The architecture of Kaligreen V2: A middleware aware of hardware opportunities to save energy

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1. Motivation

Shocking data: the reason to worry about energy...

*...The **data center sector** was estimated to have consumed about **61 billion kilowatt/hours** (kWh) in 2006 (**1.5 percent** of total U.S. electricity consumption) for a total electricity cost of about **$4.5 billion (2006 dollars).** The electricity use of the nation's servers and data centers in 2006 was more than double the electricity that was estimated to have been consumed for this purpose **in 2000. .***

Electricity demand increases from about 29 billion kWh in 2000 to nearly 73 billion kWh by 2020

...Consider CO2 emission ...

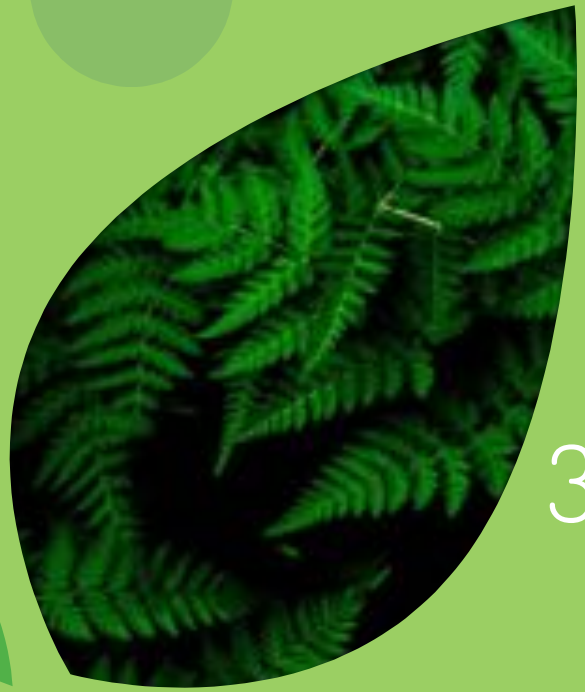
2. how software can save energy ?

Let’s talk about load balancing...

Cloud: Strategies and policies to process environmental data

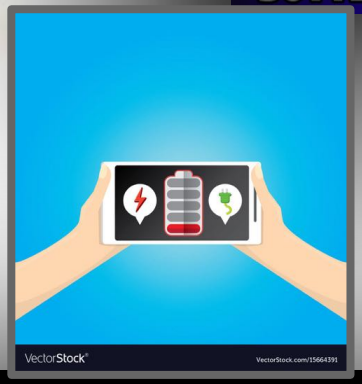
Data Center:Load balancing strategie: From the conception of a distributed application to its deployment.

Host: Load balancing algorithms and correct use of programming tools



3. What is our Problem?

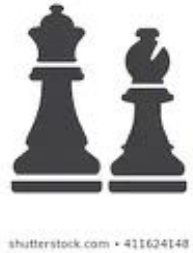

WHAT IS BOTTLENECK?
COMMON
BOTTLENECK HARDWARE!

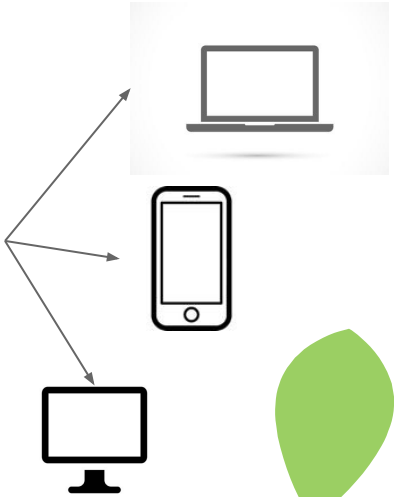

VectorStock


With i7-6820HK
Overclocking
4.0GHz+
+14%
With i7-6820HK
P15000+
+P1000~
With i7-6700HQ
3.5GHz
With i7-6700HQ
P13800
Over clock
3.5 GHz
4.0 GHz

KALIMUCHO

> *There is no decentralized way to deploy and manage an application based on microservices through user devices in order so save energy*

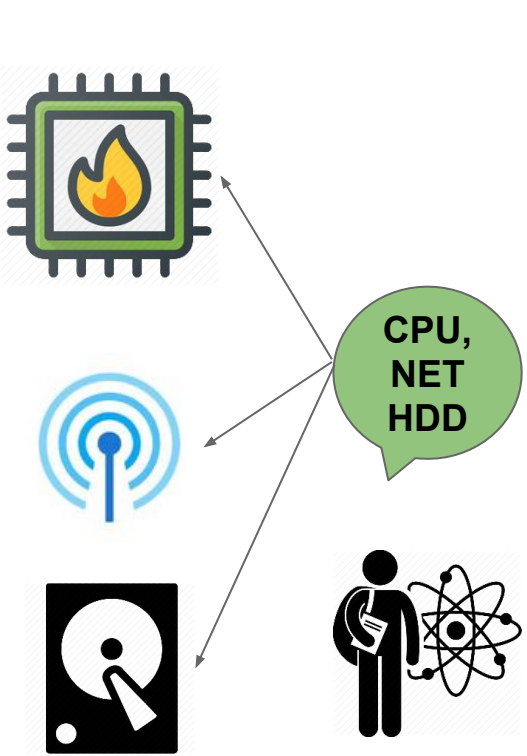


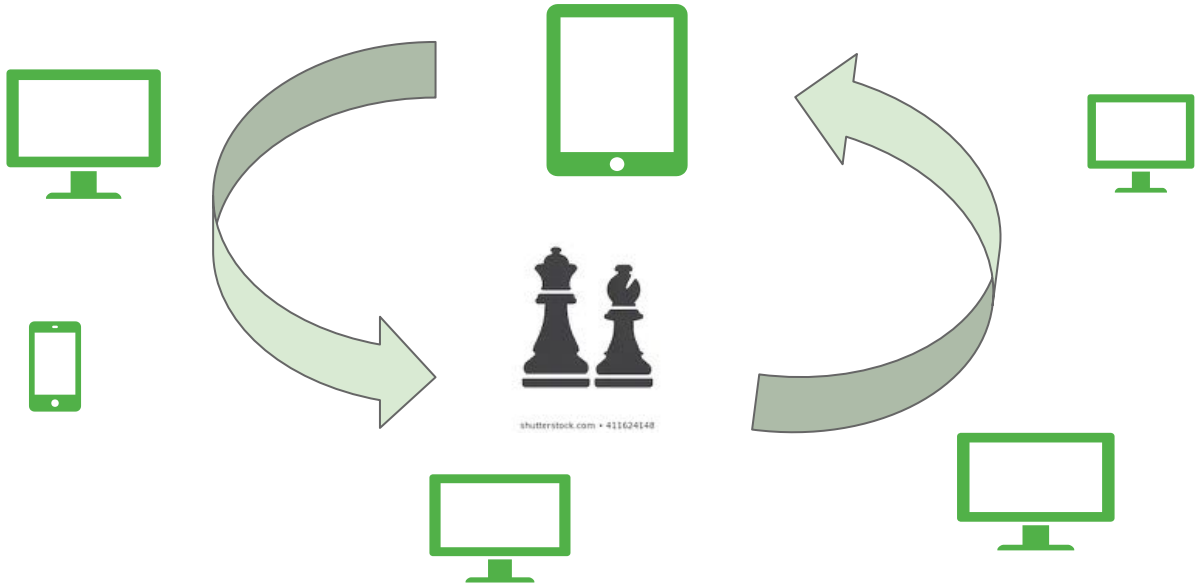


4. So, What is Kaligreen?

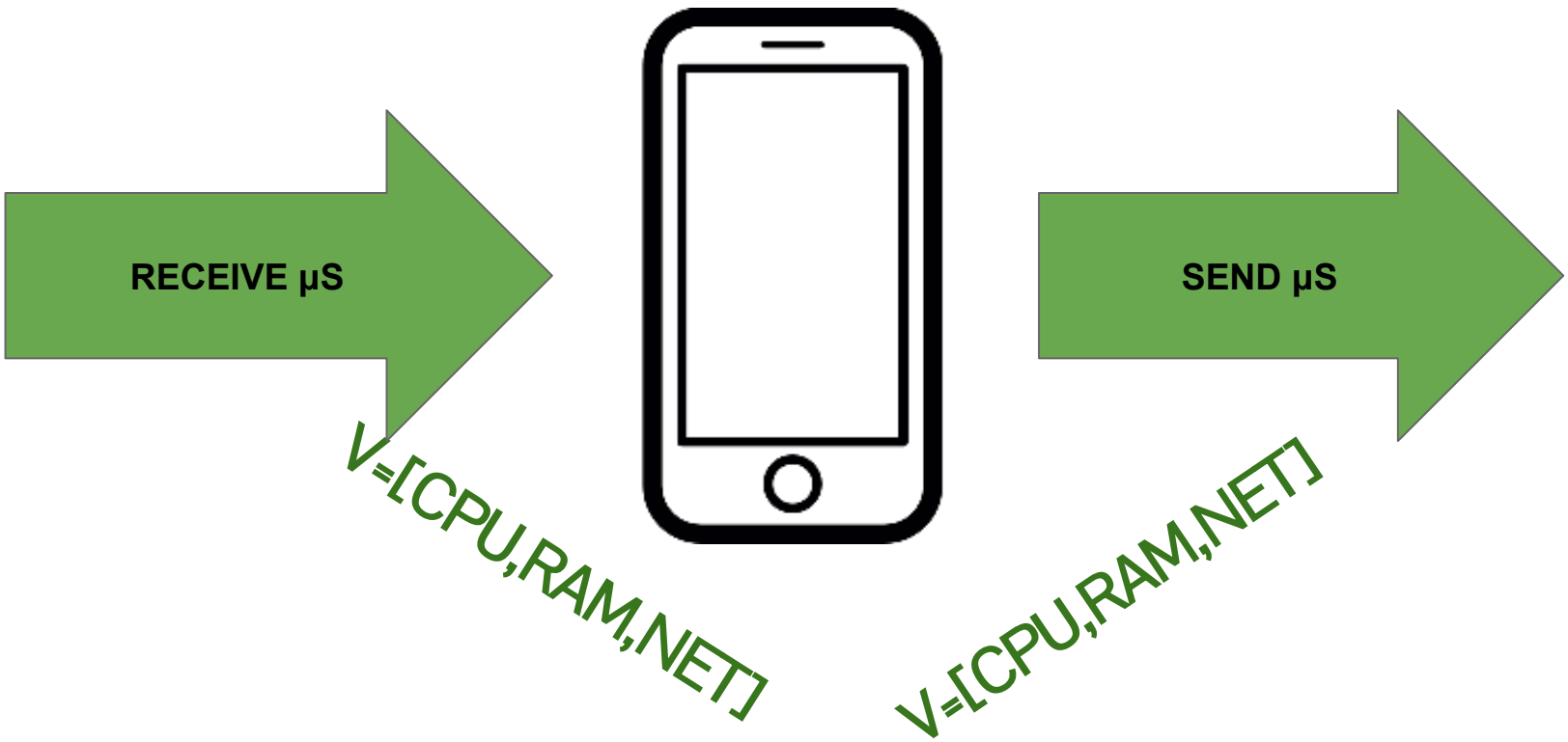
It is an autonomic extension of Kalimucho middleware capable of running distributed applications based on microservices hosted on user devices.

Can move/remove/duplicate/change microservices to save energy.





5. Kaligreen V1


RECEIVE µS
SEND µS
V=[CPU,RAM,NET]
V=[CPU,RAM,NET]

C100 – R50 – N50- B4

C80– R50 – N50

C10 – R30 – N10

C15 – R50 – N50

C100 – R90 – N50

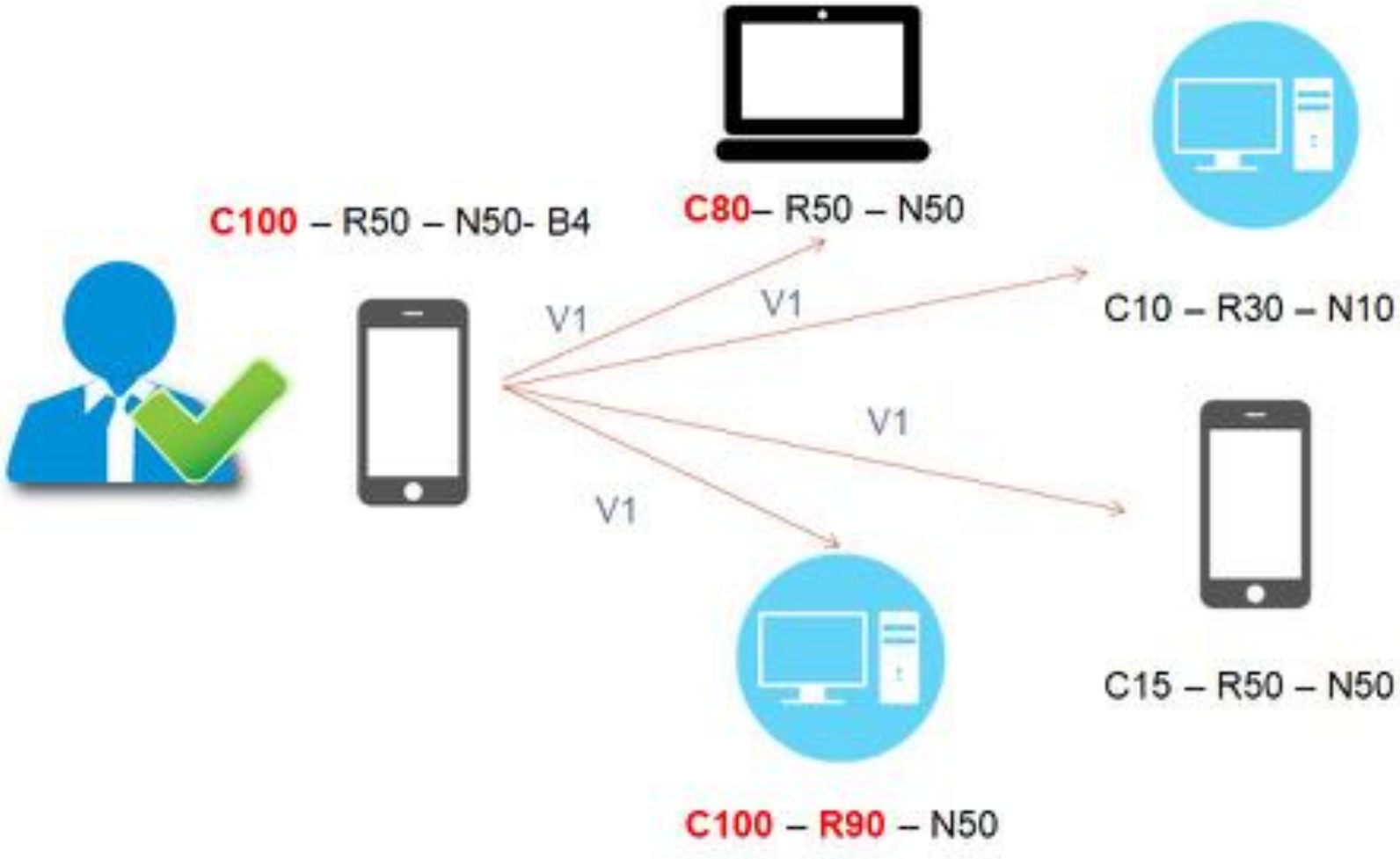
C100 – R50 – N50- B4

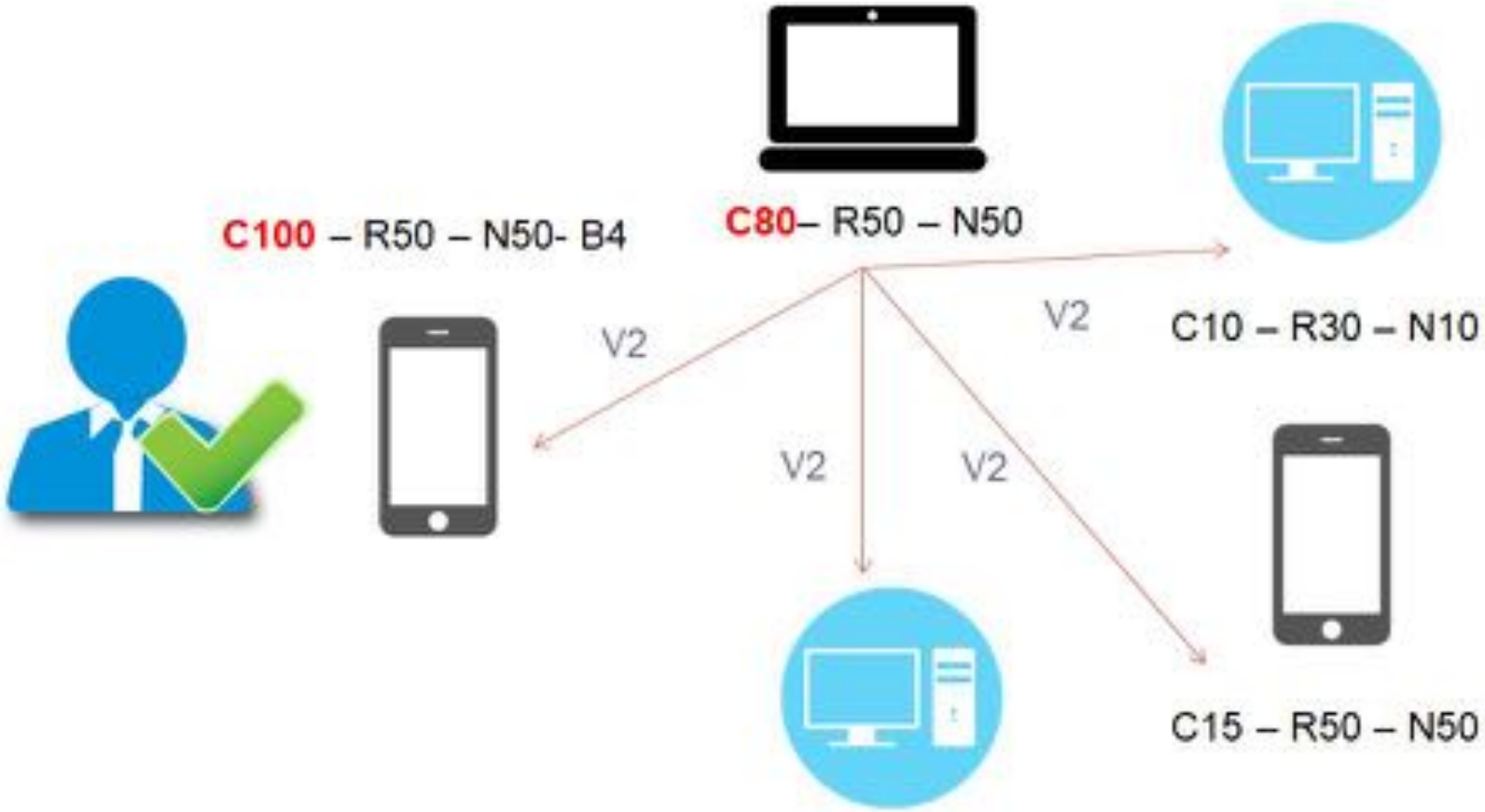
C80– R50 – N50

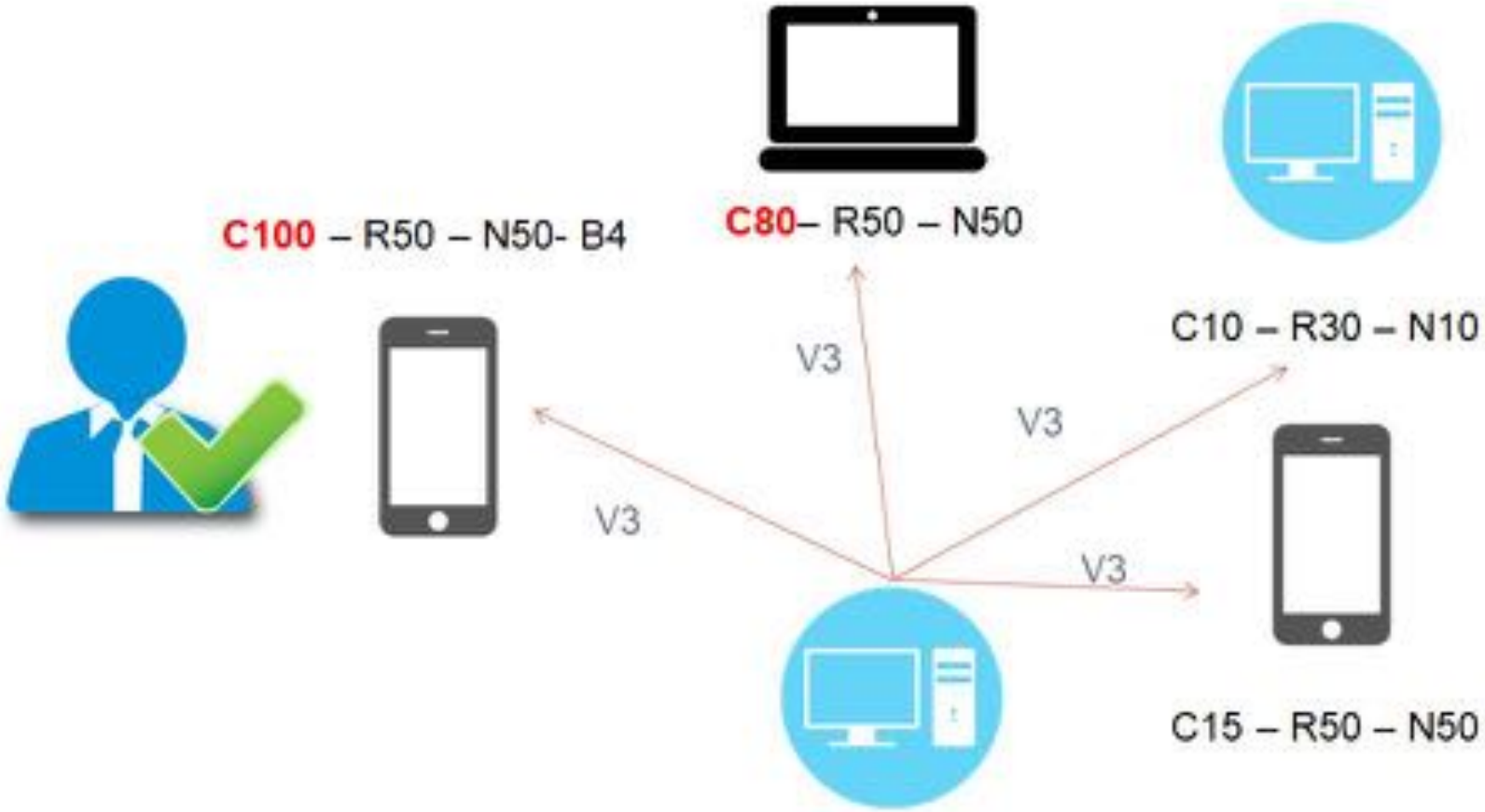
C10 – R30 – N10

C15 – R50 – N50

C100 – R90 – N50


C80– R50 – N50
C100 – R50 – N50- B4
V1
V1
V1
V1
C10 – R30 – N10
C15 – R50 – N50
C100 – R90 – N50


C80– R50 – N50
C100 – R50 – N50- B4
V2
V2
C10 – R30 – N10
V2
V2
C15 – R50 – N50
C100 – R90 – N50


C80– R50 – N50
C100 – R50 – N50- B4
C10 – R30 – N10
V3
V3
V3
V3
C15 – R50 – N50
C100 – R90 – N50

C100 – R50 – N50- B4

C80– R50 – N50

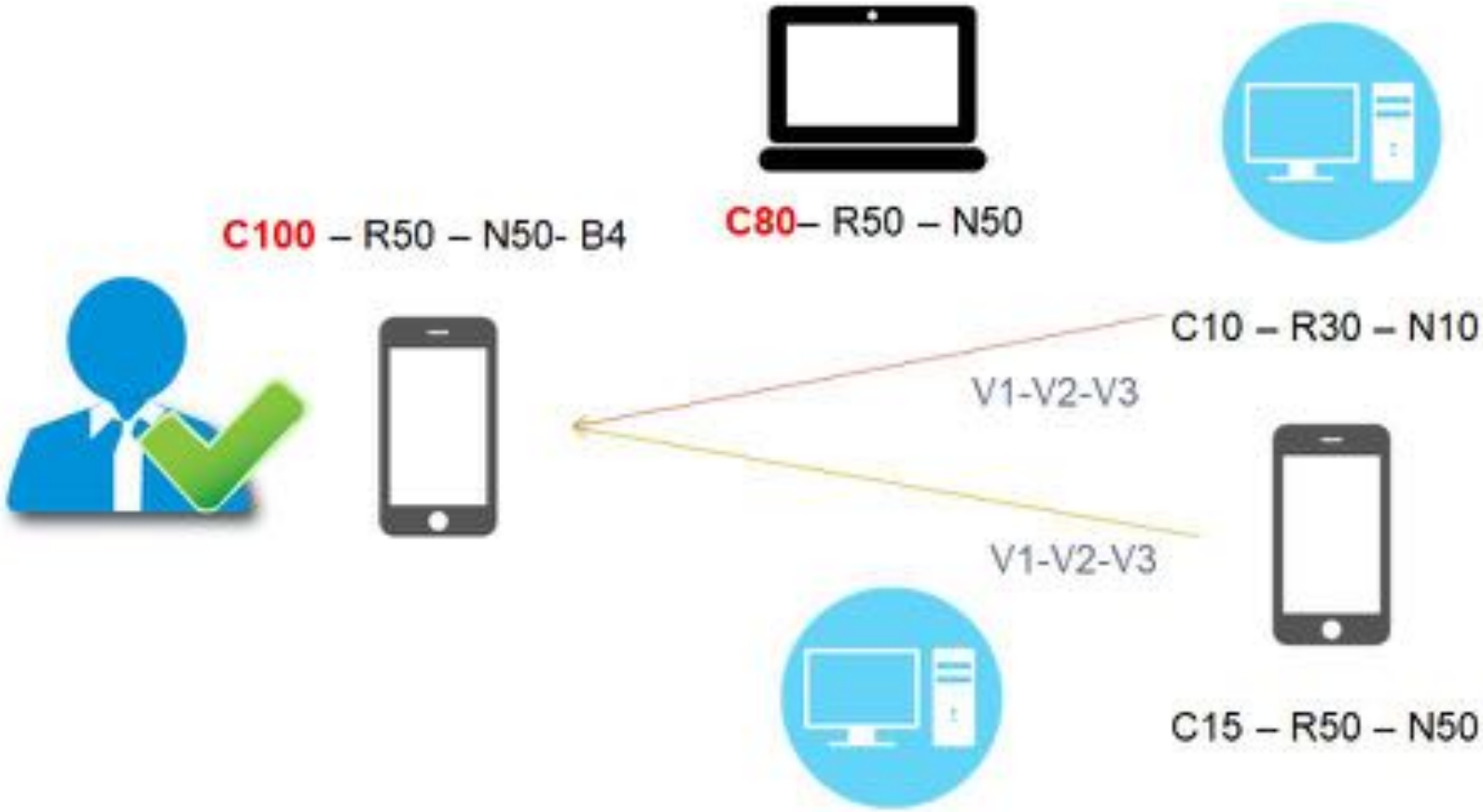
C10 – R30 – N10

V1-V2-V3

V1-V2-V3

C15 – R50 – N50

C100 – R90 – N50


C80– R50 – N50
C100 – R50 – N50- B4
C10 – R30 – N10
V1-V2-V3
V1-V2-V3
C15 – R50 – N50
C100 – R90 – N50

C100 – R50 – N50- B4

C80– R50 – N50

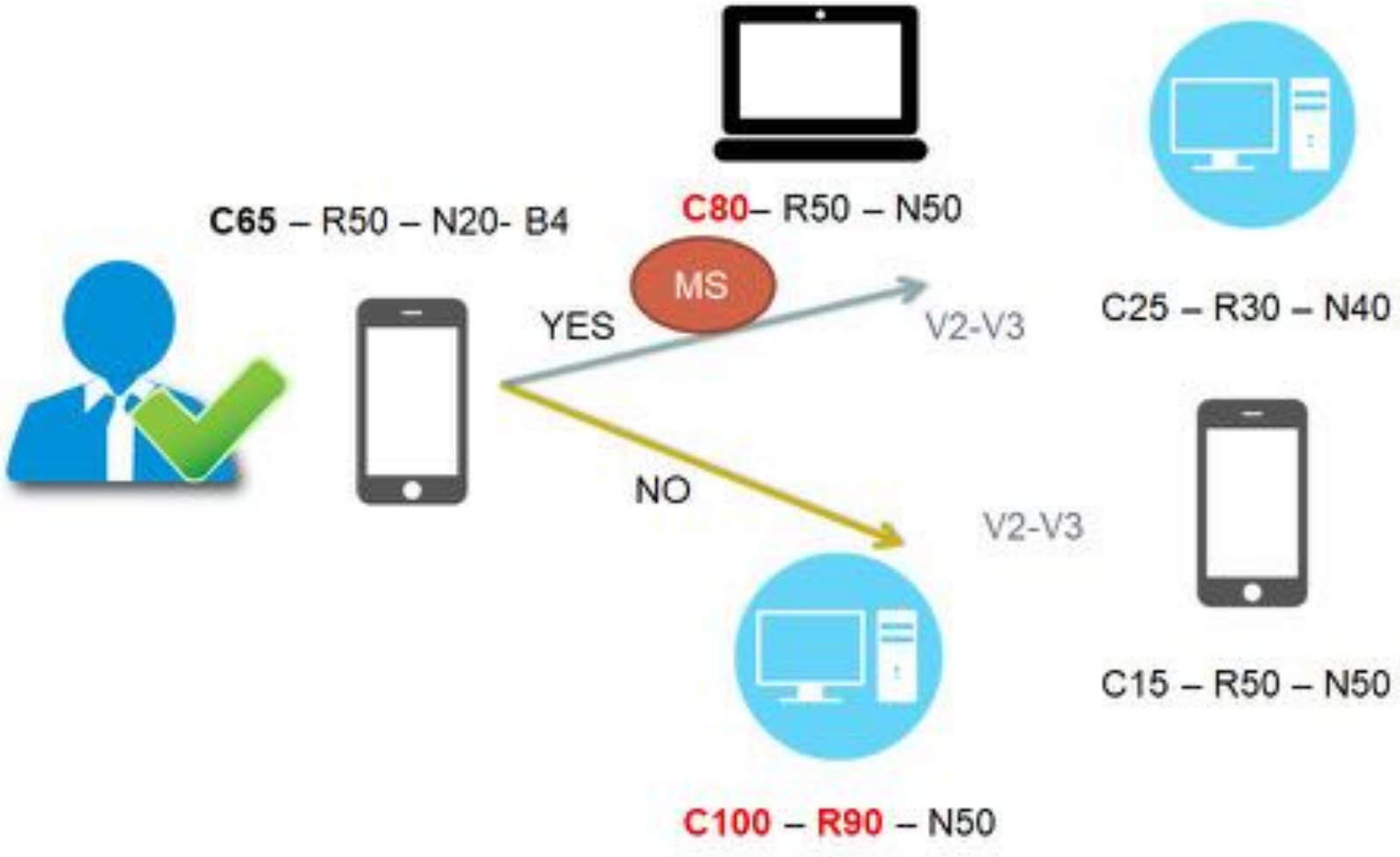
C10 – R30 – N10

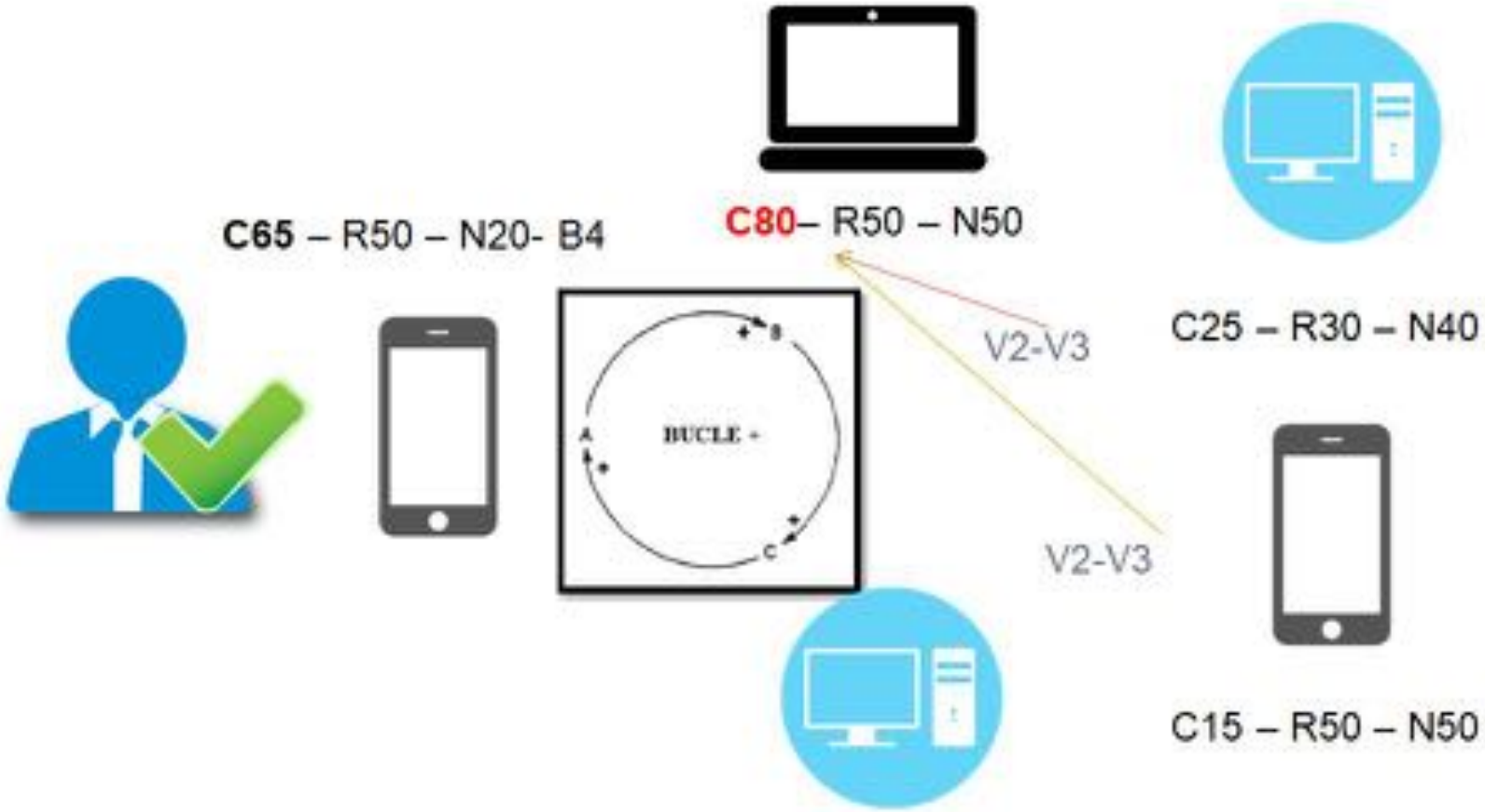
V1-V2-V3

V1-V2-V3

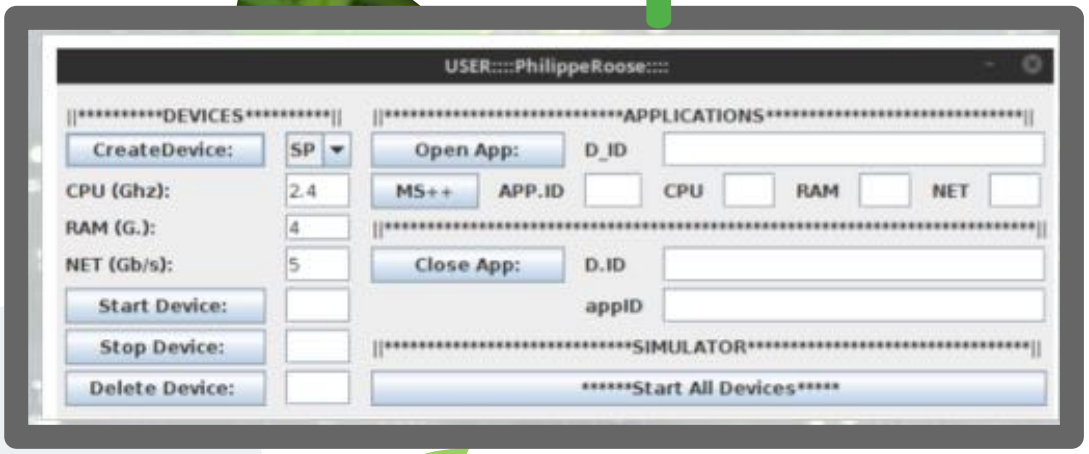
C15 – R50 – N50

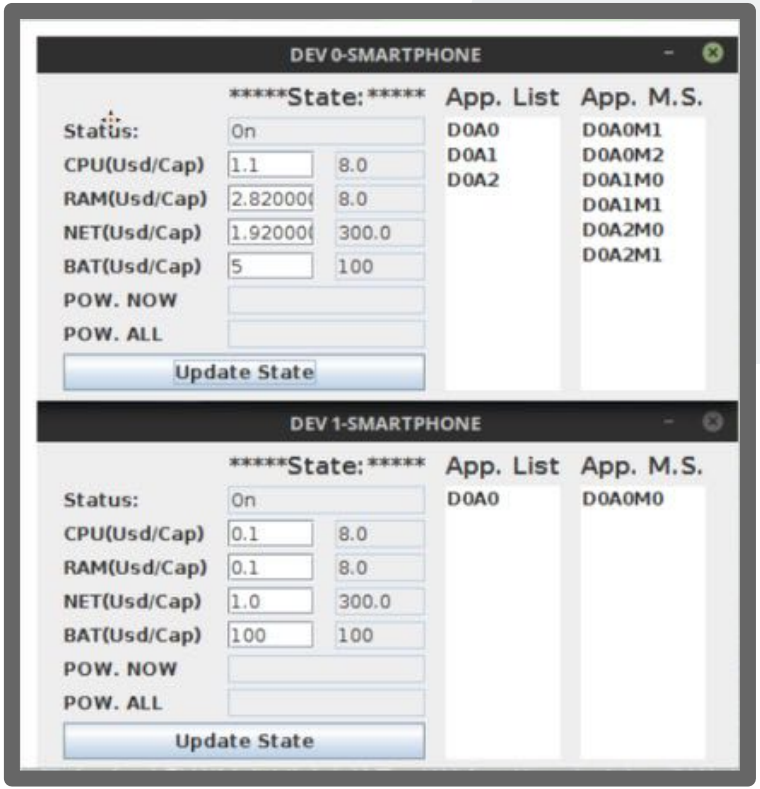
C100 – R90 – N50


C80– R50 – N50
C65 – R50 – N20- B4
MS
YES
V2-V3
C25 – R30 – N40
NO
V2-V3
C15 – R50 – N50
C100 – R90 – N50


C80– R50 – N50
C65 – R50 – N20- B4
BUCLE +
V2-V3
V2-V3
C25 – R30 – N40
C15 – R50 – N50
C100 – R90 – N50

Implementation...






```
{"appID":"D0A0","msID":"D0A0M0","CPU":"1","RAM":"1","NET":"1"}
{"appID":"D0A0","msID":"D0A0M1","CPU":"2","RAM":"1","NET":"2"}
{"appID":"D0A0","msID":"D0A0M2","CPU":"1","RAM":"3","NET":"3"}
{"appID":"D0A1","msID":"D0A1M0","CPU":"1","RAM":"1","NET":"4"}
{"appID":"D0A1","msID":"D0A1M1","CPU":"3","RAM":"2","NET":"5"}
{"appID":"D0A2","msID":"D0A2M0","CPU":"1","RAM":"2","NET":"4"}
{"appID":"D0A2","msID":"D0A2M1","CPU":"3","RAM":"1","NET":"5"}
{"appID":"D0A2","msID":"D0A2M2","CPU":"2","RAM":"1","NET":"5"}
{"appID":"D0A2","msID":"D0A2M3","CPU":"1","RAM":"1","NET":"5"}
{"appID":"D0A2","msID":"D0A2M4","CPU":"2","RAM":"2","NET":"40"}
```

```
{"msID":"D0A2M0","CONNECTION":"D0A2M3","TRATE":"200"}
{"msID":"D0A2M1","CONNECTION":"D0A2M3","TRATE":"500"}
{"msID":"D0A2M2","CONNECTION":"D0A2M3","TRATE":"700"}
{"msID":"D0A2M3","CONNECTION":"D0A2M4","TRATE":"800"}
```

Results...

Number of Devices	MS per Dvice	Avg. Applications execution time before the Algorithm	Avg. Applications execution time after the Algorithm.
2	150	2.335	2.4
3	100	2,4	2,43
4	75	2.45	2.99
5	60	2,43	3.71
6	50	2.44	3.76

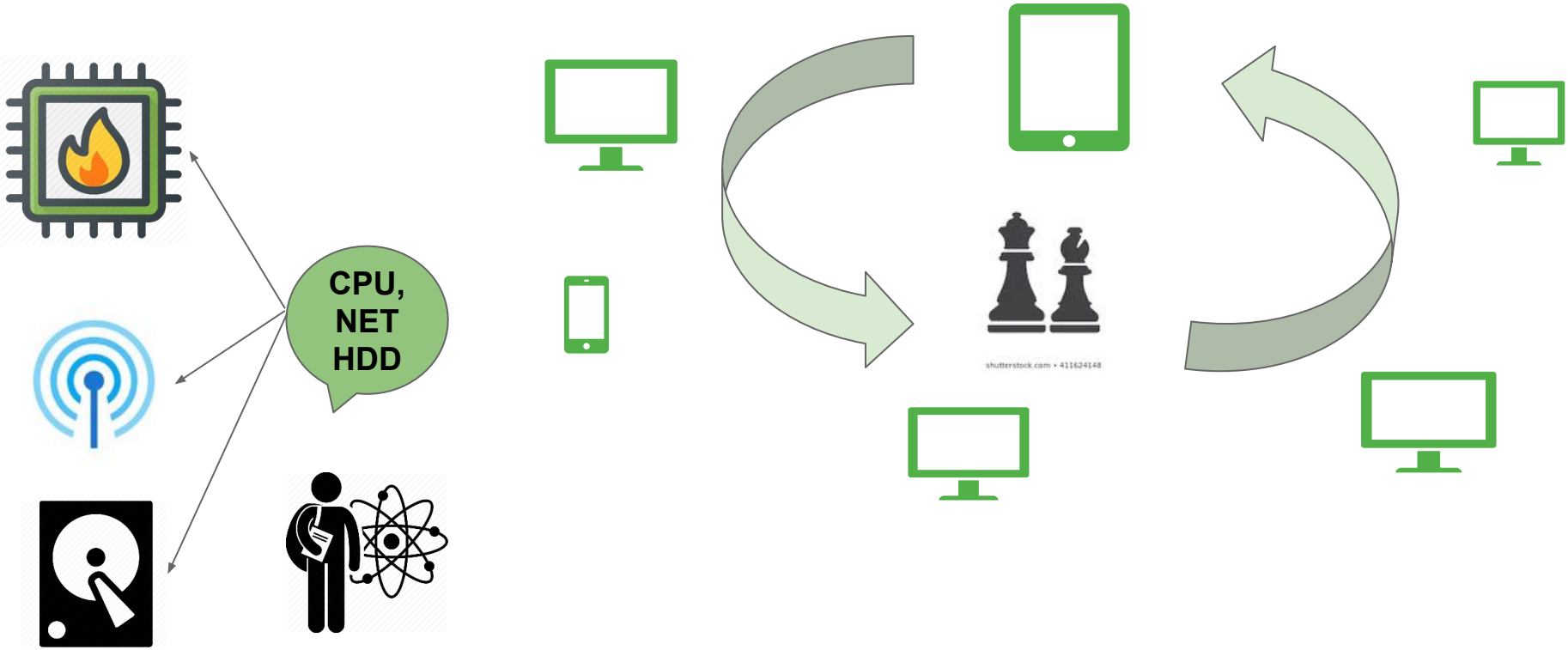
Kaligreen: Pros and Cons

PROS	CONS
- Scalable - Increases the execution time of applications on devices with battery and improve battery usage. - Does not overload the network - Decentralized and autonomous.	- Does not consider device disconnection situations. - Does not prevent infinite cyclical reconfigurations. - Does not study the opportunities of hardware components. - Does not consider the user's actual needs - Does not save energy...

5. Kaligreen V2

Kaligreen is now capable to decide

- How to deploy an application (ie. where to deploy microservices - which host devices)
- Considers **hardware component offers (will be explained in the next slide).**
- Kaligreen **can decide to move and duplicate** microservices to save energy.



Boosting, PCPG, FVFS!

Microservice Features		CPU features		
Persistent Microservice	**High CPU Consumption**	**Boosting**	**PCPG**	**DVFS**
NO	YES	Candidate	Candidate	Candidate
NO	NO	--	--	--
YES	YES	Candidate	Candidate	Candidate
YES	NO	--	Candidate	Candidate

THE CPU

THE NETWORK

I can save energy too: Reduce power; but it is not important at middleware level

Microservice Features					Network operations		
Persistent MS	Heavy MS	Use a lot of Bandwidth	A lot of dependencies with others MS and Data in device	large MS data	Move MS	Duplicate MS	Move MS Data
YES	YES	YES	YES	YES	Candidate	Candidate	--
YES	YES	YES	YES	NO	Candidate	Candidate	Candidate
YES	YES	YES	NO	YES	Candidate	Candidate	--
YES	YES	YES	NO	NO	Candidate	Candidate	Candidate
YES	YES	NO	YES	YES	--	Candidate	--
YES	YES	NO	YES	NO	--	Candidate	Candidate
YES	YES	NO	NO	YES	Candidate	Candidate	--
YES	YES	NO	NO	NO	Candidate	Candidate	Candidate
YES	NO	YES	YES	YES	Candidate	Candidate	--
YES	NO	YES	YES	NO	Candidate	Candidate	Candidate
YES	NO	YES	NO	YES	Candidate	Candidate	--

THE HARD DISK

I can save energy if I'm off!

Condition	Action
if Hdd requirements of Application M.S. == total load of hard disk now	Candidate to move (Hdd will be able to turn off itself)

Algorithm 1 Algorithm 1: Selecting candidate microservices

1: $L\_M \leftarrow List\_of\_all\_Microservices$
2: **while** *true* **do**
3: $L\_CPU \leftarrow filter\_by\_Table1(L\_M)$
4: $L\_DISK \leftarrow filter\_by\_Table3(L\_M)$
5: $L\_NETWORK \leftarrow filter\_by\_Table2(L\_M)$
6: $SLEEP(T)$
7: **end while**

> *Then, Kaligreen can order the lists according to CPU, network, disk and overall microservice consumption*

$$MS\_Cons = T*(F(N+extern)+F(D)+F(C)) \quad (1)$$

In this moment, we are working on a scheduling algorithm based on P2P, graph theory and statistical approaches

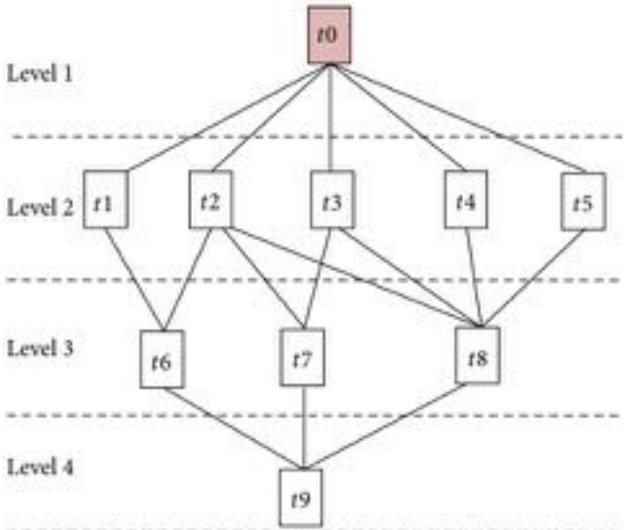


Figure donne by Piyush Chauhan and Nitin: Decentralized Scheduling Algorithm for DAG Based Tasks on P2P Grid

Thanks!

Time for questions!...