

Why Should I Teach Performance Evaluation to Students in Networking?

Michela Meo

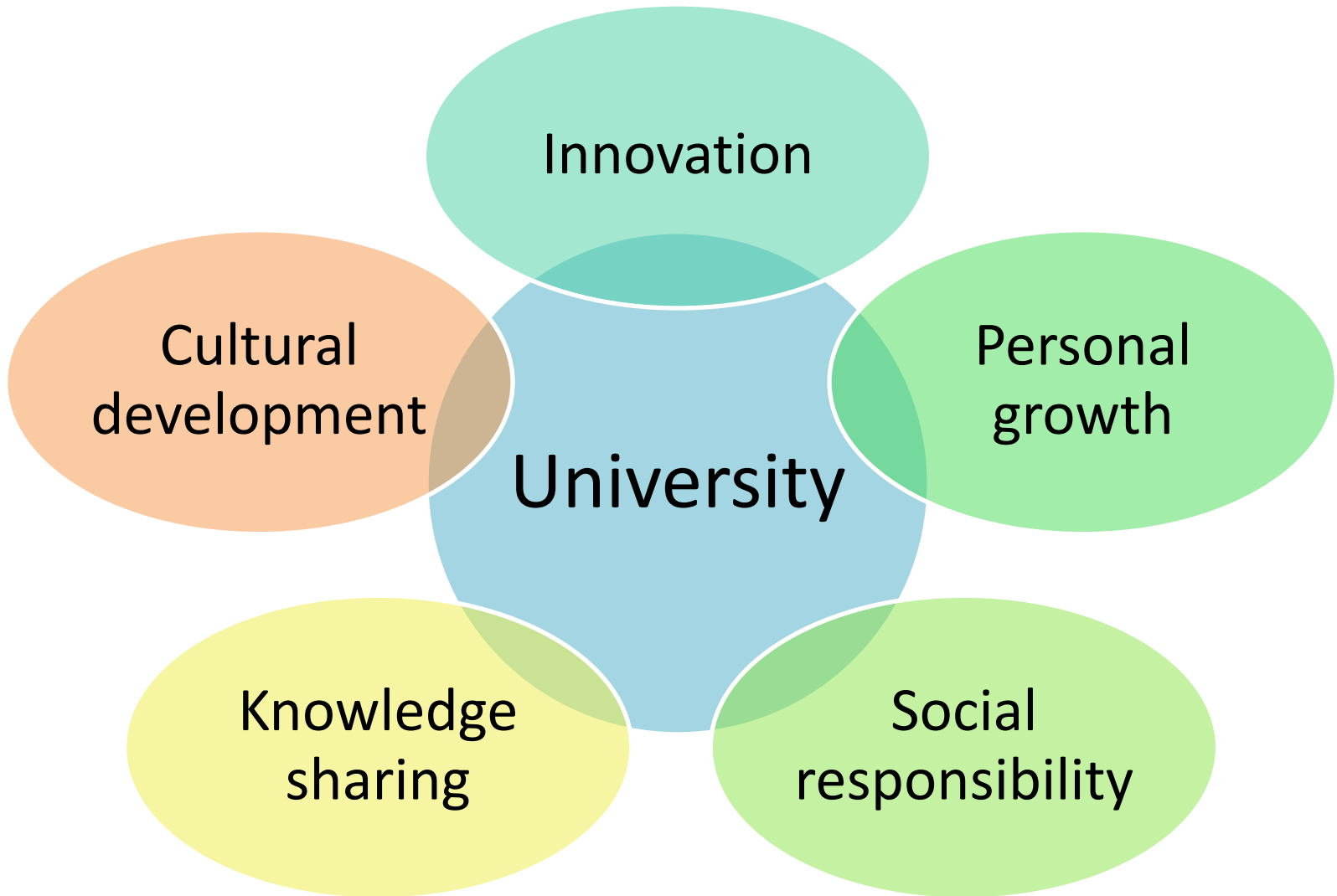
Politecnico di Torino, Italy

"The function of education is to teach one to think intensively and to think critically. "

Martin Luther King



Source: "The Purpose of Education",
<https://kinginstitute.stanford.edu/king-papers/documents/purpose-education>

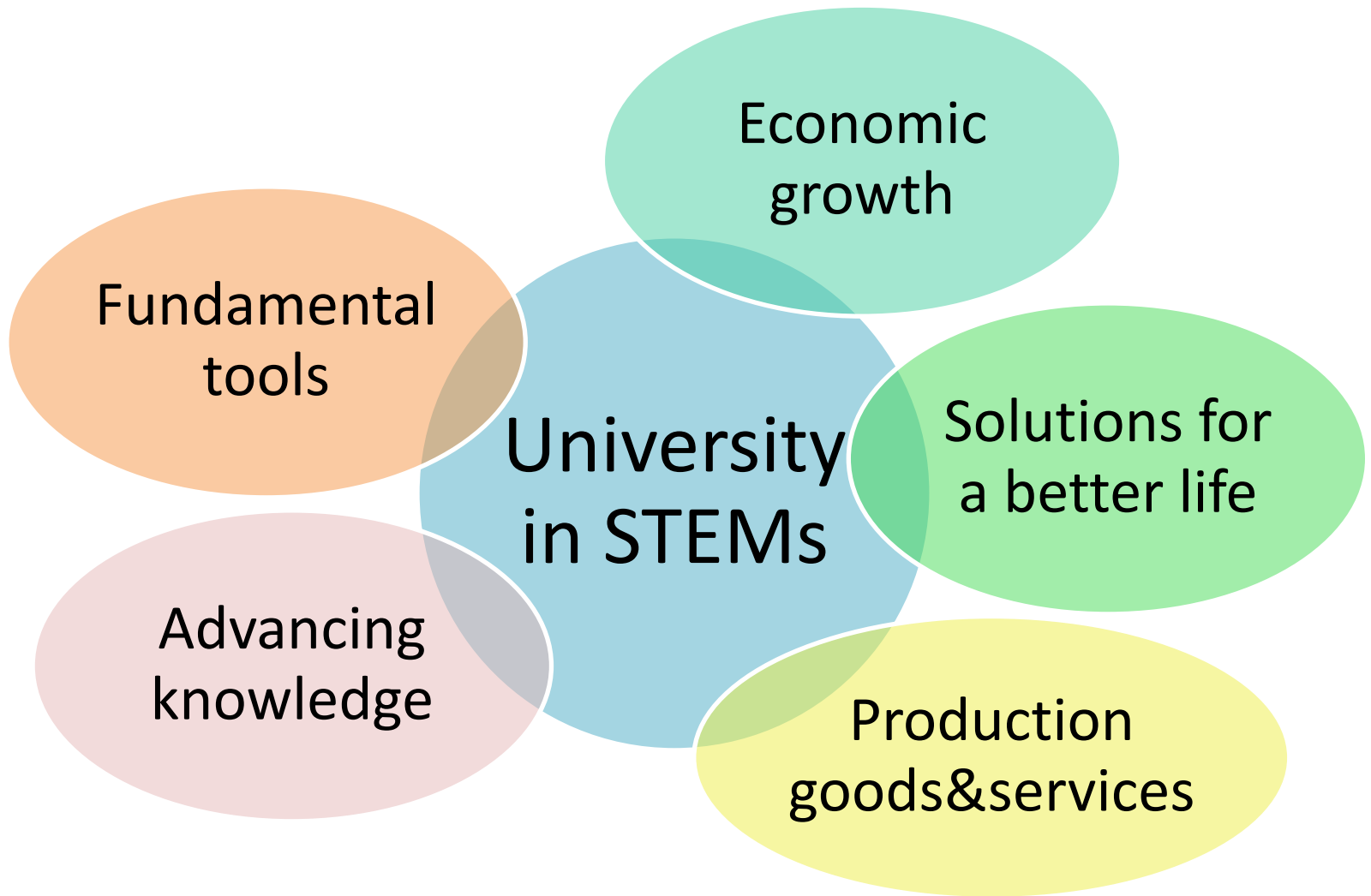


SUSTAINABLE DEVELOPMENT GOALS



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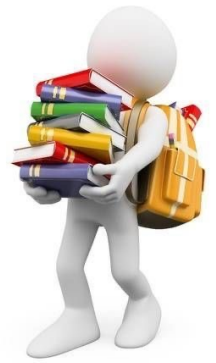




SUSTAINABLE DEVELOPMENT GOALS



Objectives of education in STEM



Knowledge

- Fundamental concepts in science
- Fundamental mathematical principles
- Grasping impact of technologies
- Holistic views

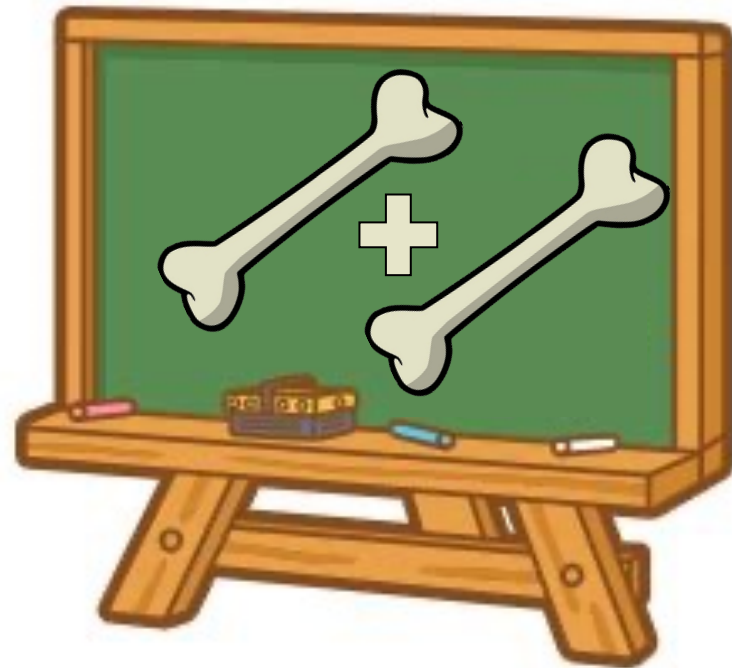
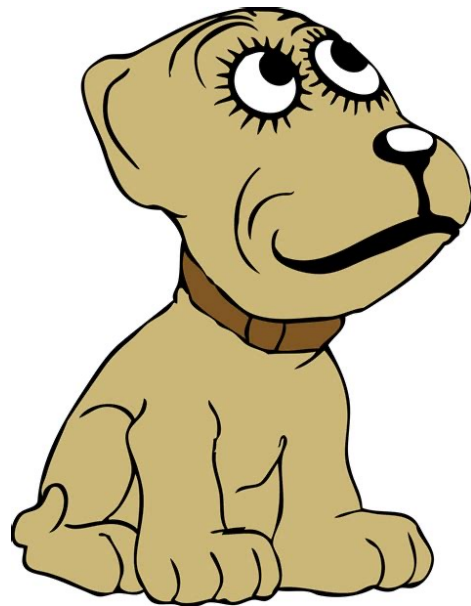
Skills

- Scientific method: hypothesis, experiments, data, ...
- Critical thinking
- Creative thinking
- Using tools

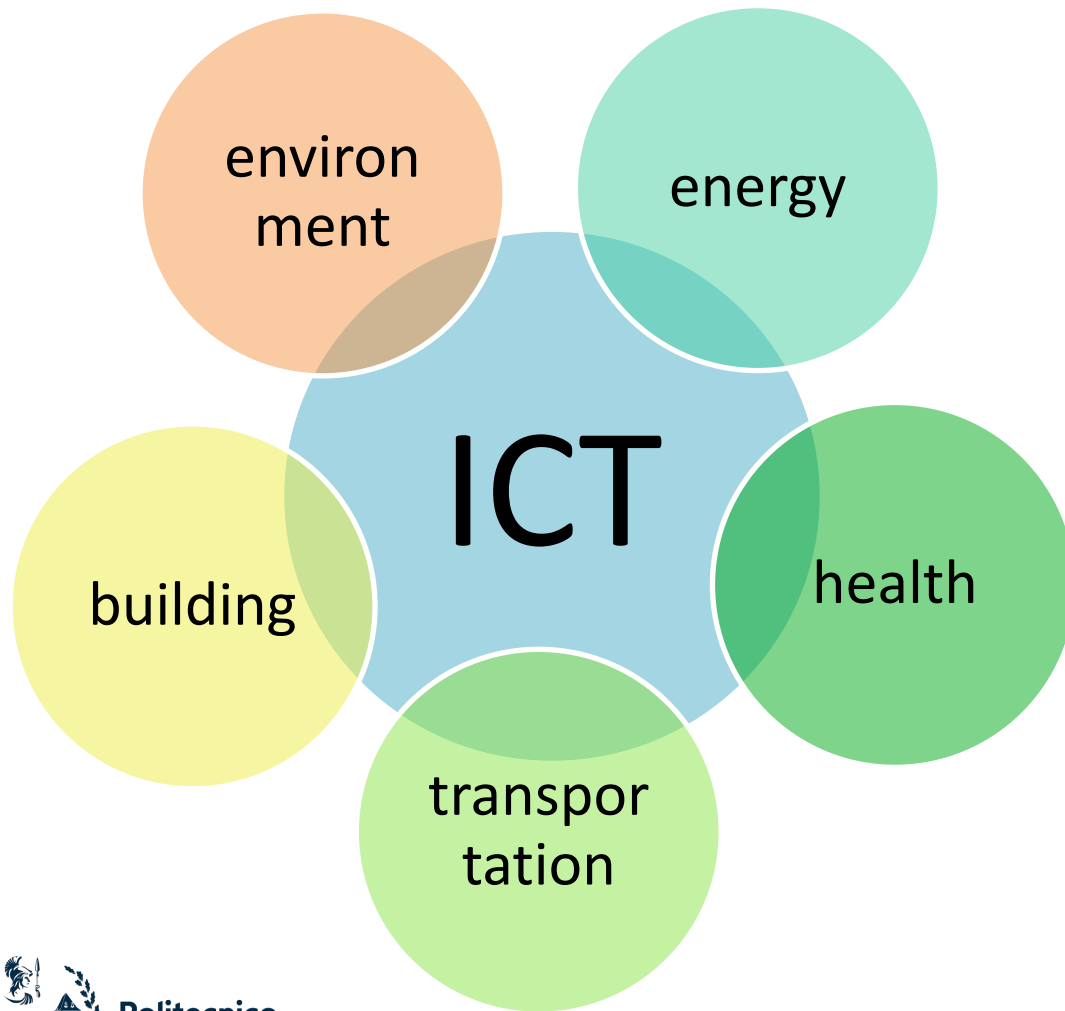
What do students want?



About my experience



MSc: ICT for Smart Societies



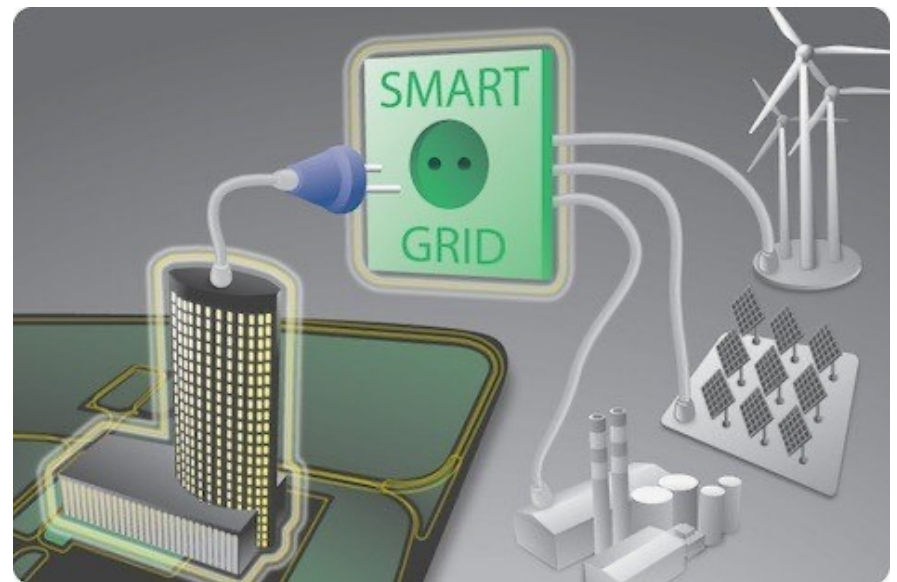
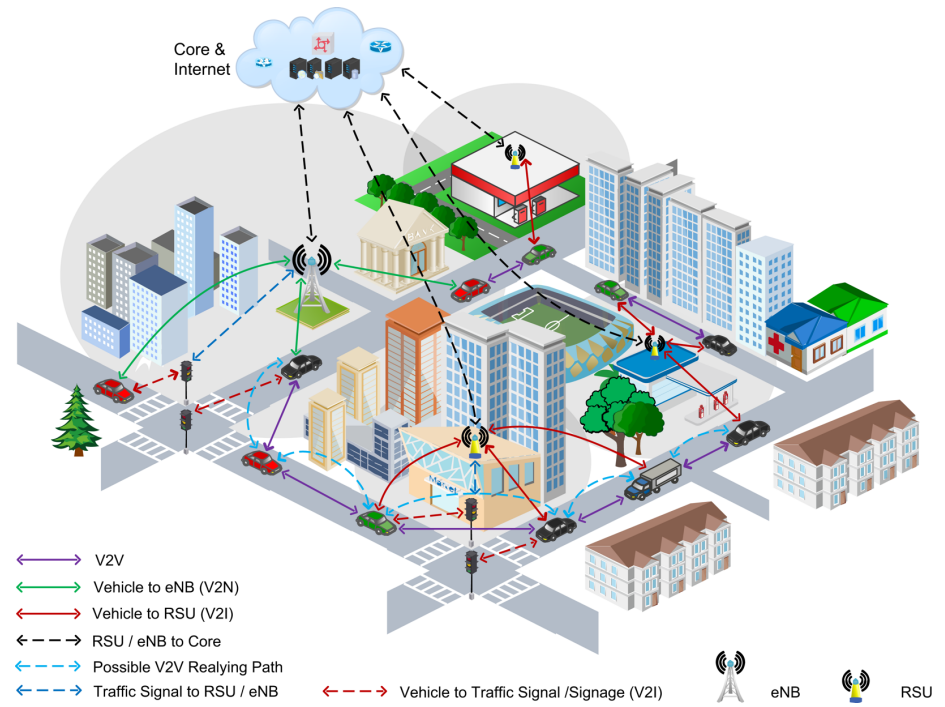
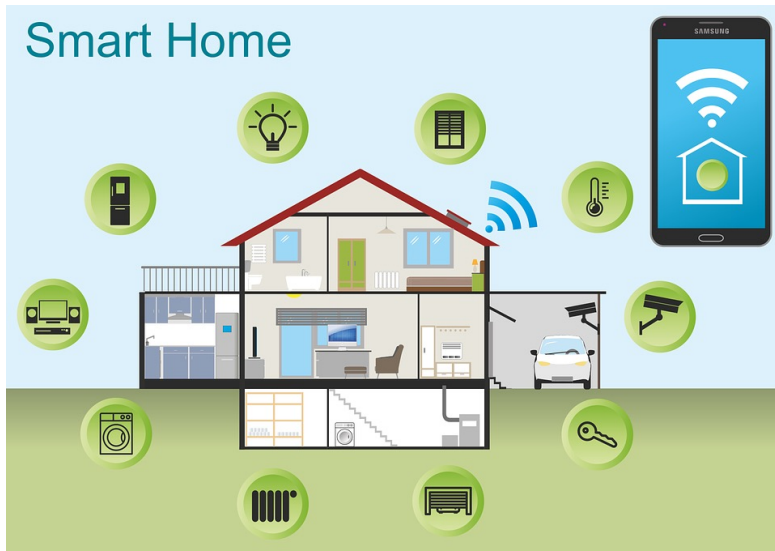
Interdisciplinary MSc

- ICT
 - ML & AI
 - Communications & networking
- Domain knowledge

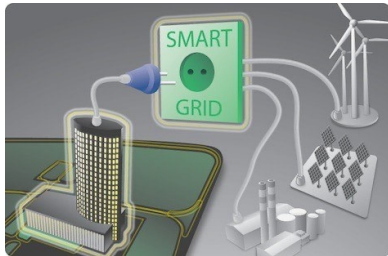
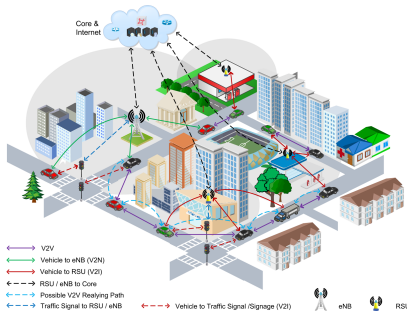
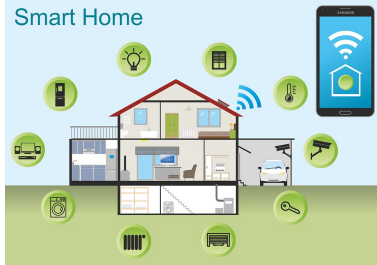


make *** smarter

ICT for Smart Societies



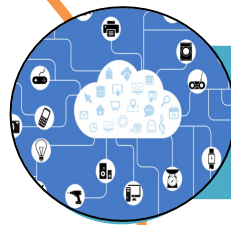
Smart environments → networking



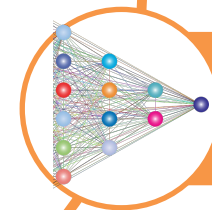
Collect & receive data

Transport

Store and elaborate

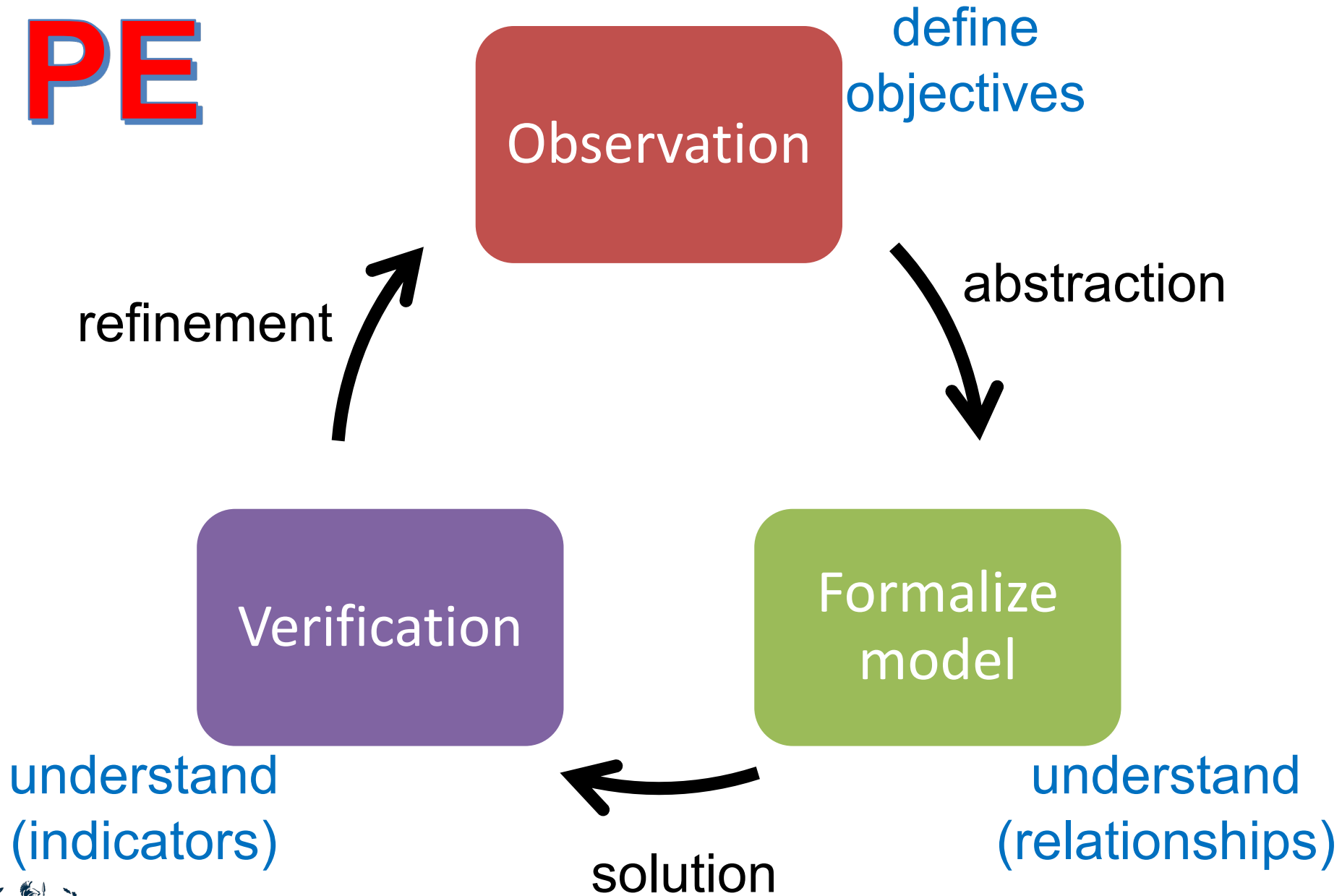


networking

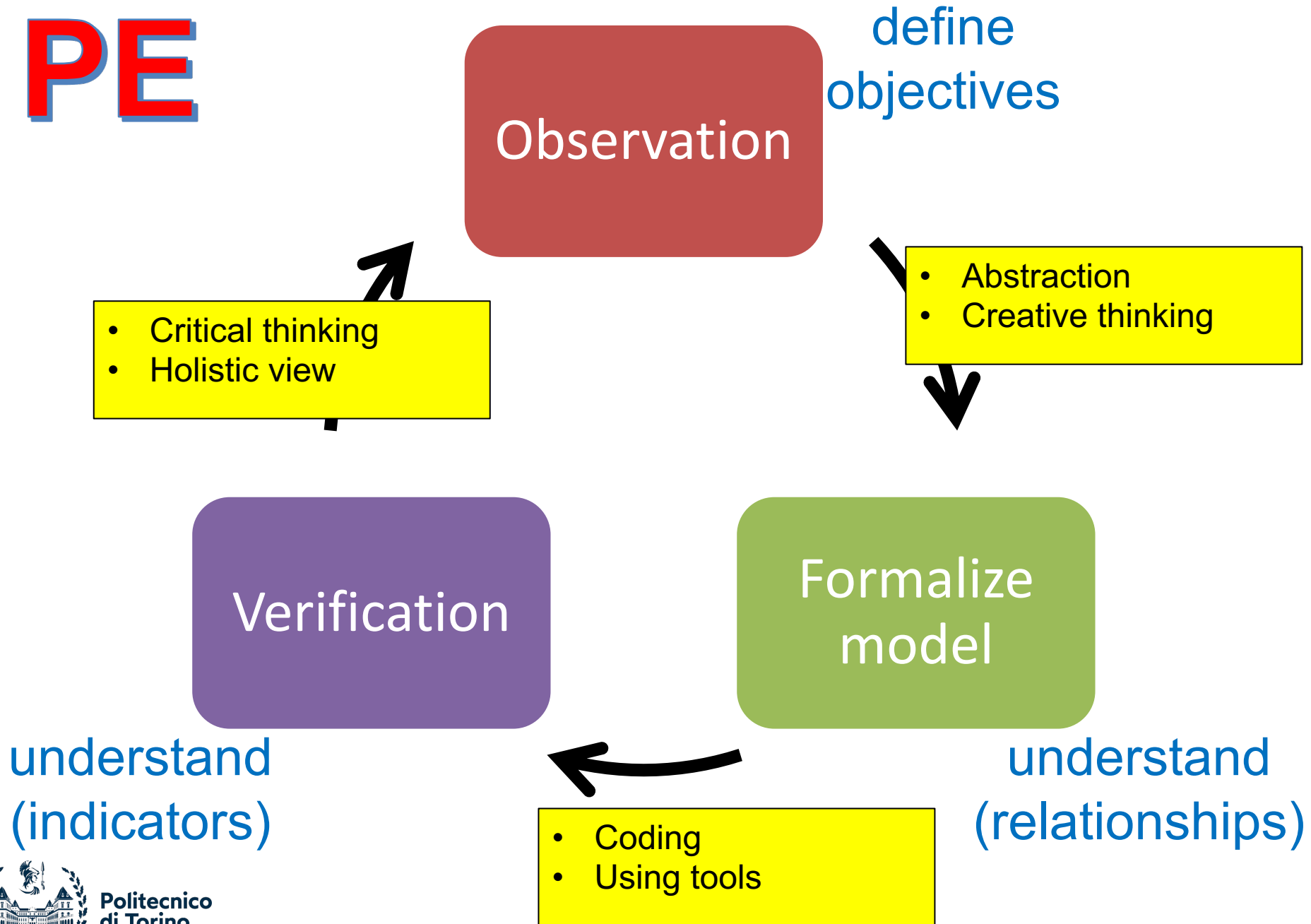


algorithms

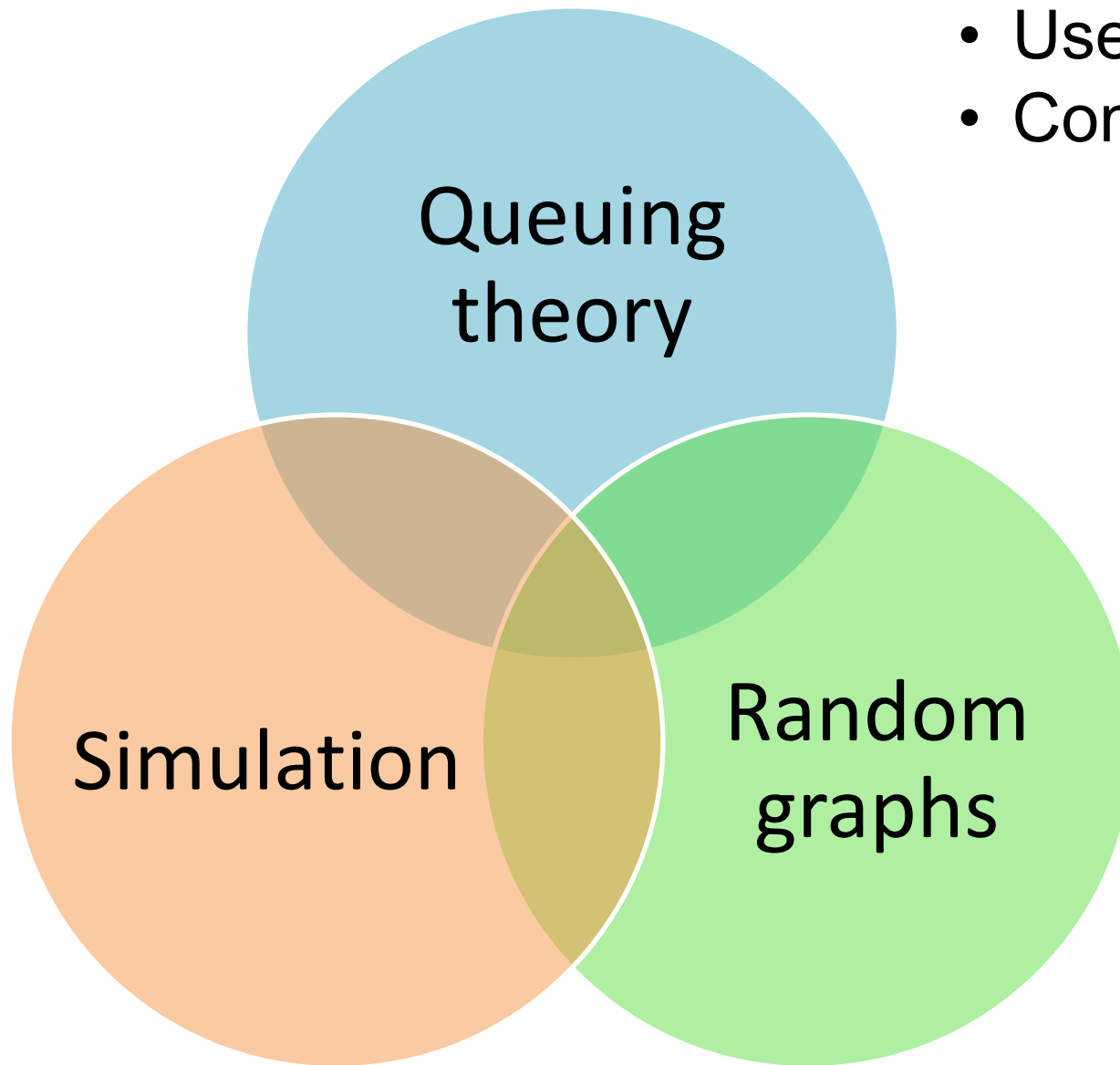
PE



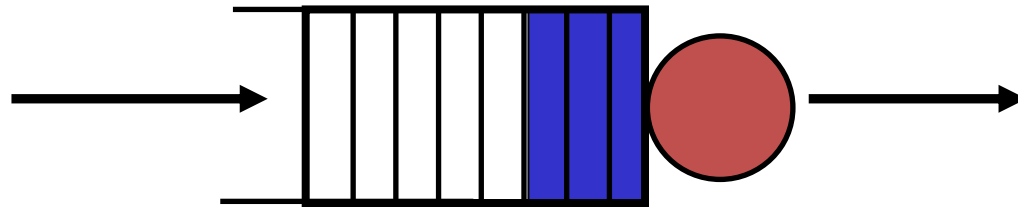
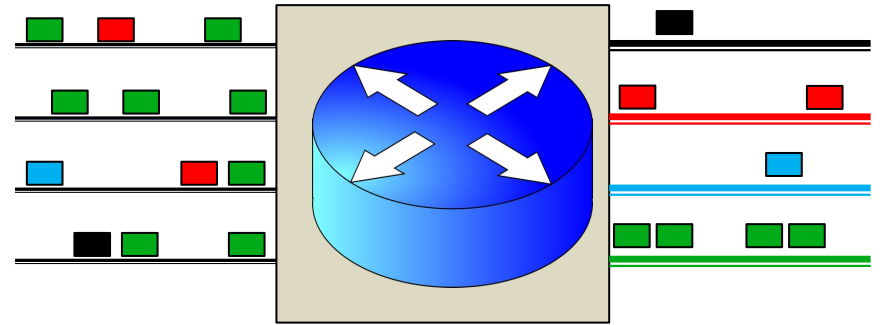
PE



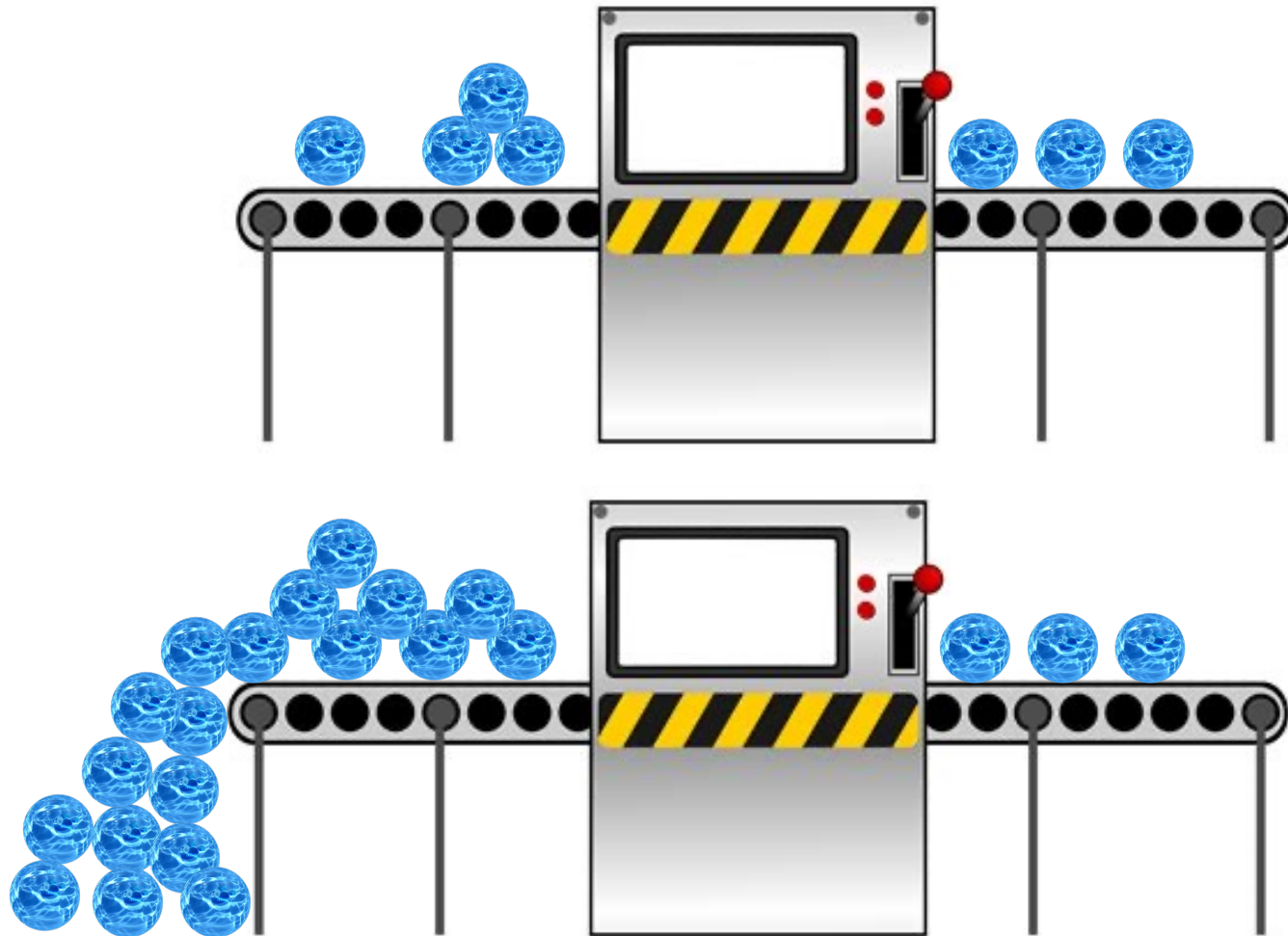
- Useful
- Complementary



Queuing theory



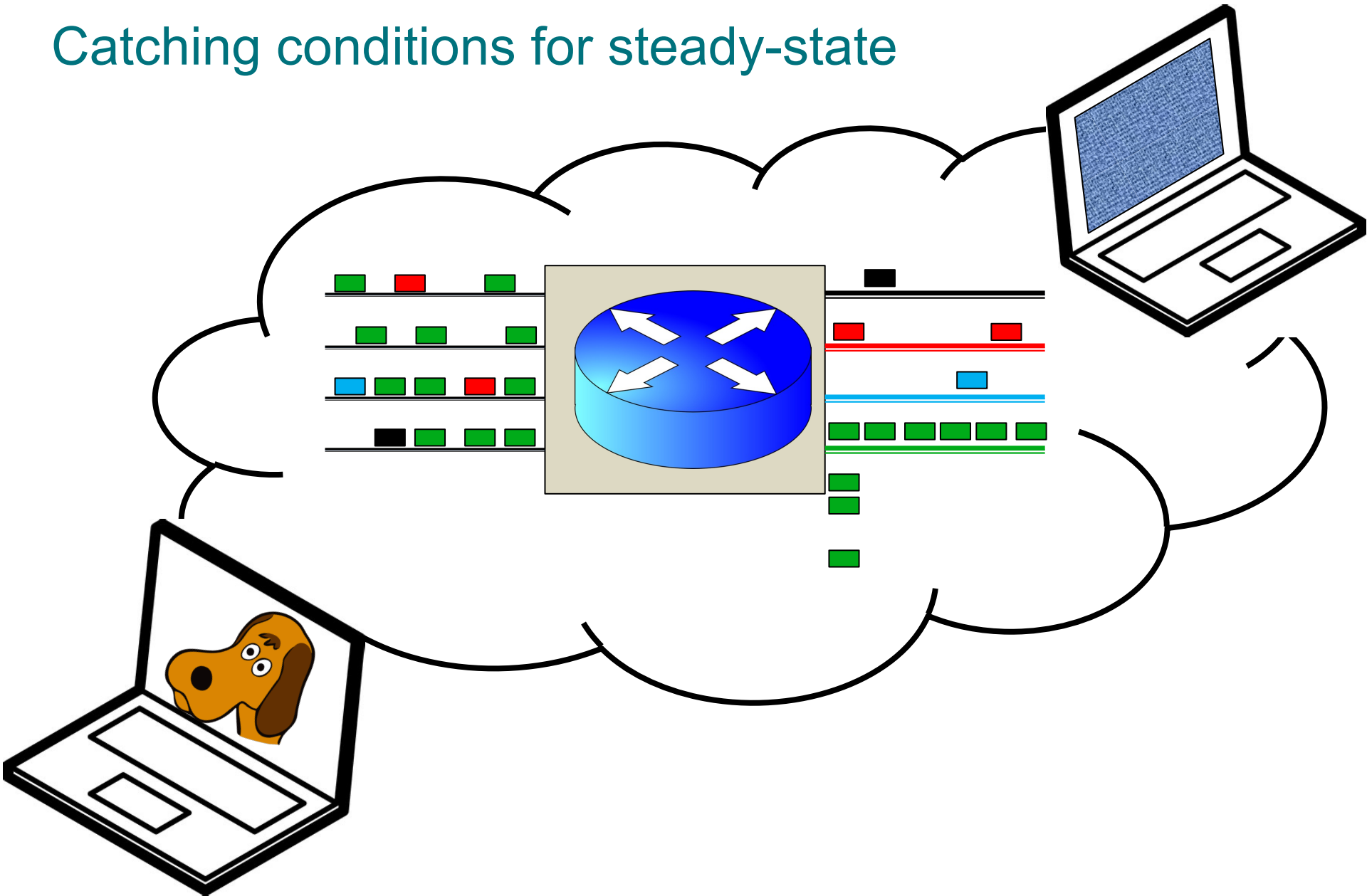
Catching conditions for steady-state



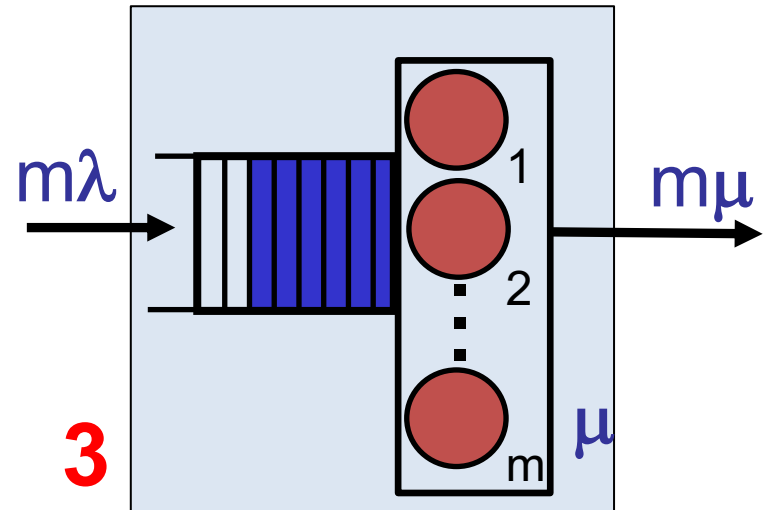
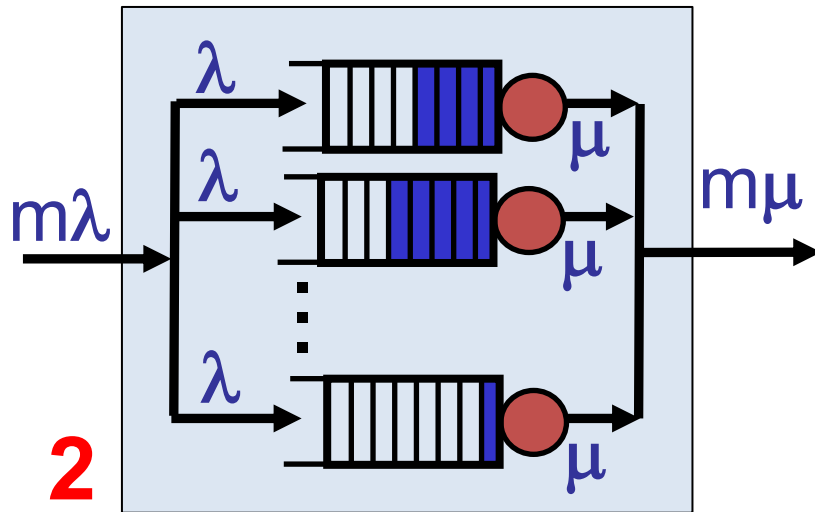
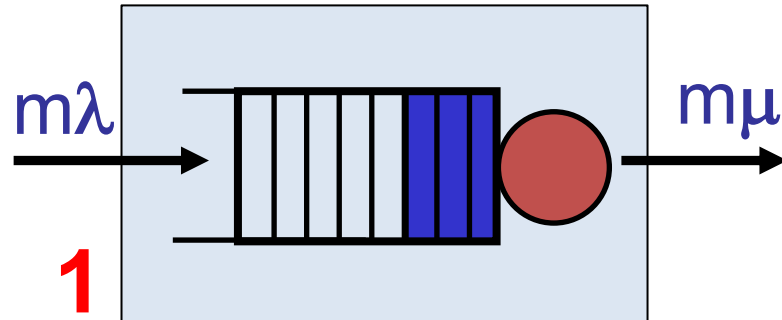
Catching conditions for steady-state



Catching conditions for steady-state



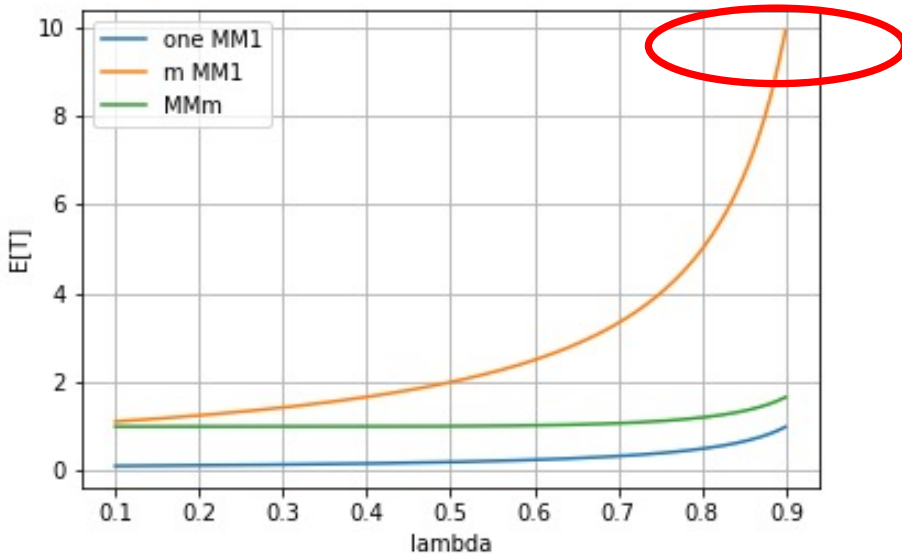
Some of the hints from queuing theory



Comparison of the 3 systems

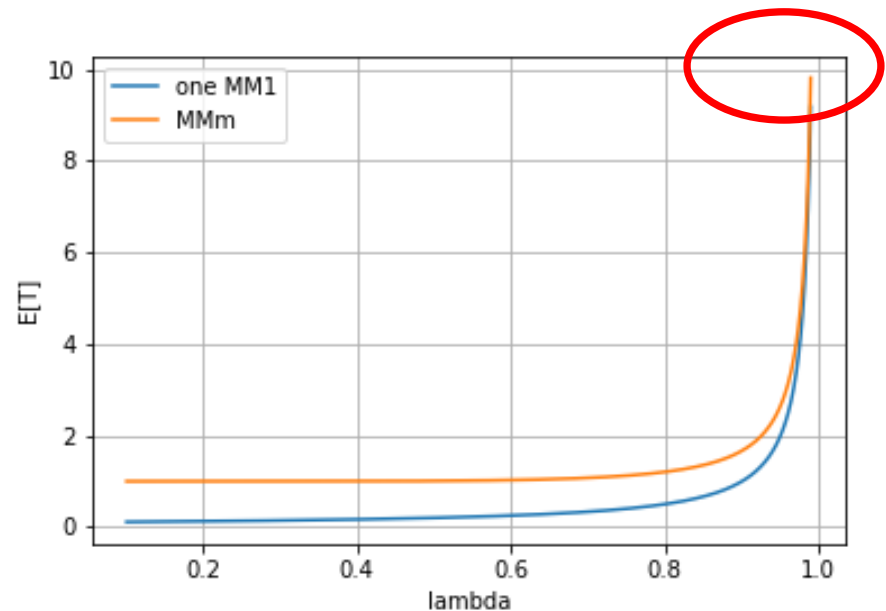
$m=10, \mu=1$

system 2
is much worse



effect of service
time at low load

1 and 3 behave the
same at high load



Lessons learnt in networking

- Don't segregate traffic
- Don't split the bandwidth
- Welcome multiplexing

The M/G/1 queue

$$E[T] = E[S] + \rho E[S] \frac{(1 + C_s^2)}{2(1 - \rho)}$$

Pollaczek-Khintchin
formula

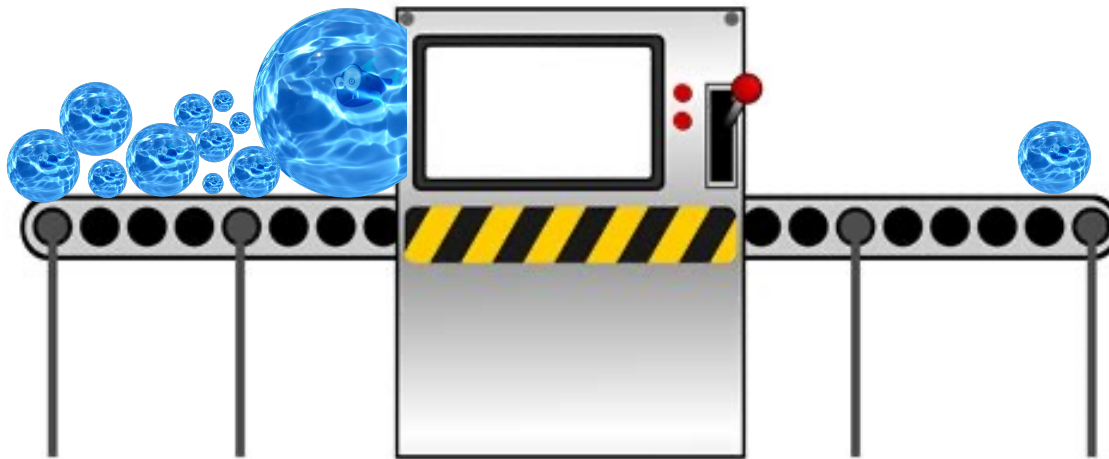
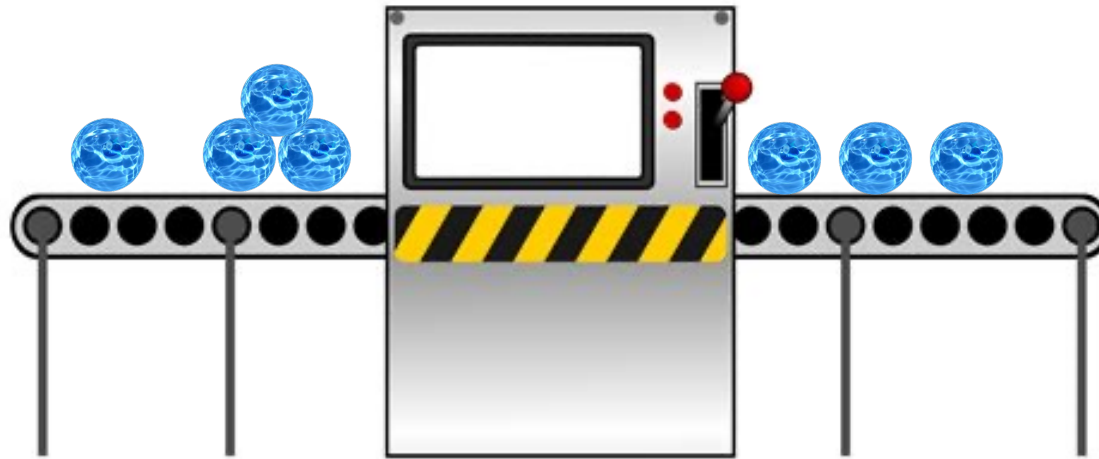
- For the M/M/1 queue

$$E[T^{(a)}] = \frac{1}{\mu} + \frac{\rho}{\mu} \frac{1}{1 - \rho}$$

service time waiting time

- For the M/D/1 queue

$$E[T^{(b)}] = \frac{1}{\mu} + \frac{\rho}{\mu} \frac{1}{2(1 - \rho)}$$



Lessons learnt in networking

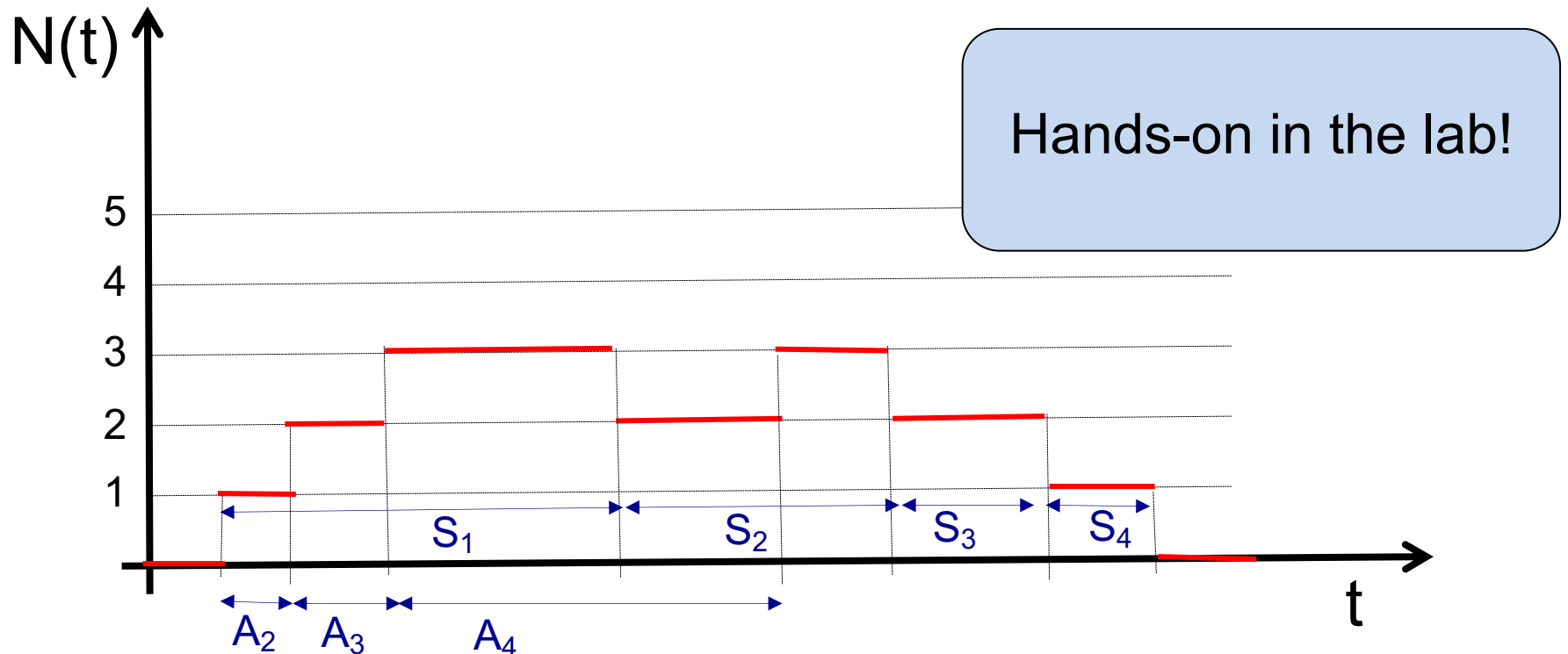
- Be careful to the variance
- Consider traffic shaping

Lessons learnt from queuing networks

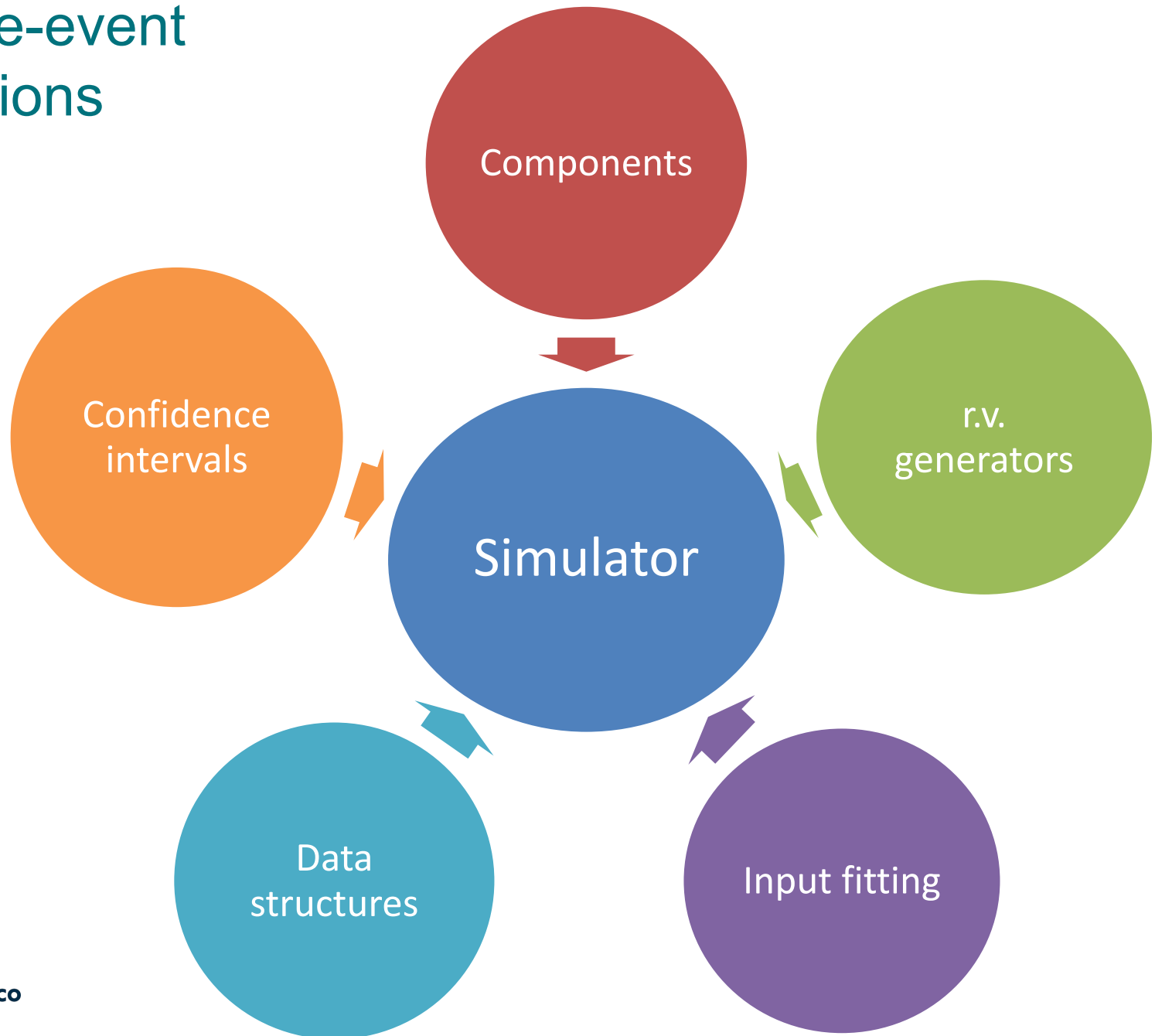
- Look for the bottleneck
- Sizing capacities
- Effect of routing
- Be careful on the second bn

Discrete-event simulations

- Change perspective, **complementary approach**
- Stochastic processes \rightarrow time evolution
- Stochastic characterization \rightarrow observe statistics



Discrete-event simulations



In the lab: Duration of simulation

The screenshot shows the Spyder Python IDE interface. The main editor displays the code for 'queue-misure.py':

```
226 print("Point ", i, " load=", load)
227 punti.append(load)
228 data = Measure(0,0,0,0,0,0)
229 arr_t=ser_t/load
230 sce=Scenario(load, arr_t, ser_t, MaxSimTime, data)
231
232 simula(sce)
233 res.append(data.delay/data.dep)
234 resTeo.append(1/(0.1-1.0/sce.arr_t))
235 resIT.append(data.IdleTime/MaxSimTime)
236 resTeoIT.append(1.0-punti[i])
237
238
239
```

The console output shows the following data points:

Point	load
17	0.8825
18	0.905
19	0.9275

Two graphs titled 'Average Delay' are shown. Both graphs plot Delay [ms] on the y-axis (ranging from 20 to 140) against Load on the x-axis (ranging from 0.5 to 0.9). The left graph compares 'simulation' (blue line) and 'theory' (orange line). The right graph compares 'simulation' (blue line) and 'theory' (orange line). Both graphs show a non-linear increase in delay as the load increases, with the simulation results closely following the theoretical results.



In the lab: Sample paths (the seed)

The screenshot displays the Spyder Python IDE interface. The top-left pane shows the source code for 'queue-misure.py', with the following visible lines:

```
174 time = 0
175 # Queue of the clients
176 queue=[]
177
178 # Future Event Set: the list of events in the form: (time, type)
179 FES = PriorityQueue()
180 # schedule the first arrival at t=0
181 FES.put((0, "arrival"))
182 # Initialize the random number generator
183 random.seed(10)
184
185
186 # *****
187 # Event_loop
```

The top-right pane shows the console output:

```
Point 17 load= 0.8825
Point 18 load= 0.905
Point 19 load= 0.9275
In [0]:
```

Below the code editor are two side-by-side line graphs, both titled 'Average Delay'. Both graphs plot 'Delay [ms]' on the y-axis (ranging from 20 to 140) against 'Load' on the x-axis (ranging from 0.5 to 0.9). Each graph contains two data series: 'simulation' (blue line) and 'theory' (orange line). The two lines in both graphs are nearly identical, showing an exponential-like increase in delay as the load increases.

The bottom status bar of the IDE shows: LSP Python: ready, Kite: ready, conda: base (Python 3.8.3), Line 183, Col 18, UTF-8, LF, RW, Mem 68%.



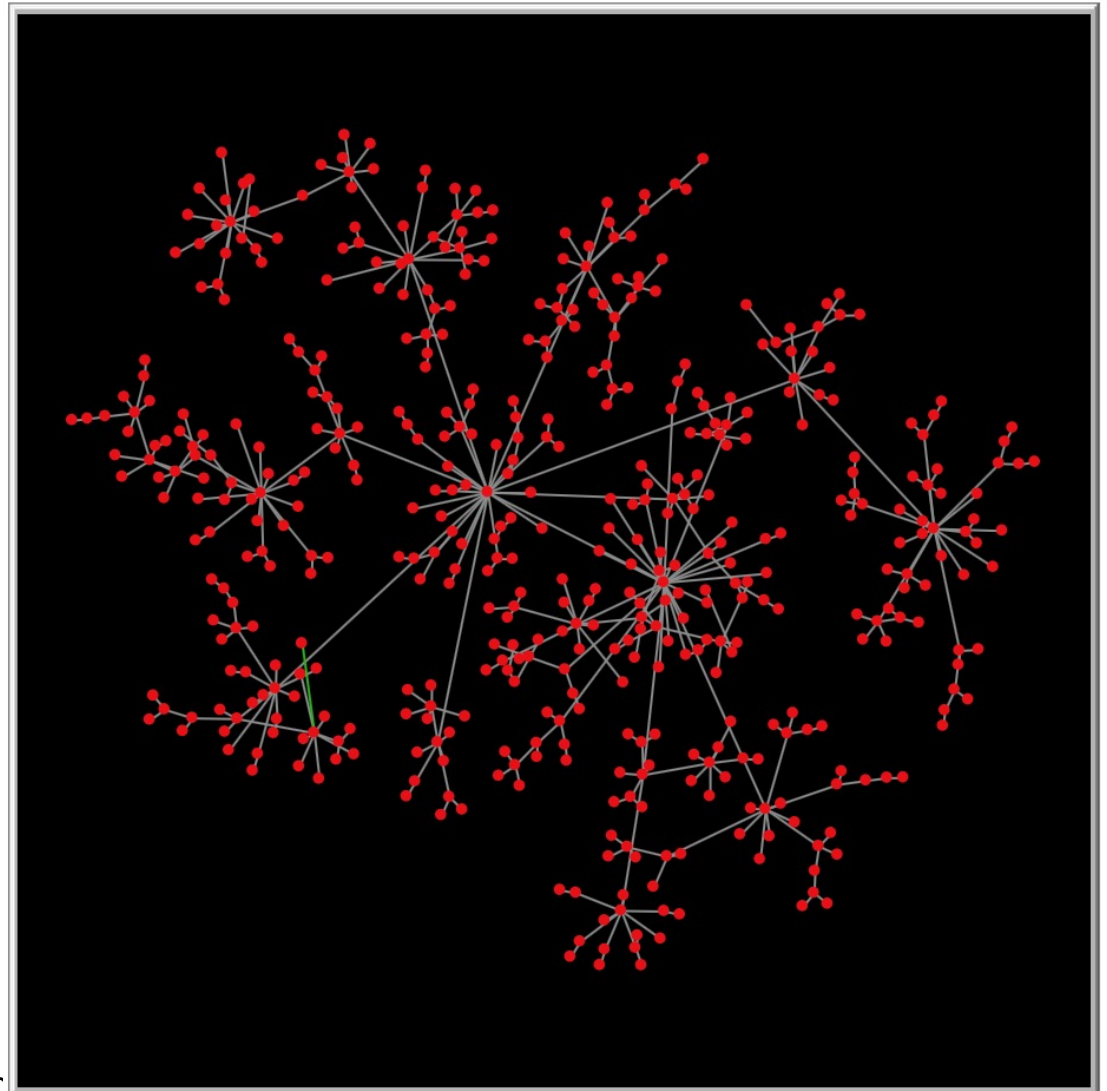
Lessons learnt on simulation vs analytical modeling

- There is not a best way
- Complementary approaches
- Integration of approaches increases knowledge

Random graph theory: complex systems

Change perspective

- Modeling
- Focus (interactions)
- Indicators

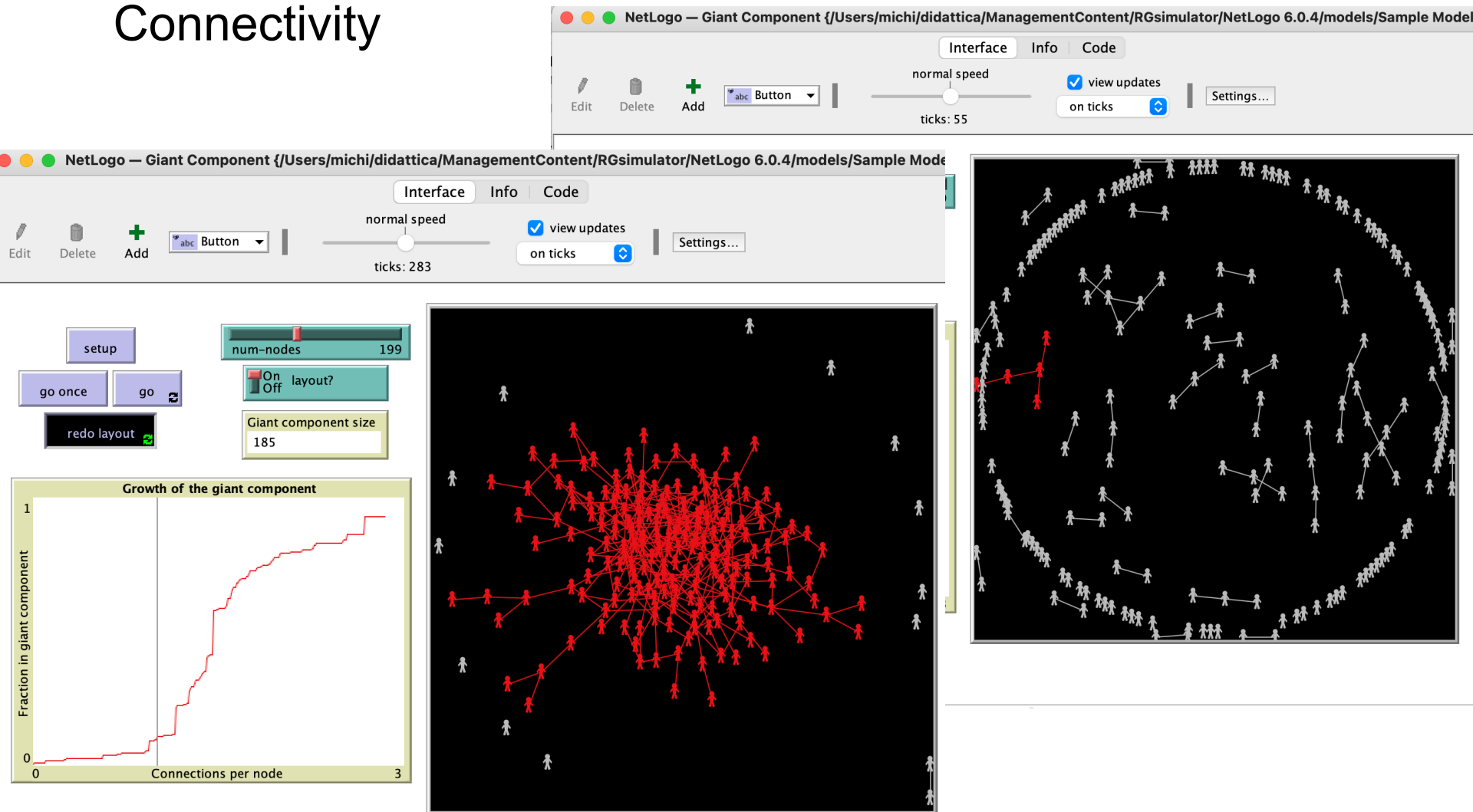


Random graph theory

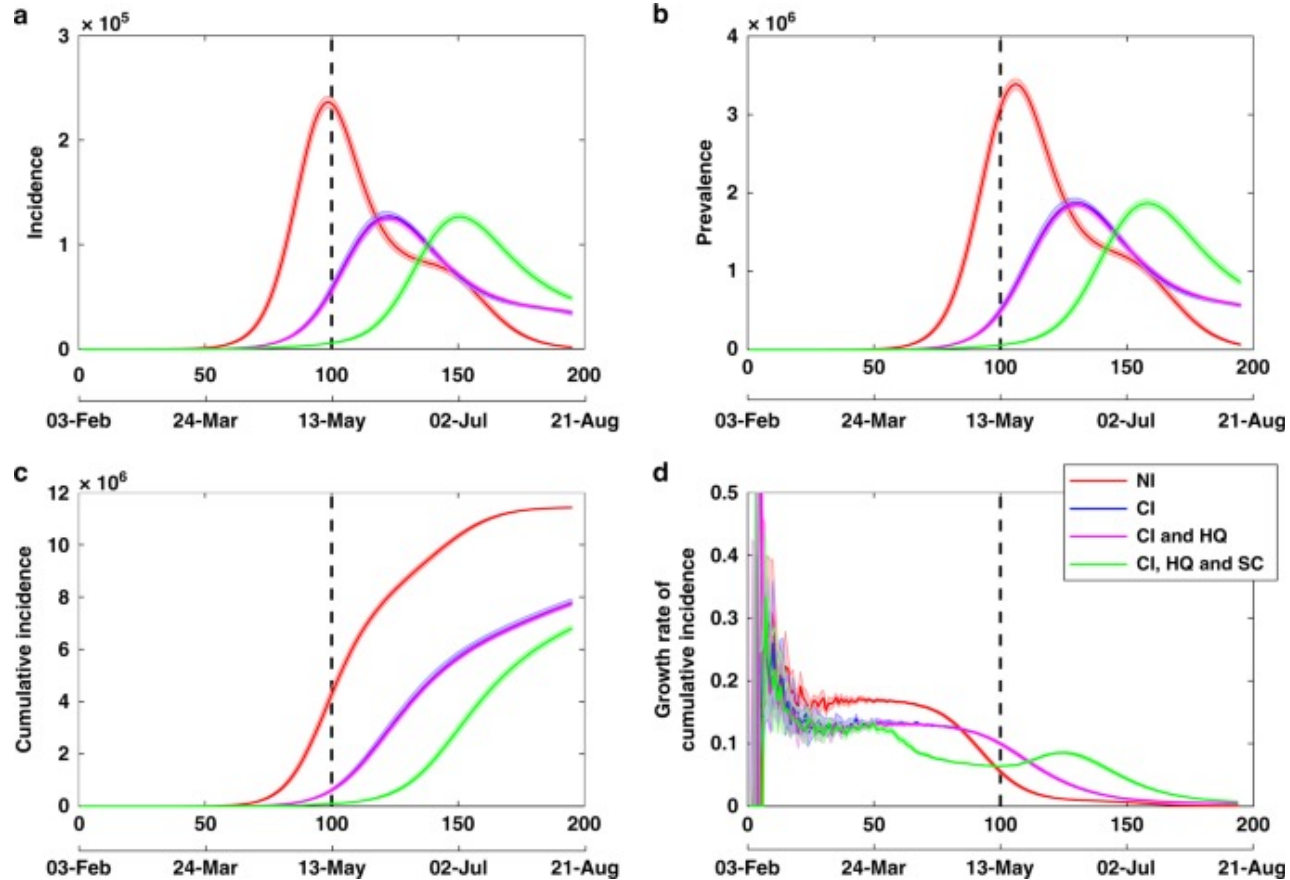
Obtained with
netlogo simulator

<https://ccl.northwestern.edu/netlogo/>

Connectivity



Epidemic models

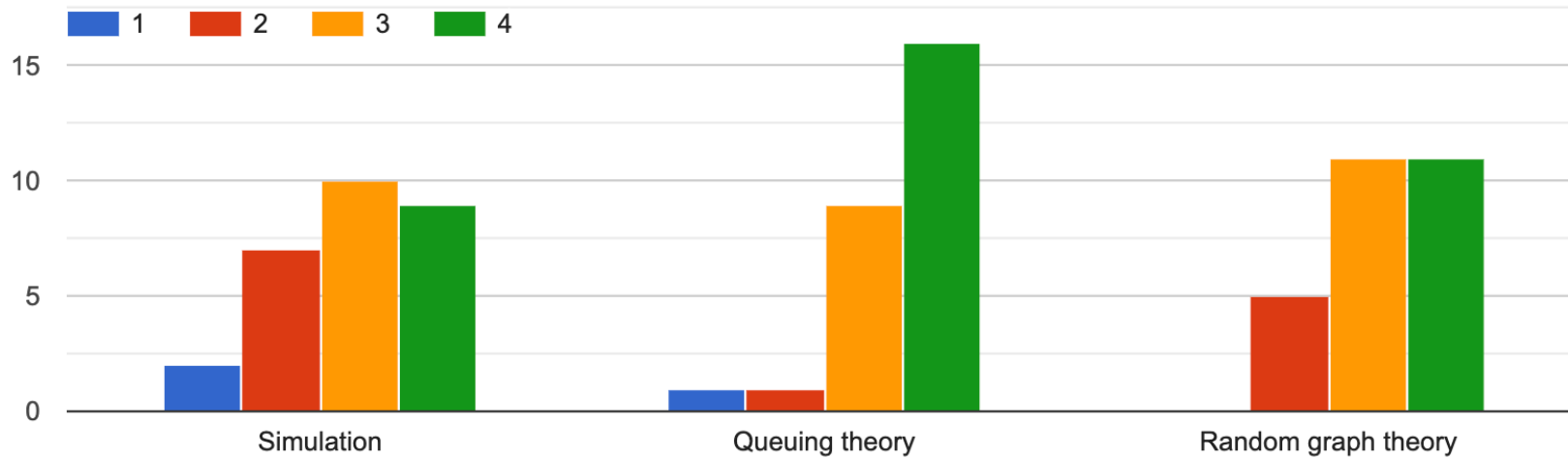


Source: S. Chang et al., “Modelling transmission and control of the COVID-19 pandemic in Australia”, Nature Communications, Nov 2020

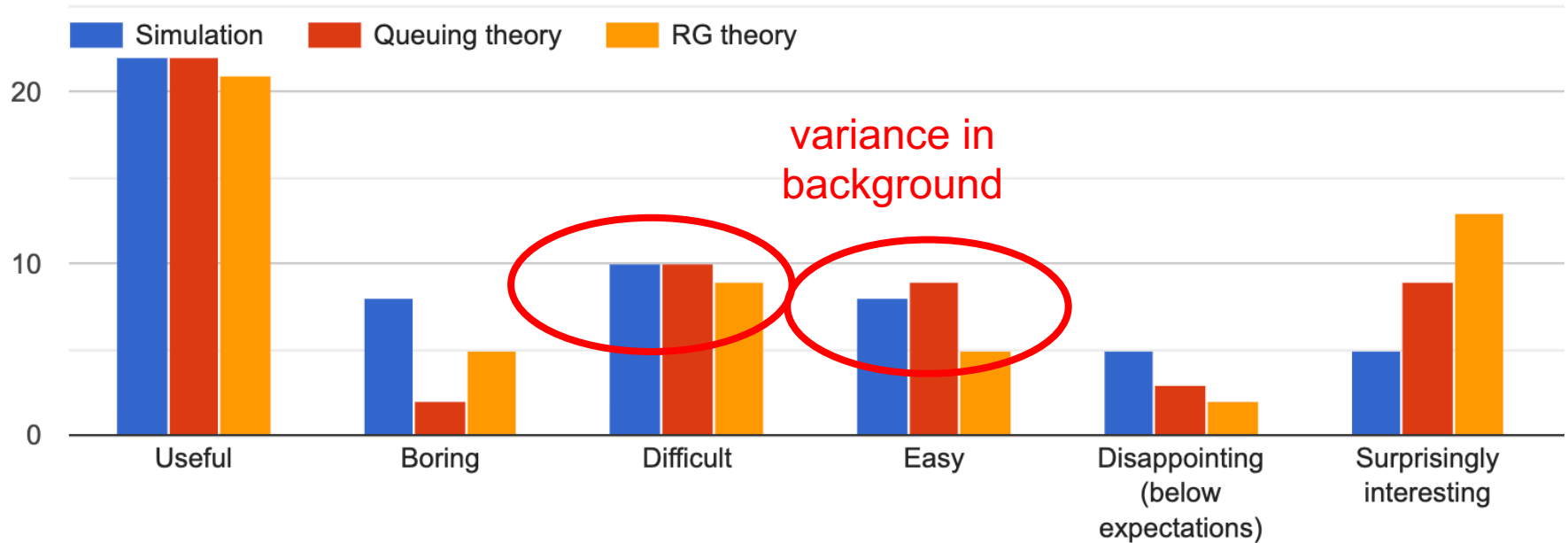
Asking to students

Asking to students

1. How much did you enjoy learning the following:
(1: not at all; 4: I enjoyed much)



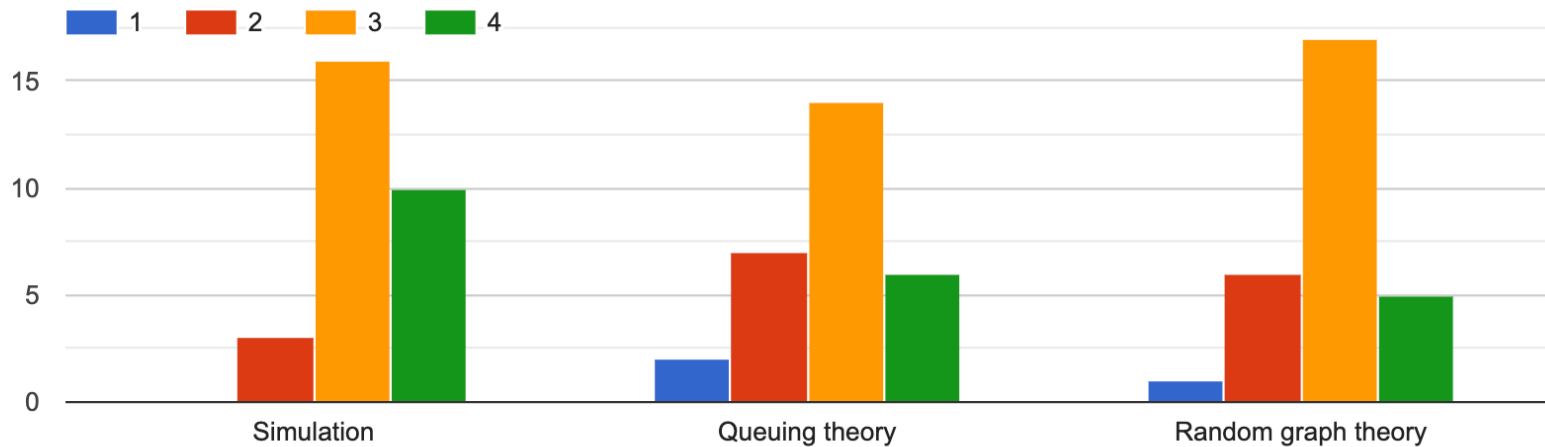
Asking to students



Asking to students

2. In your opinion, will these topics be useful in your future working life?

(1: useless; 4: very useful)



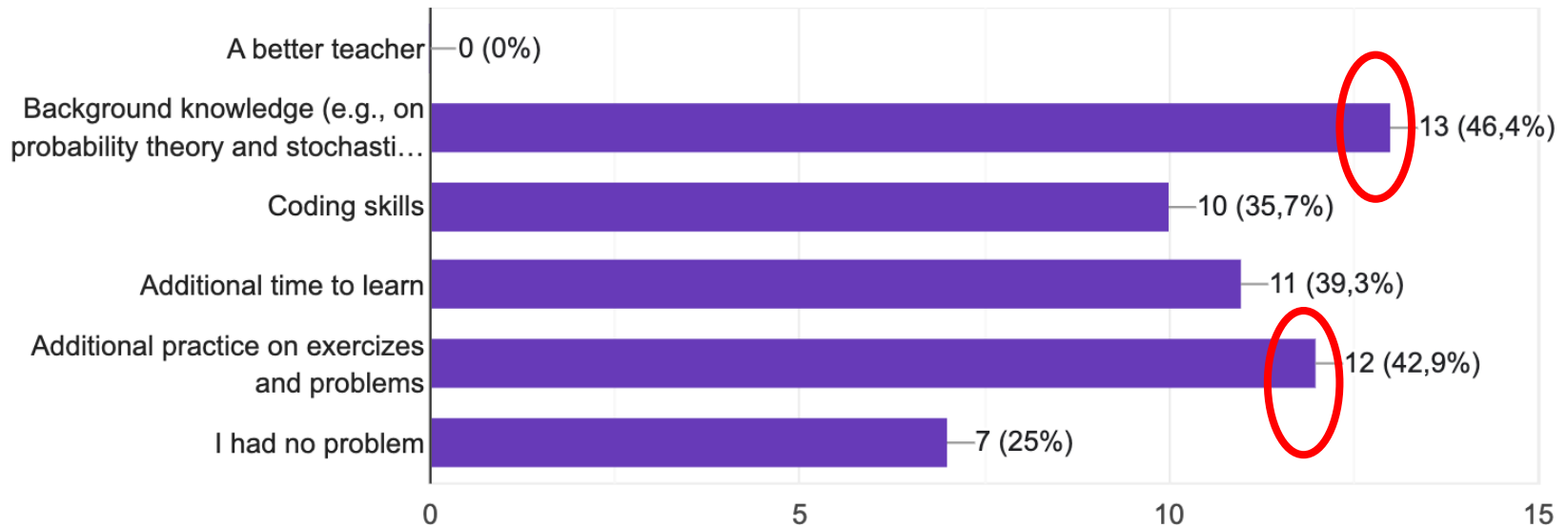
Students

- Appreciated also theoretical stuff
- Found it useful

Asking to students

7. When you had problems (if any) what did you miss?

28 risposte



- Learning needs time
- Background a potential issue

Wrap-up

- I enjoy teaching (performance evaluation)!
- Students are interested if it is
 - useful
 - creative
- Students like to practice
 - Problem solving
 - Hands on asap
- Warning about
 - Background knowledge (theory, math, probability)
 - Give them time to learn

Thanks!

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