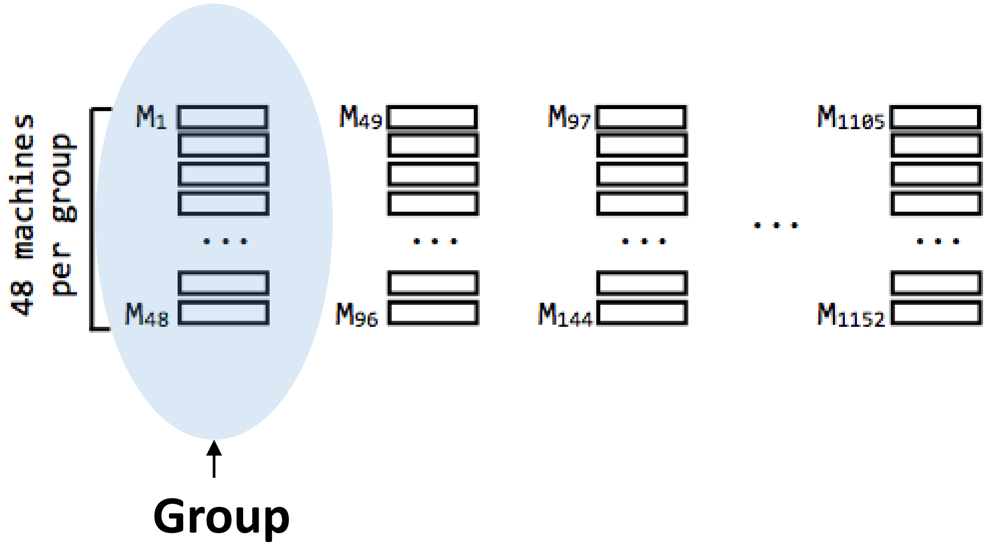
DC Networks

- Each physical machine has a unique ID



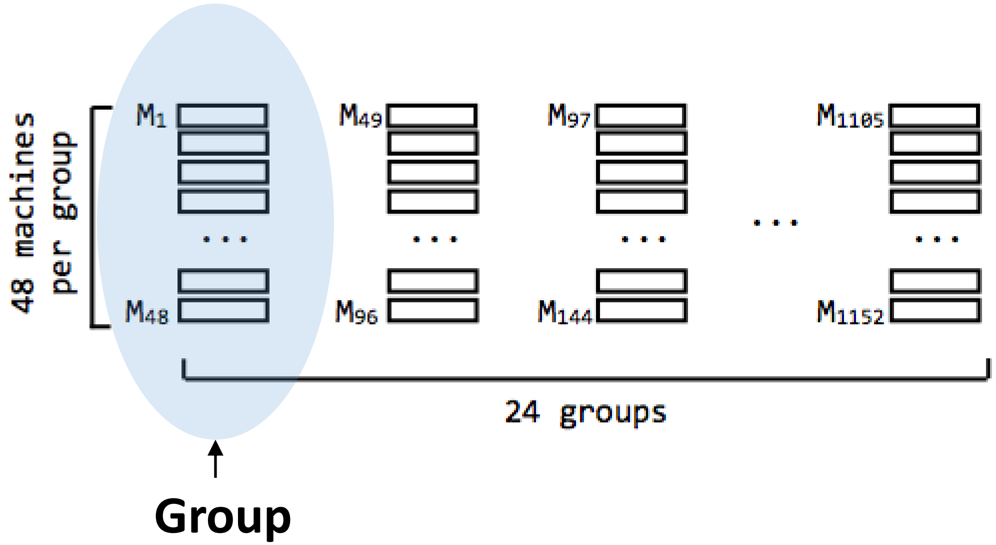
DC Networks

- These machines are divided into groups

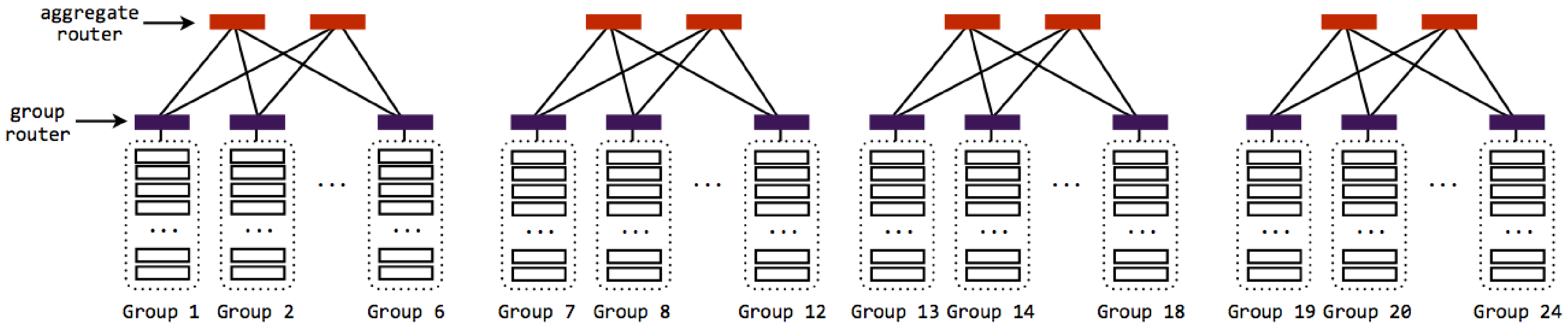


DC Networks

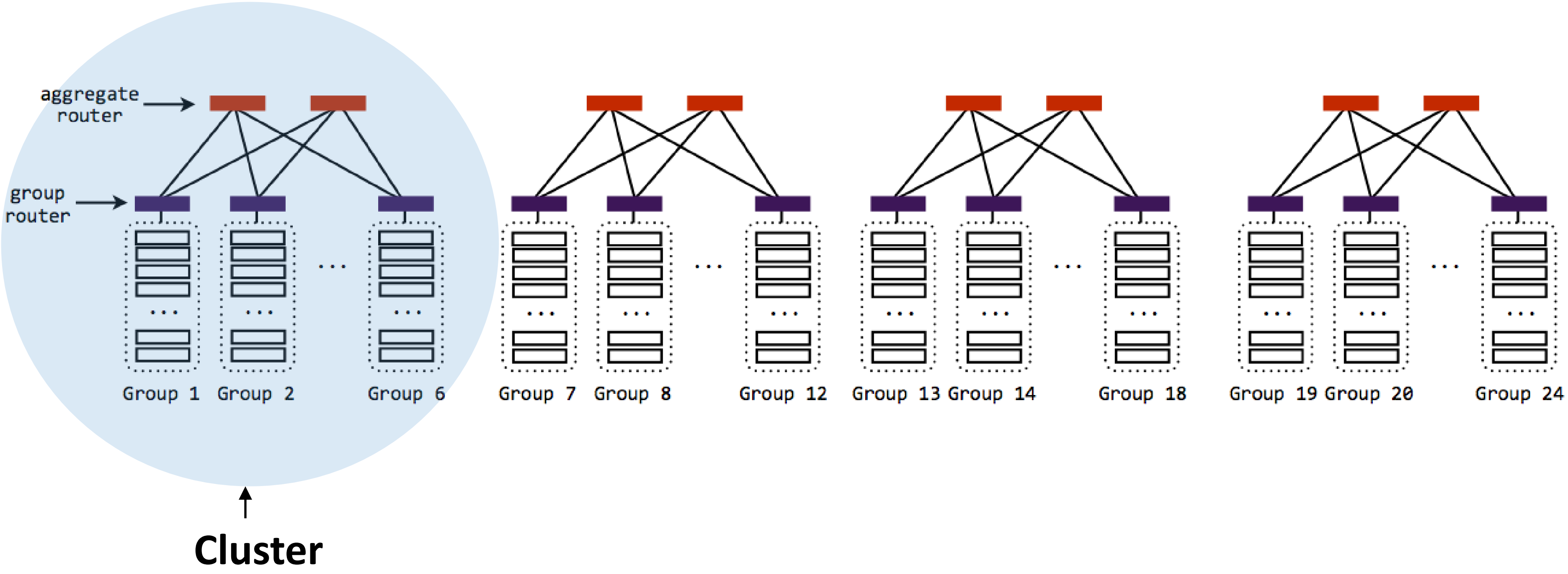
- **Machines in the same group are connected with a extremely fast network connection.**



DC Networks


aggregate router
group router
...
Group 1
Group 2
Group 6
Group 7
Group 8
Group 12
Group 13
Group 14
Group 18
Group 19
Group 20
Group 24

DC Networks


aggregate router
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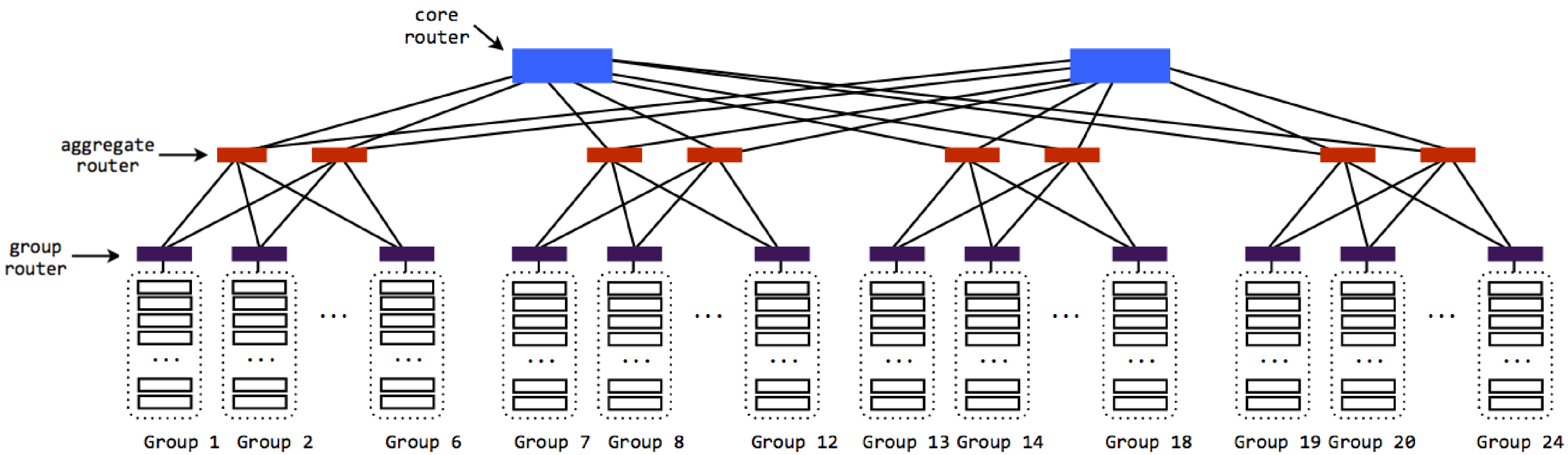
Cluster

DC Networks


core
router
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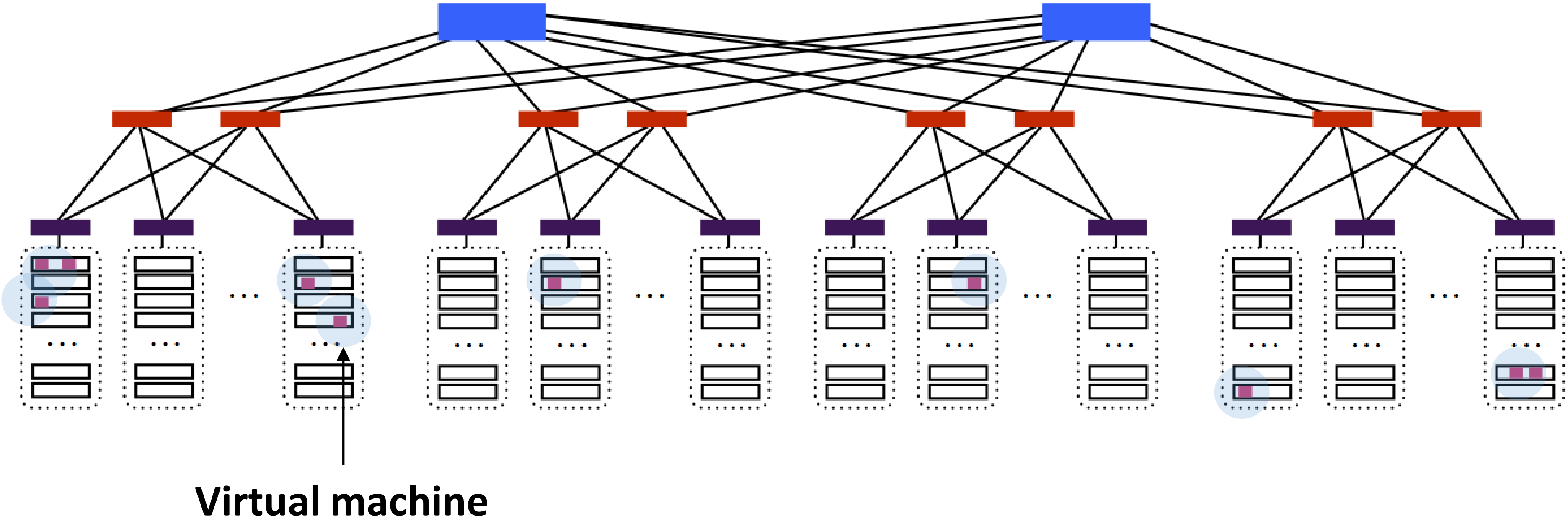
Virtual Machines (VMs)

- A physical machine is home to many different VMs
- Each physical machine can host 4 VMs



Running Jobs in a DC Network

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- User divides the computation into smaller jobs and puts each job in a VM
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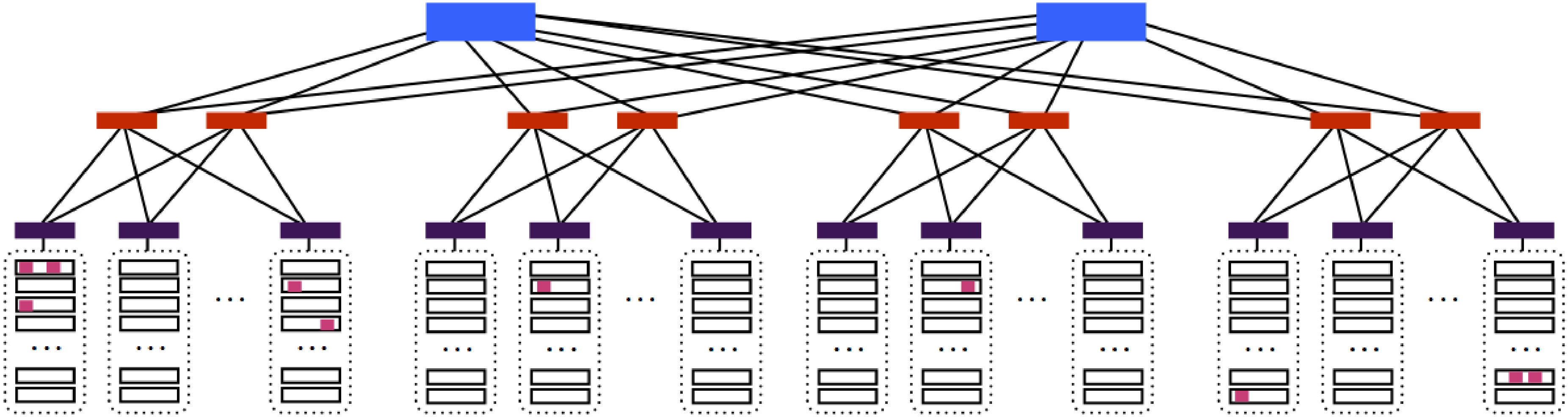
  - VMs communicate with each other to finish the task
- **Users are paying for each VM (!)**
  - $0.1/min per VM

Summary

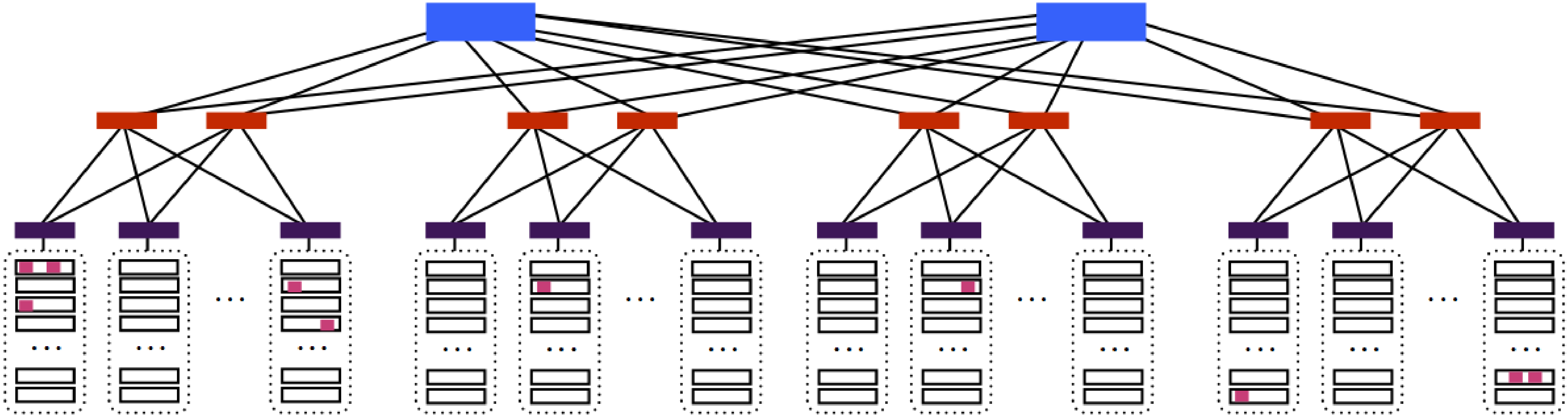


- **The price of a VM** **-** $0.1/min

VM Placement Problem

VM Placement Problem

- Your app needs multiple VMs, and they can be located anywhere on the network



VM Placement Problem

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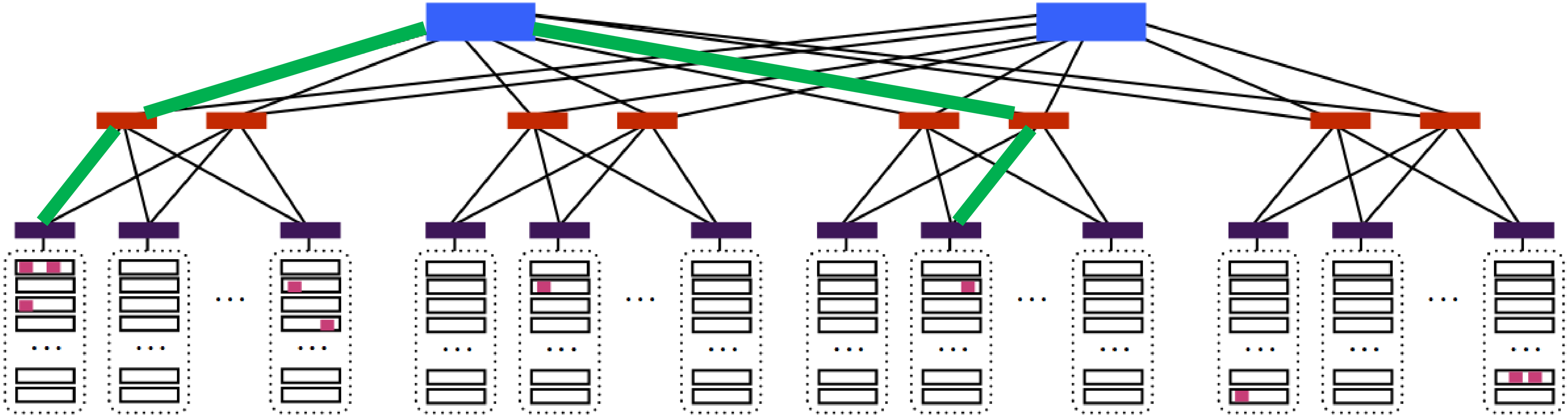
- If your app has to transfer a large amount of data, the network becomes the bottleneck



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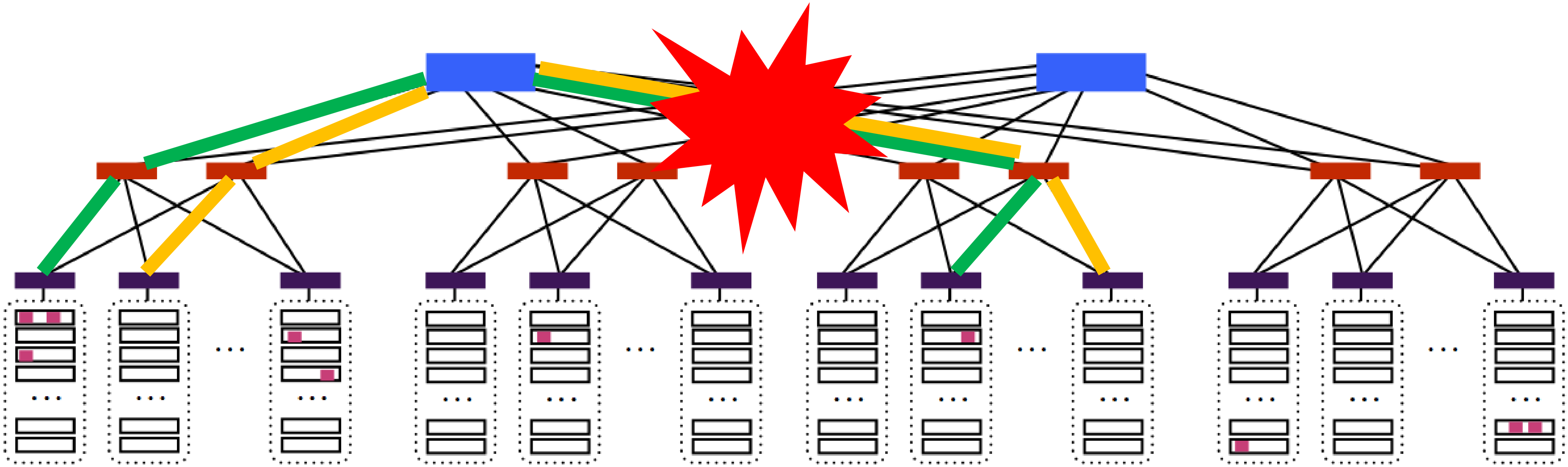

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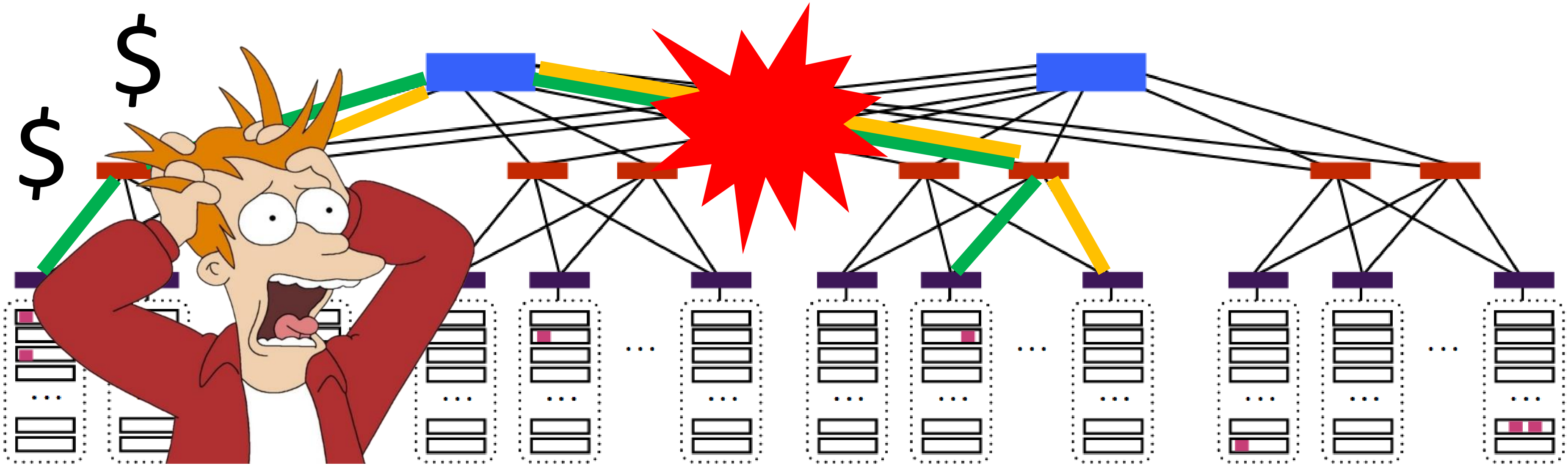

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- Place your VMs to minimize the time until the completion of the app
  - Time ↓ , Cost ↓ ($0.1/min per VM)
- Adapt the placement in real time to cope with nwk changes
  - Arrival/departure of other clients
  - Completion of existing task

Available Functions

1. **bool place(v, m)**

   - Place virtual machine v on physical machine m

2. **machine_id random_place(v)**

   - Place virtual machine v on a random physical machine, and returns that machine's ID

3. **int progress(u, v)**

   - Returns the number of bytes that virtual machines u and v have left to transfer to each other.

4. **int machine_occupancy(m)**

   - Return the number of VMs currently running on PM m.

5. **double tcp_throughput(v)**

   - Return the throughput of the TCP connection from this VM to VM v over the last 100ms *(passive monitoring)*

System Design

System Components

- **Measurement –** Learn the properties of the paths between the VMs
  - What to measure?
    - Available bandwidth? App’s throughput?
  - How to measure?
    - Active probing/passive monitoring?
  - How often to measure?
  - Overhead of measurements
    - $, traffic

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  - Overhead of measurements
- It takes a few RTTs to get an accurate measurement
  - Ex. Measuring the throughput (netperf) takes ***multiple seconds***

System Components

- **Placement –** given the measurements, where do you place the VMs
    - How to make the placement decision?
    - How do you interact with other users?
    - Is everything distributed/centralized?

Straw man #1

For v in VMs, **random_place(v)**

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- Ignores other paths that may have significantly higher throughput
- Does not consider other clients

Straw man #2

Try to put all the VMs in the same group

```
For each group
    For m in PMs,
        available_vms +=machine_occupancy(m)
        if available_vms >= n
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- You may not have enough VMs in one group

Straw man #3 - Straggler

1. Place all VMs randomly
2. Loop repeatedly
    a. Collect progress() values between all pairs
    b. Compute %progress (using matrix B – total to be transferred)
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Straw man #4

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- You may not have enough VMs in one group
- The path between the VMs that you pick may deliver low throughput.

Some hints…

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- Passive monitoring vs. active probing
    - Passive monitoring
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- Exploit the DC network topology

Lessons from DP1

- Detailed performance analysis
  - Provide real numbers
  - Get your hands dirty and do some real measurements
- Detailed explanation on the use cases
- Guideline
  - Make reasonable assumptions
  - Try your best to justify your design
  - Persuade your instructor to implement your design