

Why Should I Teach Performance Evaluation to Students in Networking?

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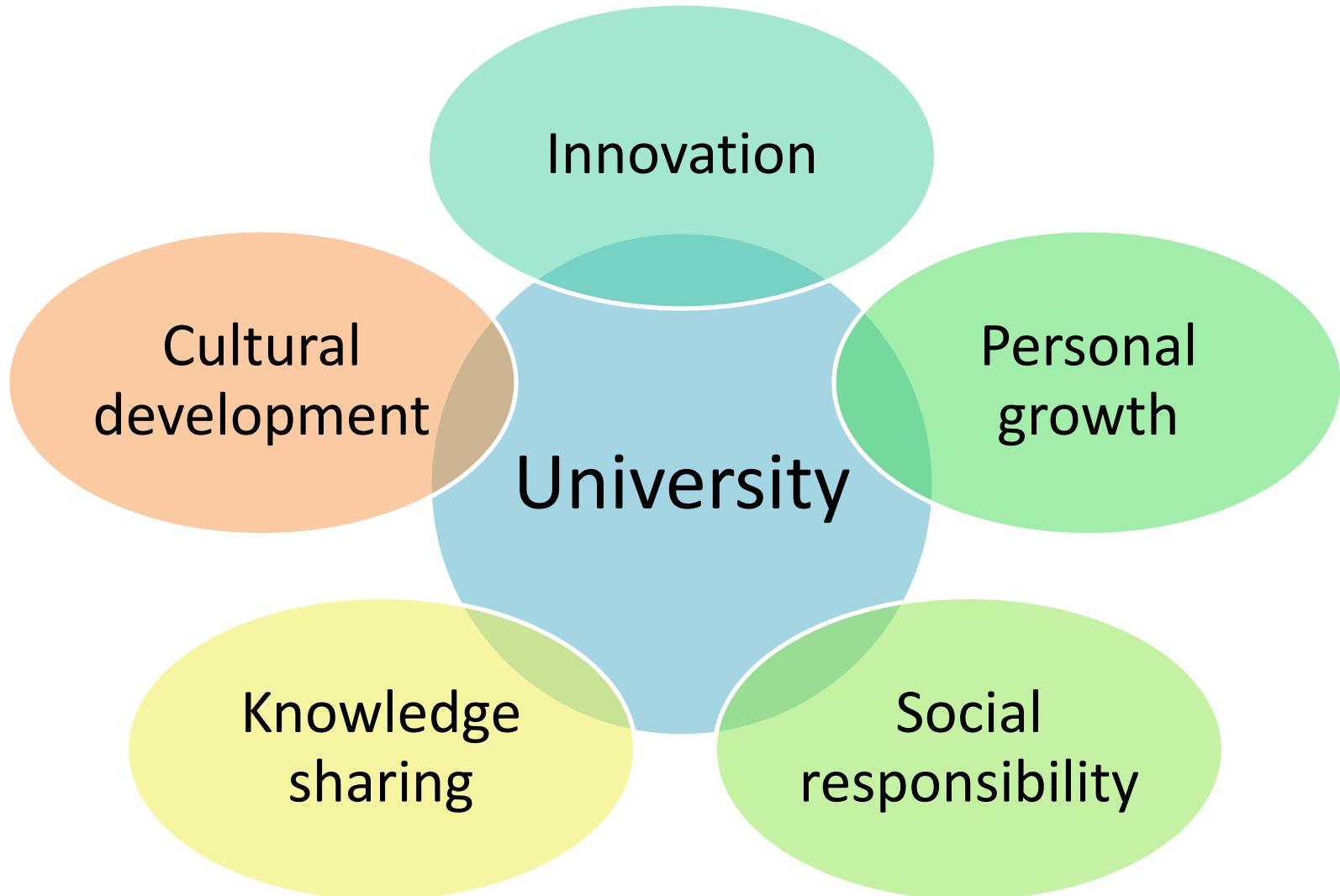


Politecnico
di Torino

"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

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS

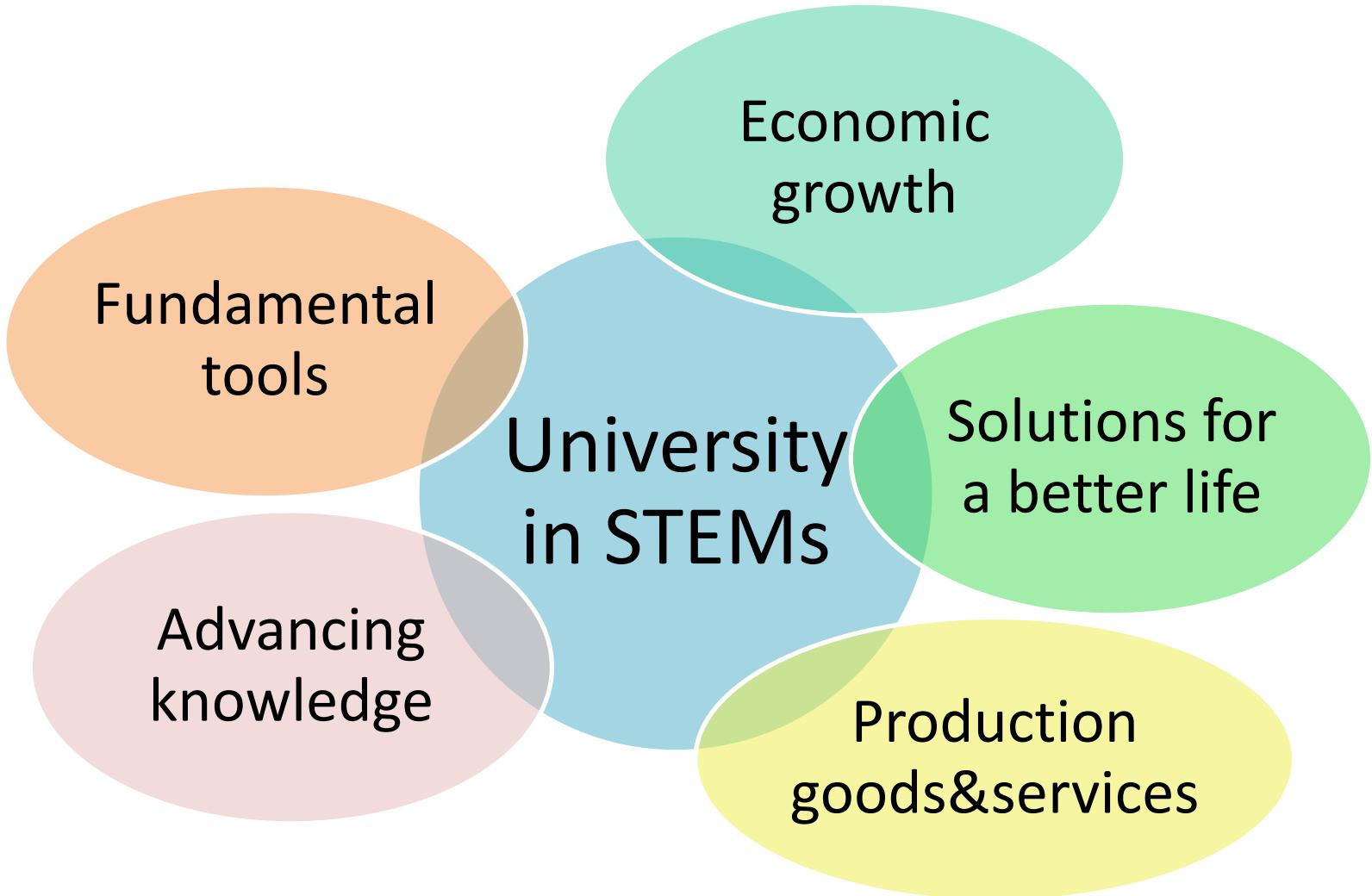


17 PARTNERSHIPS FOR THE GOALS



SUSTAINABLE DEVELOPMENT GOALS





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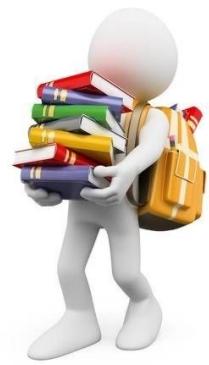
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17 PARTNERSHIPS FOR THE GOALS



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?



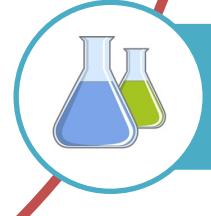
Useful and interesting



Sound good in a CV

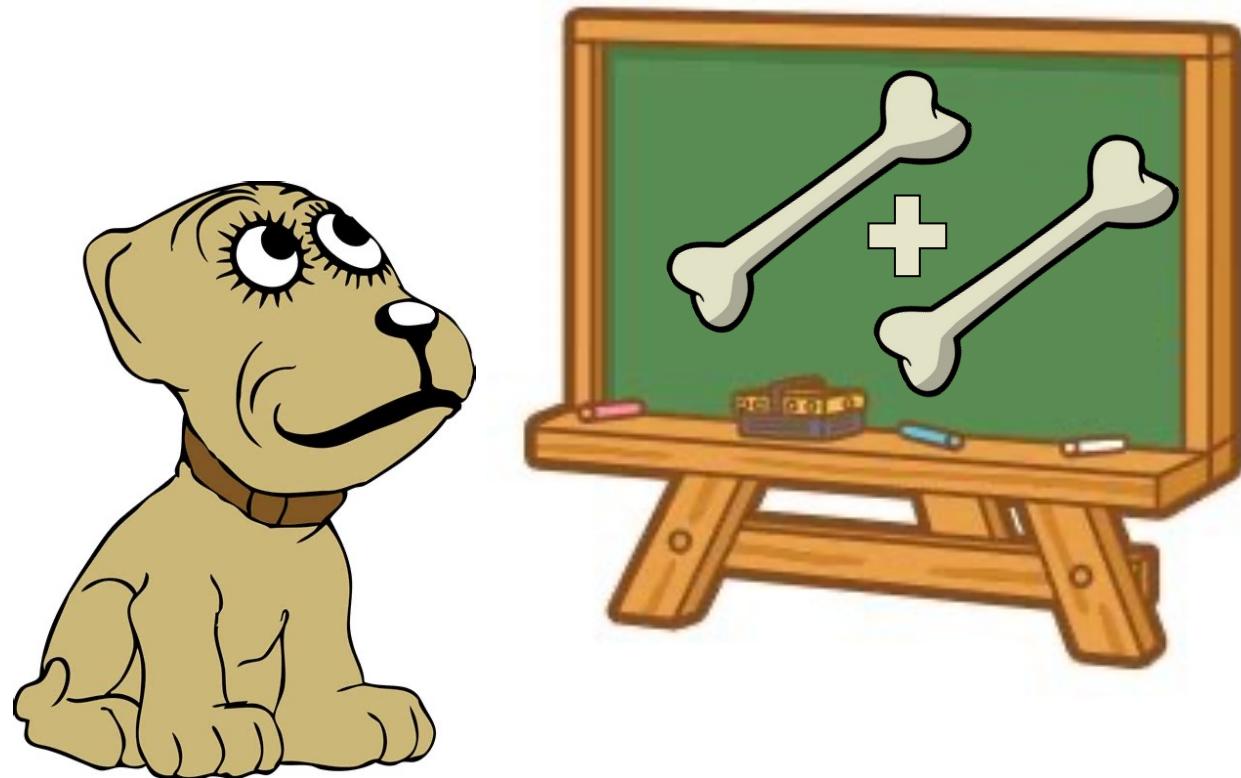


Short start up time

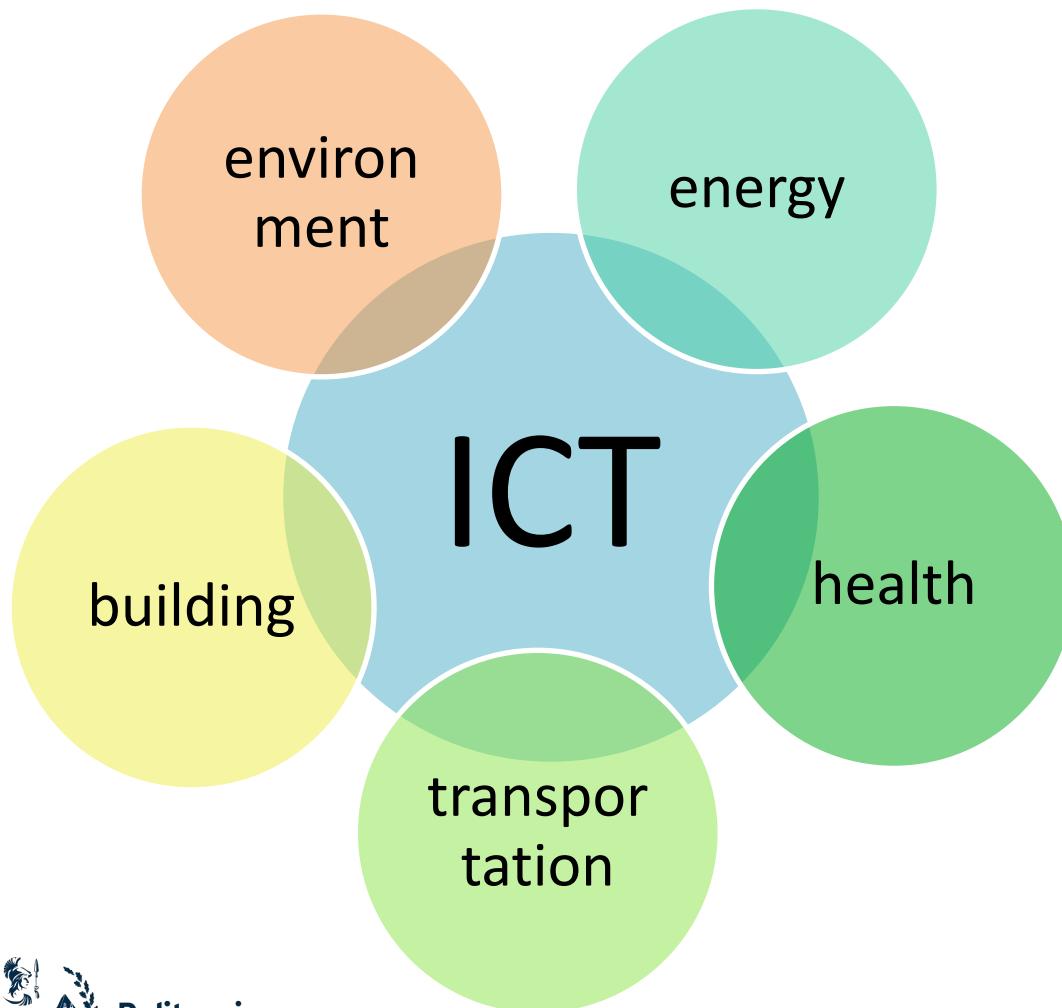


Hands-on learning experience

About my experience

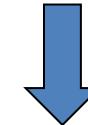


MSc: ICT for Smart Societies



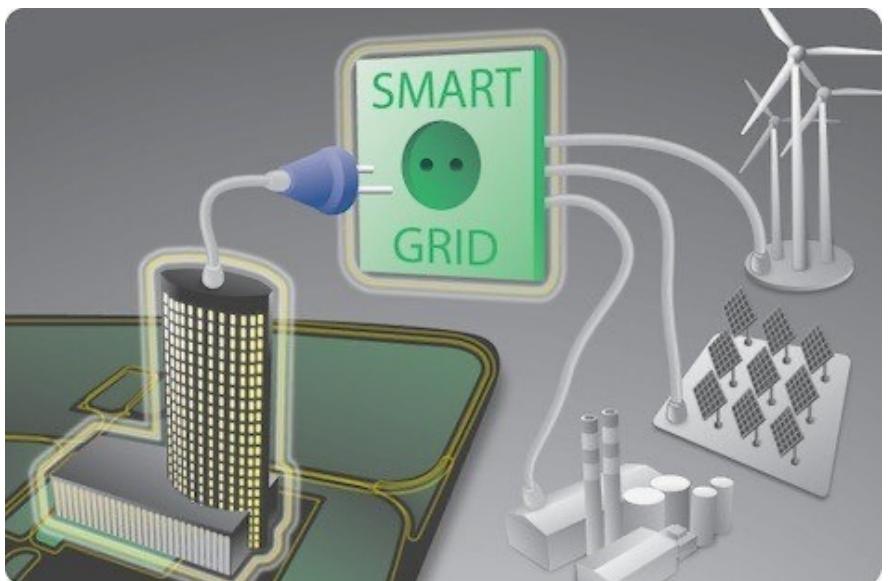
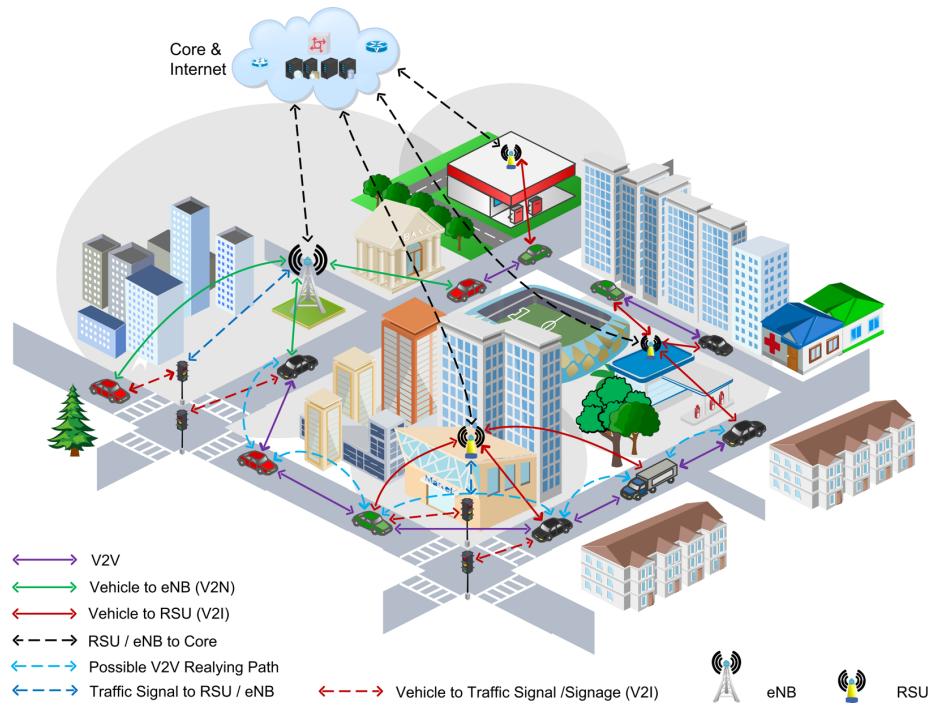
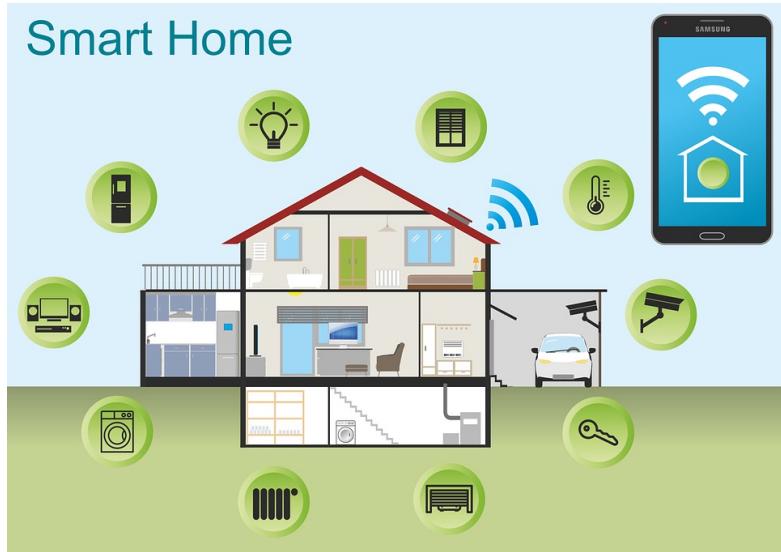
Interdisciplinary MSc

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

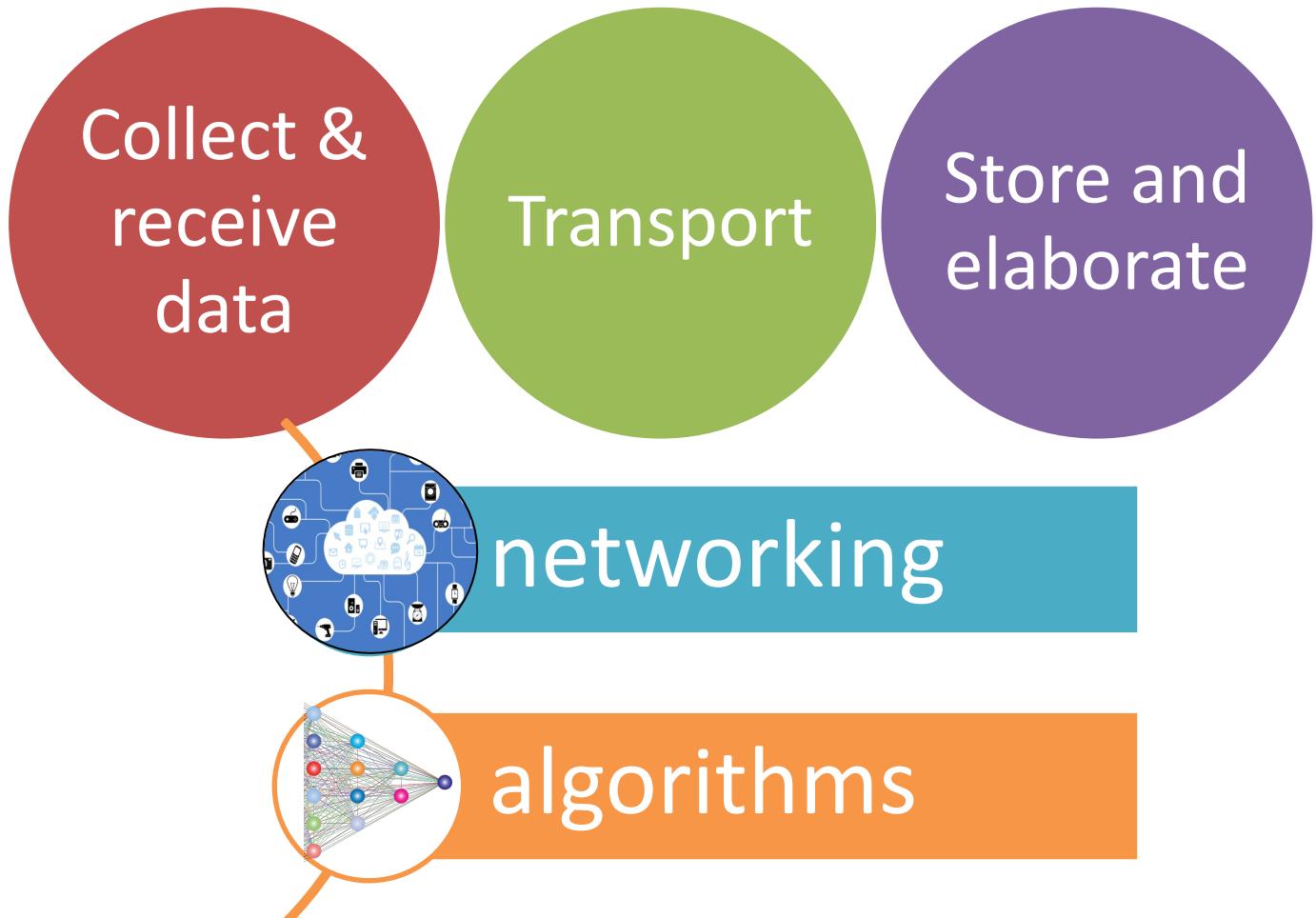
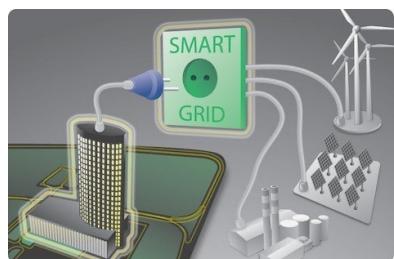
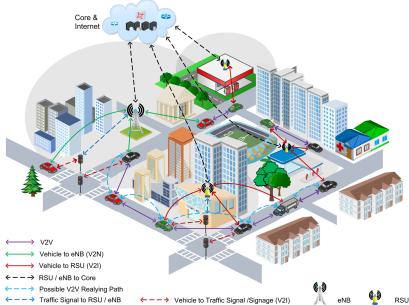
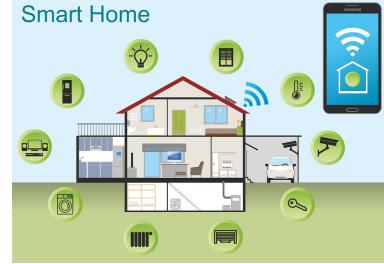


make *** smarter

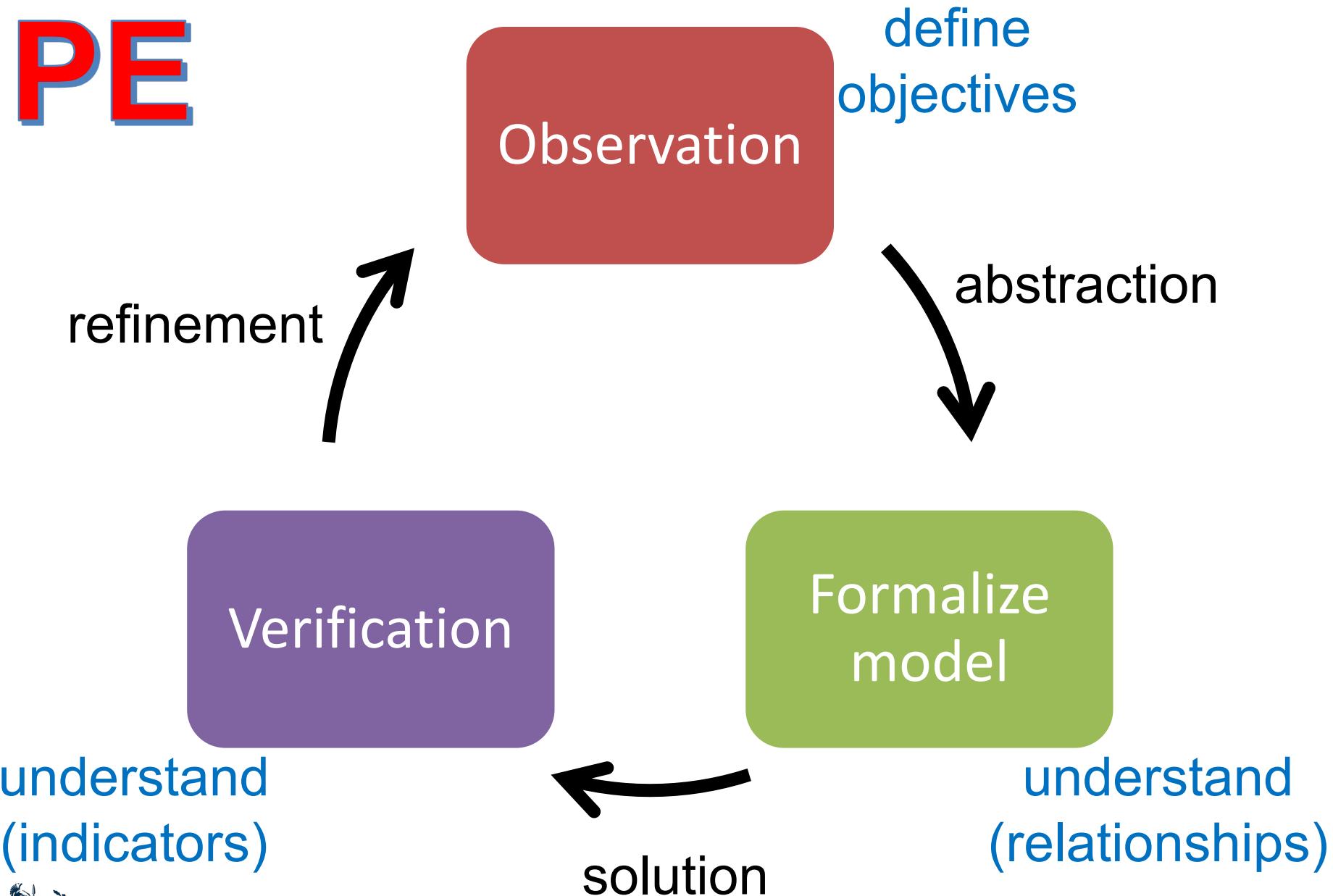
ICT for Smart Societies



Smart environments → networking



PE



PE

Observation

define objectives

- Critical thinking
- Holistic view

- Abstraction
- Creative thinking

Verification

understand
(indicators)

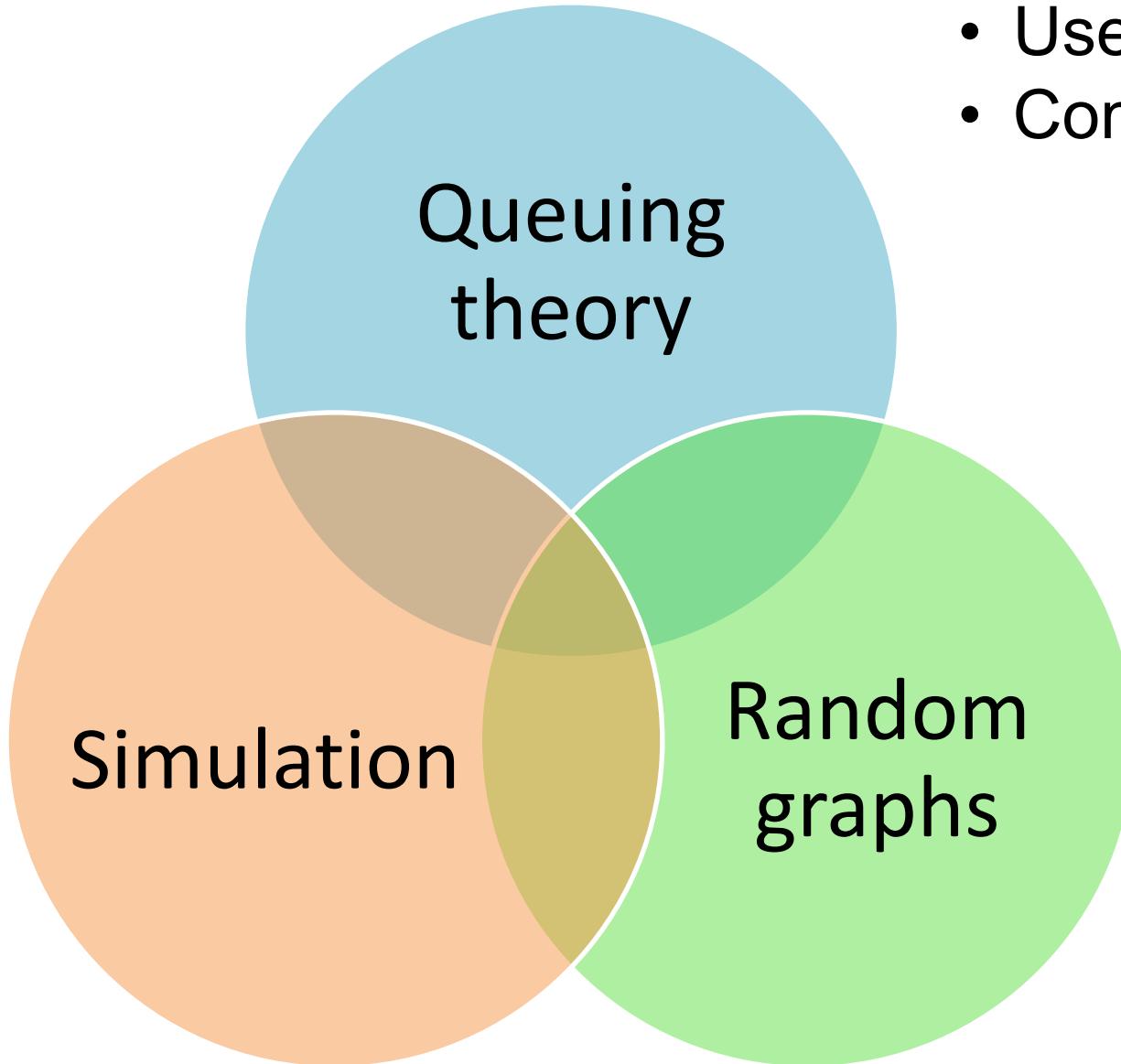
Formalize model

understand
(relationships)

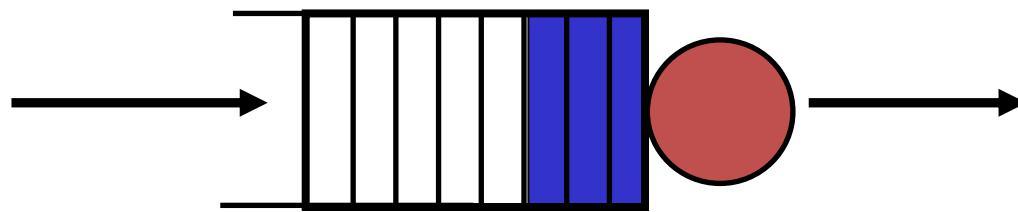
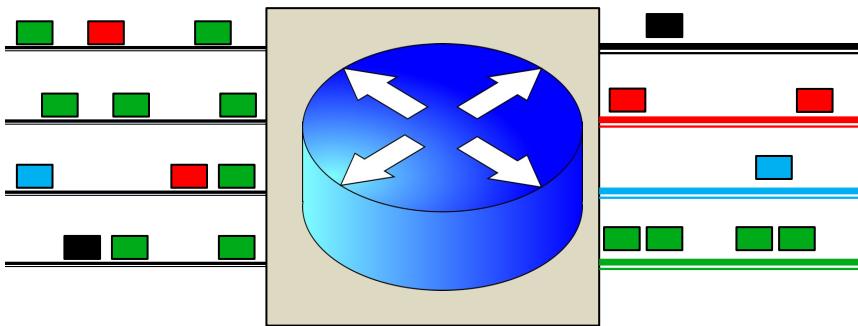
- Coding
- Using tools



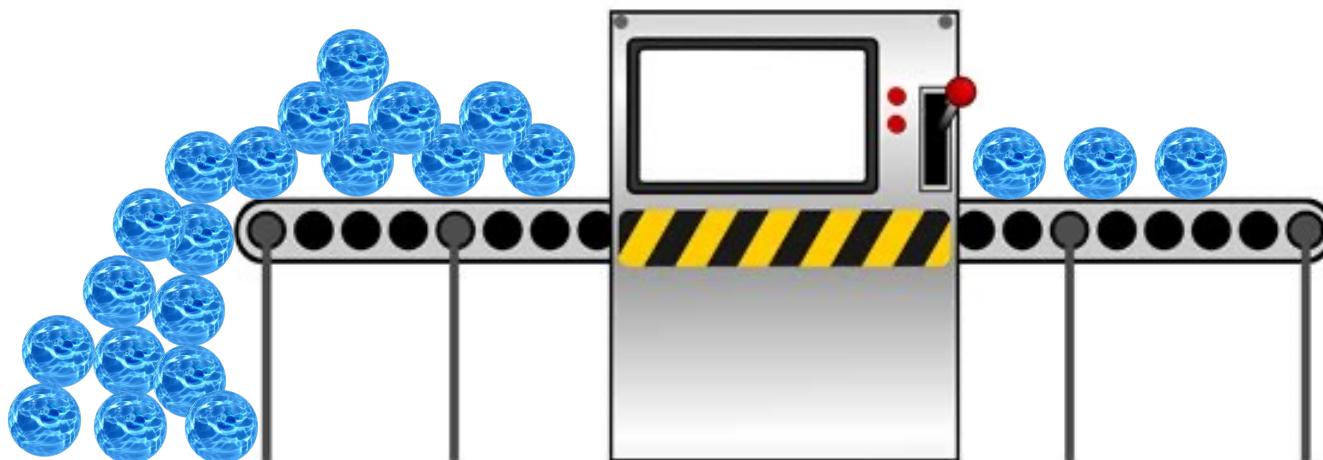
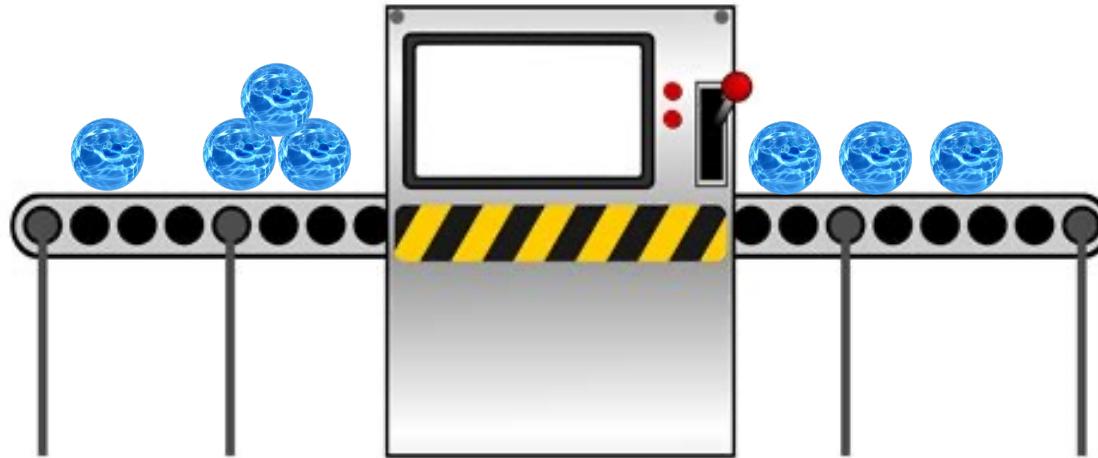
- Useful
- Complementary



Queuing theory



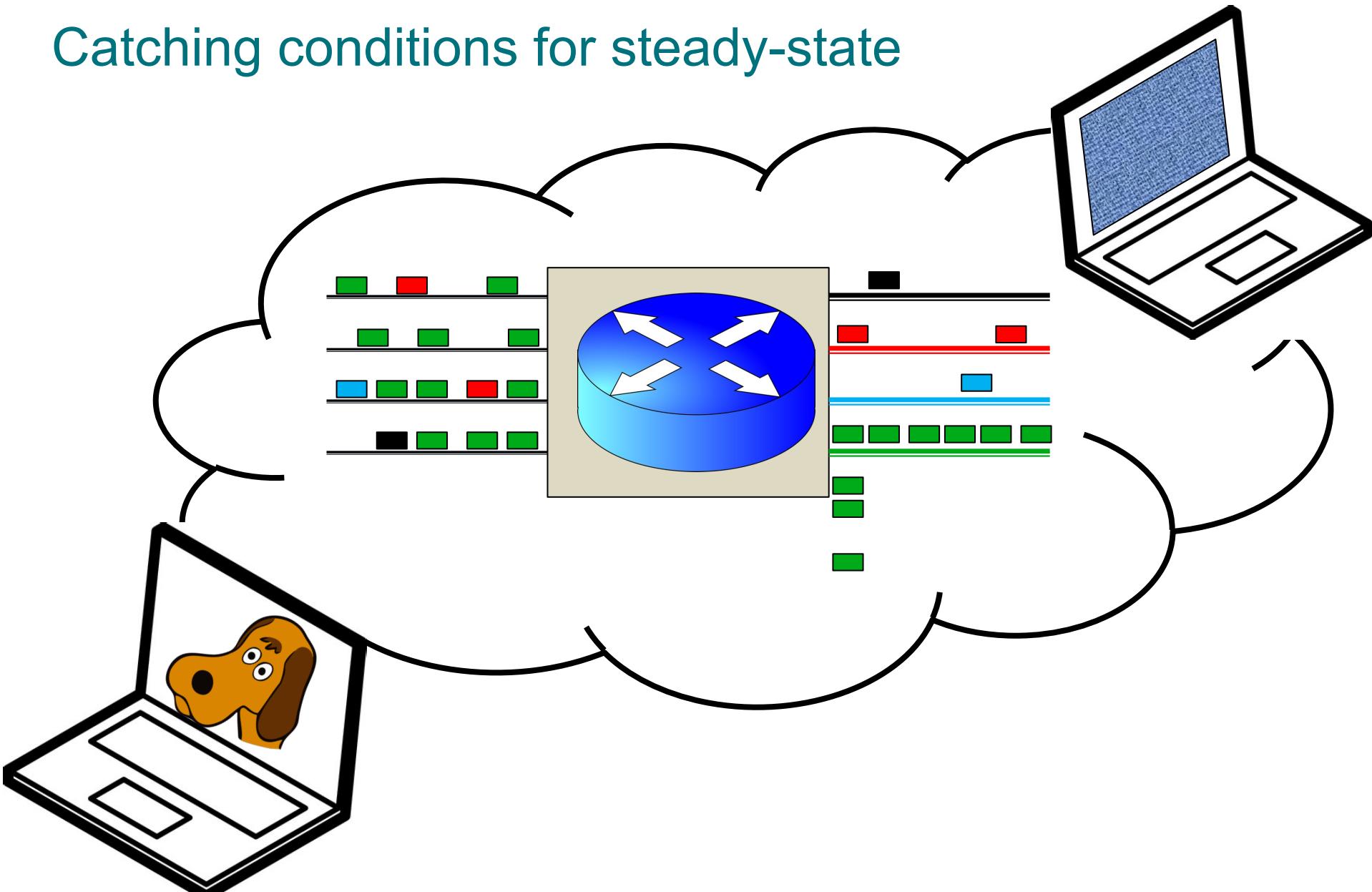
Catching conditions for steady-state



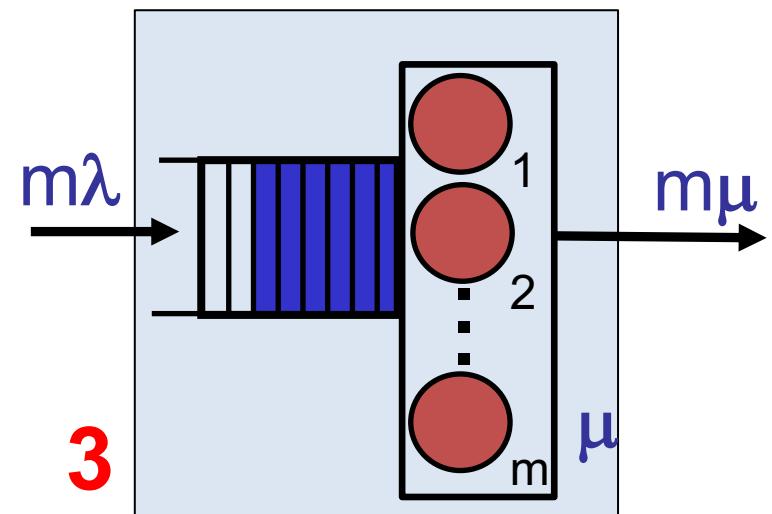
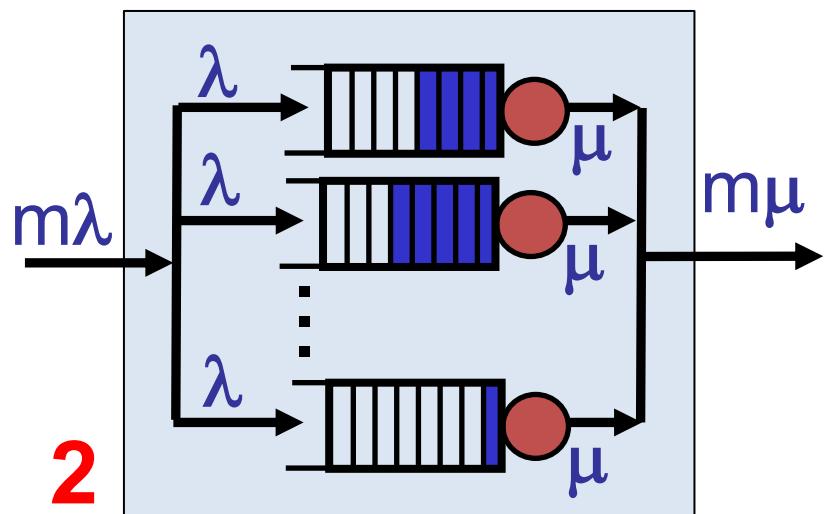
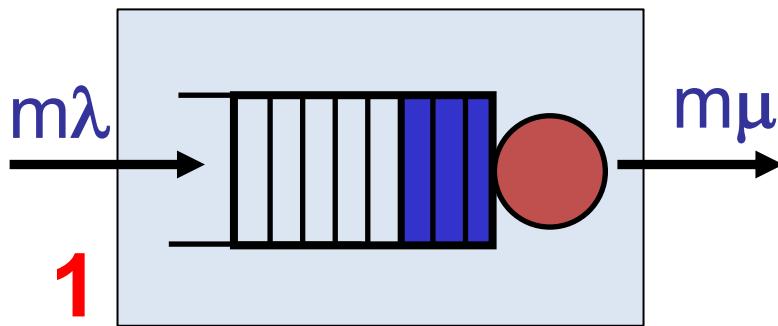
Catching conditions for steady-state



Catching conditions for steady-state



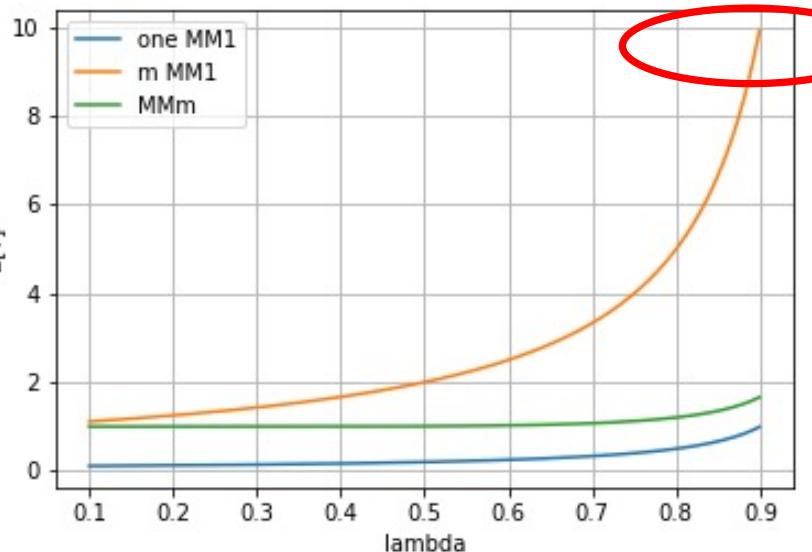
Some of the hints from queuing theory



Comparison of the 3 systems

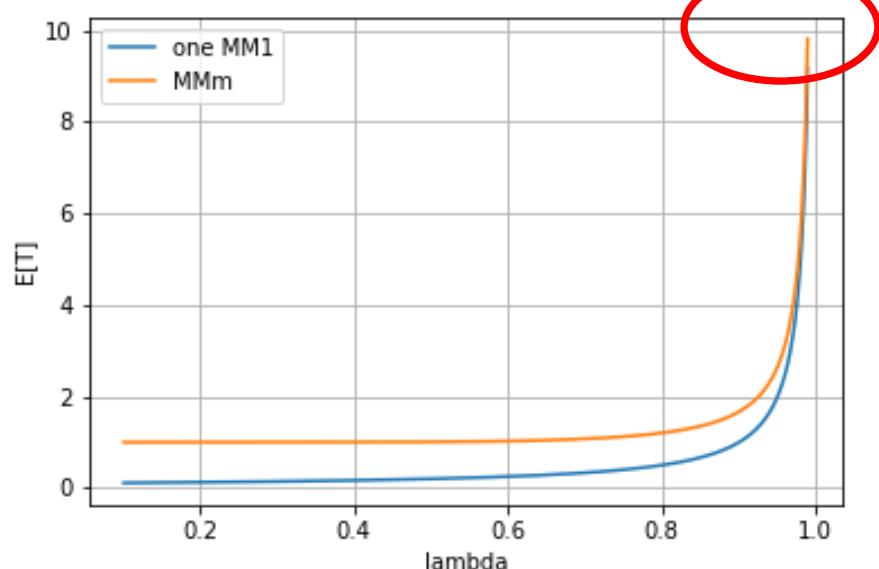
$m=10, \mu=1$

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

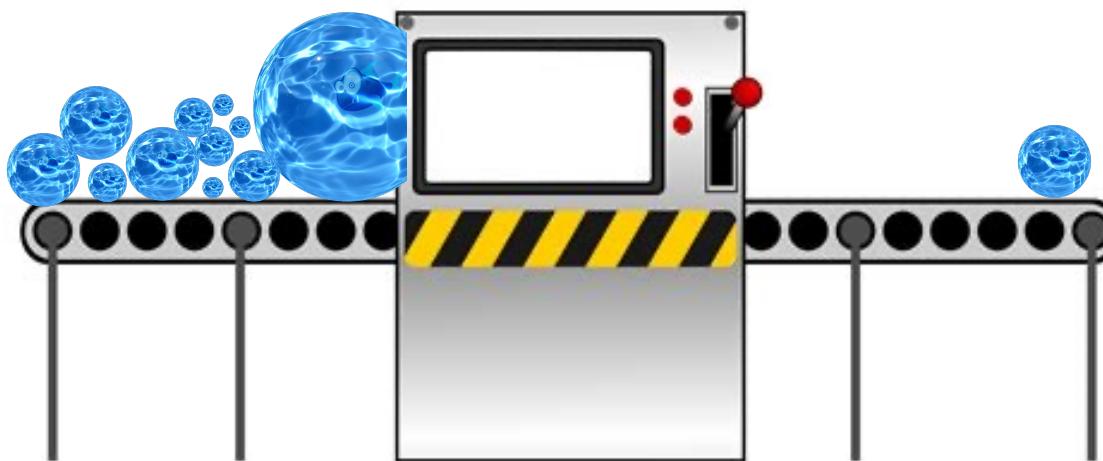
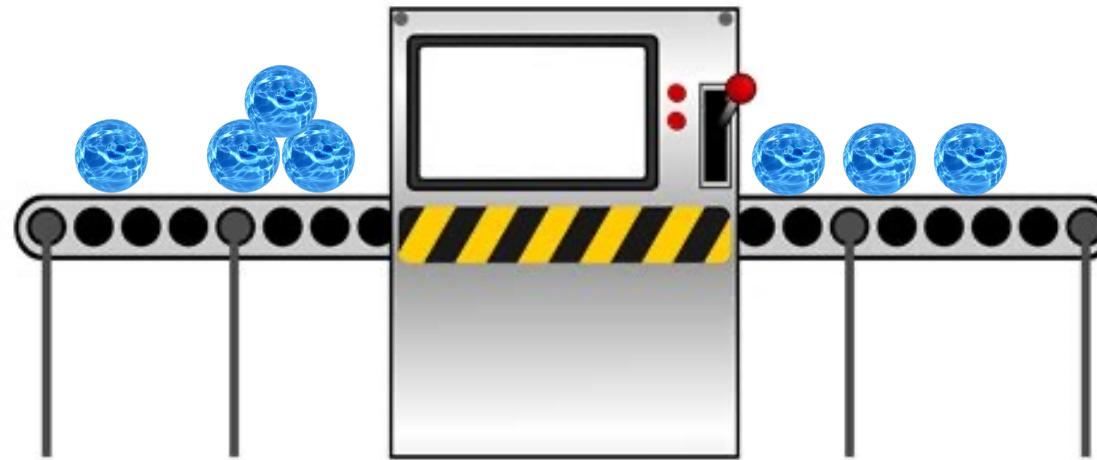
- For the M/M/1 queue

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

↑
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



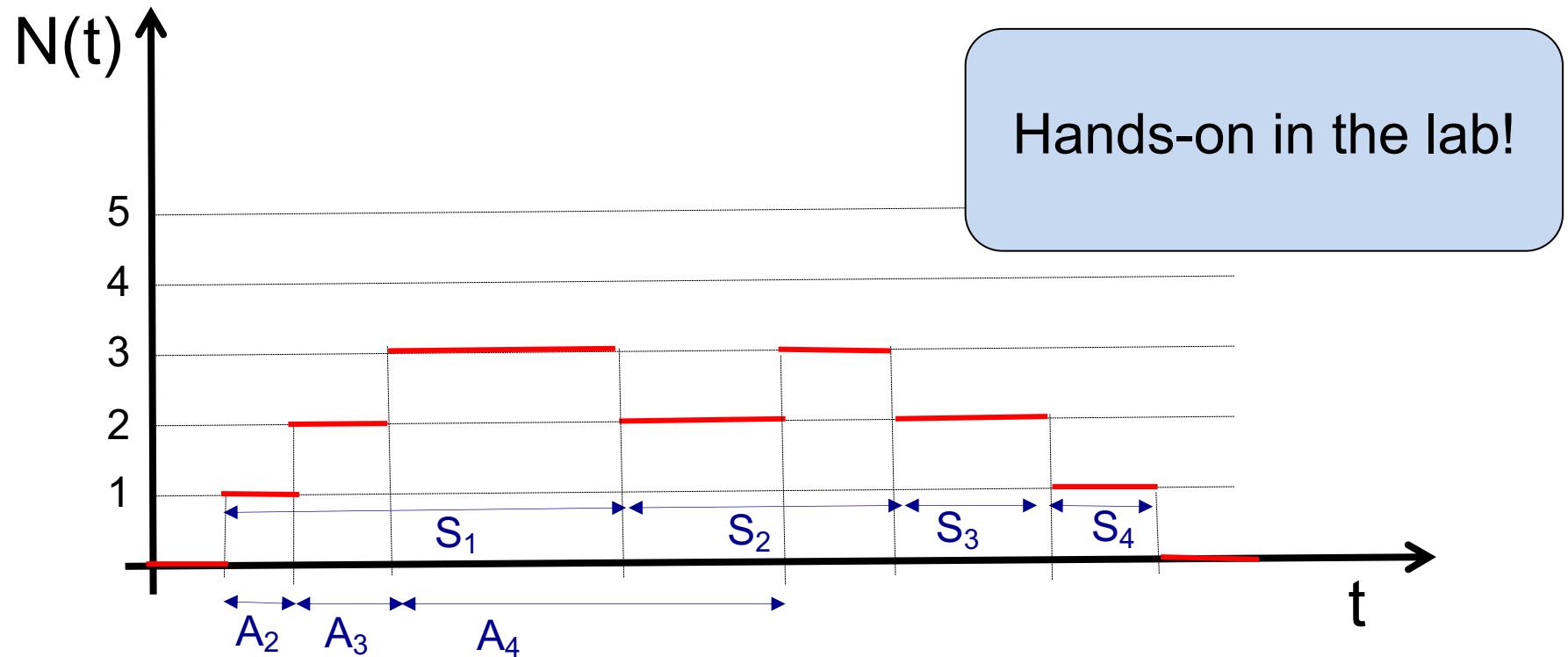
Lessons learnt from queuing networks

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

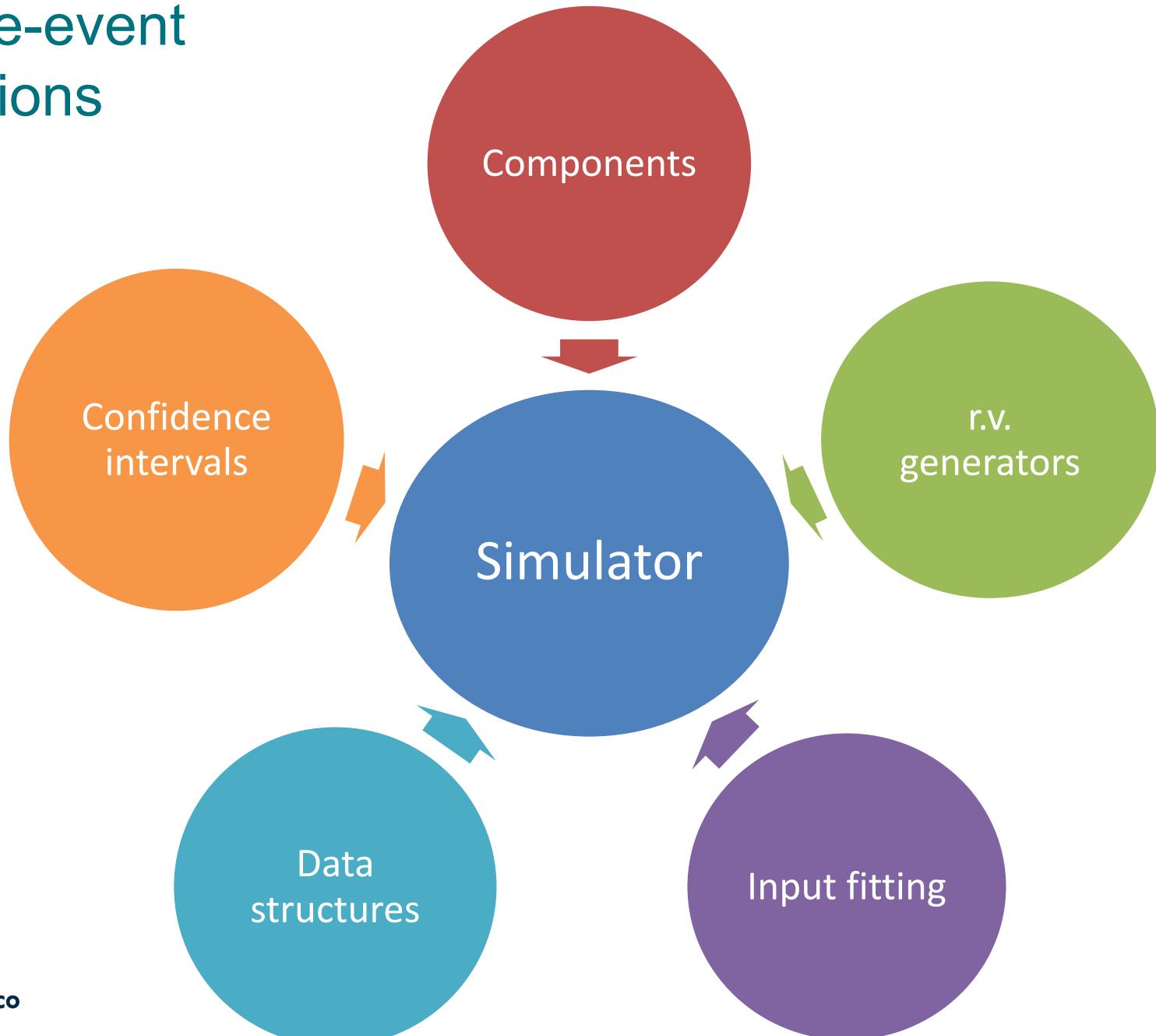


Discrete-event simulations

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



Discrete-event simulations



In the lab: Duration of simulation

Spyder (Python 3.8)

/Users/michi/Dropbox (Politecnico di Torino Staff)/didattica/CodiceCASD/queue-misure.py

ExactApprox.py SoluzionePuntoSingolo_05.py queue.py queue-misure.py

```
226 print("Point ",i," load=",load)
227 punti.append(load)
228 data = Measure(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
```

Variable explorer Files Help

Console 1/A

In [8]:

IPython console History

Average Delay

Delay [ms]

Load

Average Delay

Delay [ms]

Load

LSP Python: ready Kite: ready conda: base (Python 3.8.3) Line 183, Col 18 UTF-8 LF RW Mem 68%

In the lab: Sample paths (the seed)

Spyder (Python 3.8)

/Users/michi/Dropbox (Politecnico di Torino Staff)/didattica/CodiceCASD/queue-misure.py

ExactApprox.py SoluzionePuntoSingolo_05.py queue.py queue-misure.py

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

Source Console Object

Console 1/A

Variable explorer Files Help

In [8]:

IPython console History

Average Delay

Delay [ms]

Load

simulation theory

Average Delay

Delay [ms]

Load

simulation theory

LSP Python: ready Kite: ready conda: base (Python 3.8.3) Line 183, Col 18 UTF-8 LF RW Mem 68%

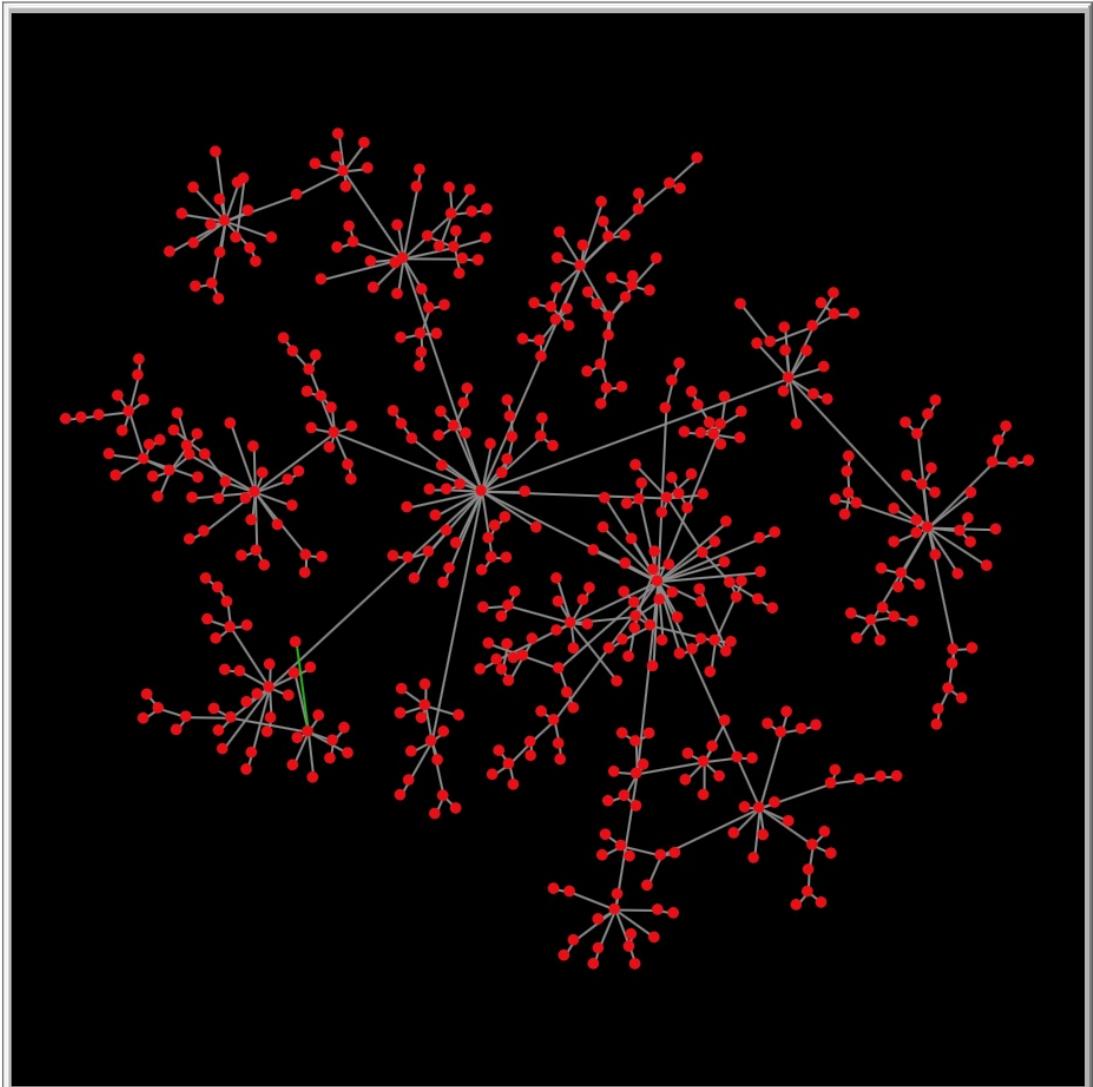
Lessons learnt on simulation vs analytical modeling

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

Random graph theory: complex systems

Change perspective

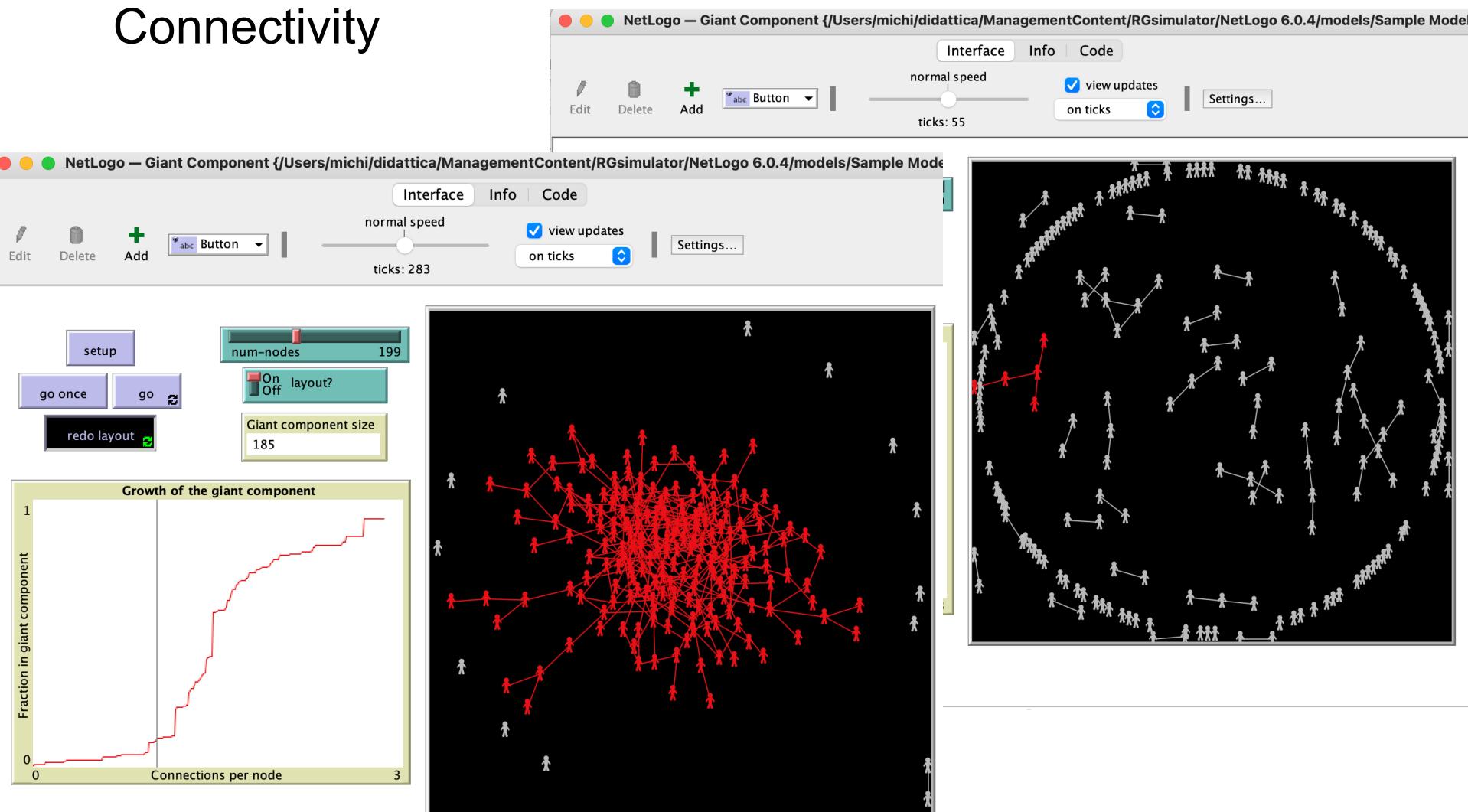
- Modeling
- Focus (interactions)
- Indicators



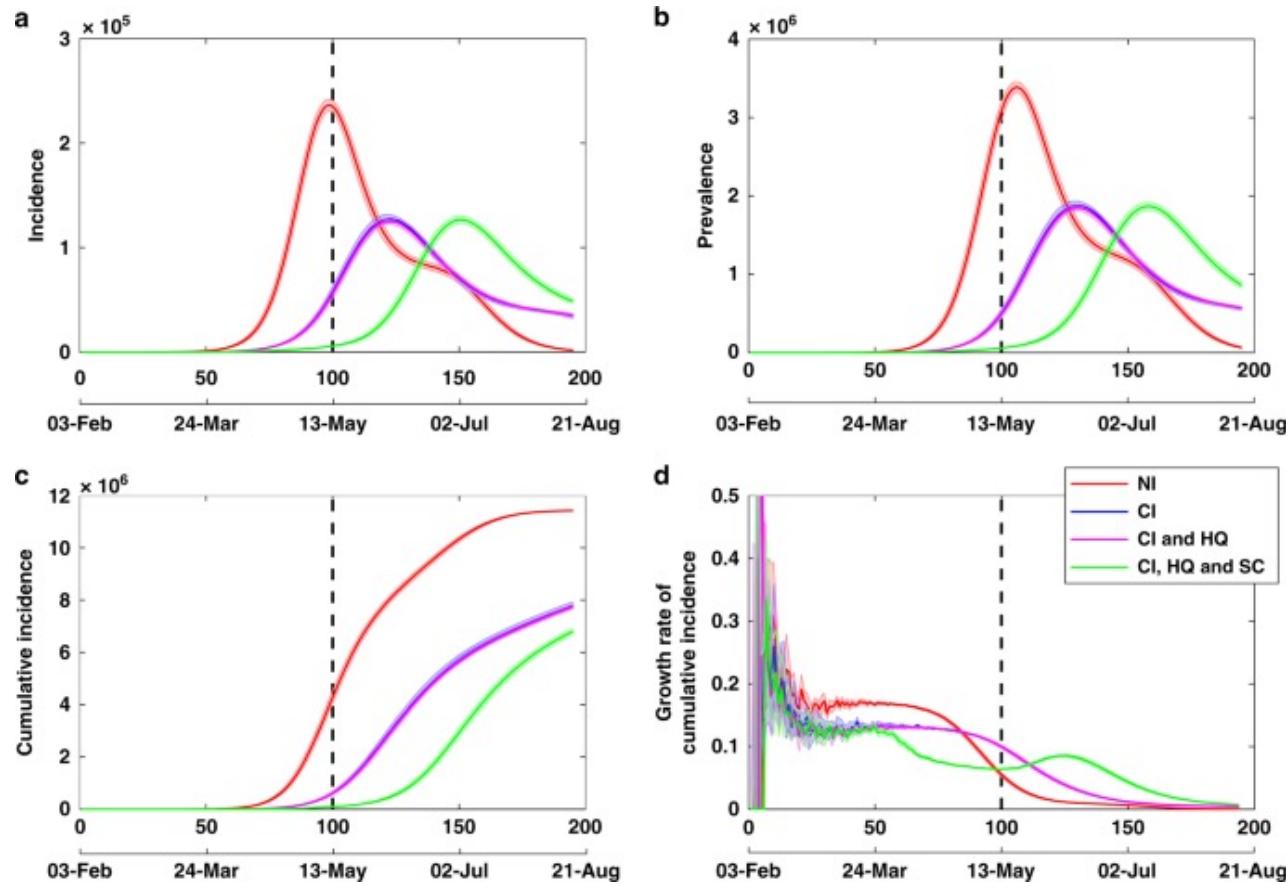
Random graph theory

Connectivity

Obtained with
netlogo simulator
<https://ccl.northwestern.edu/netlogo/>



Epidemic models



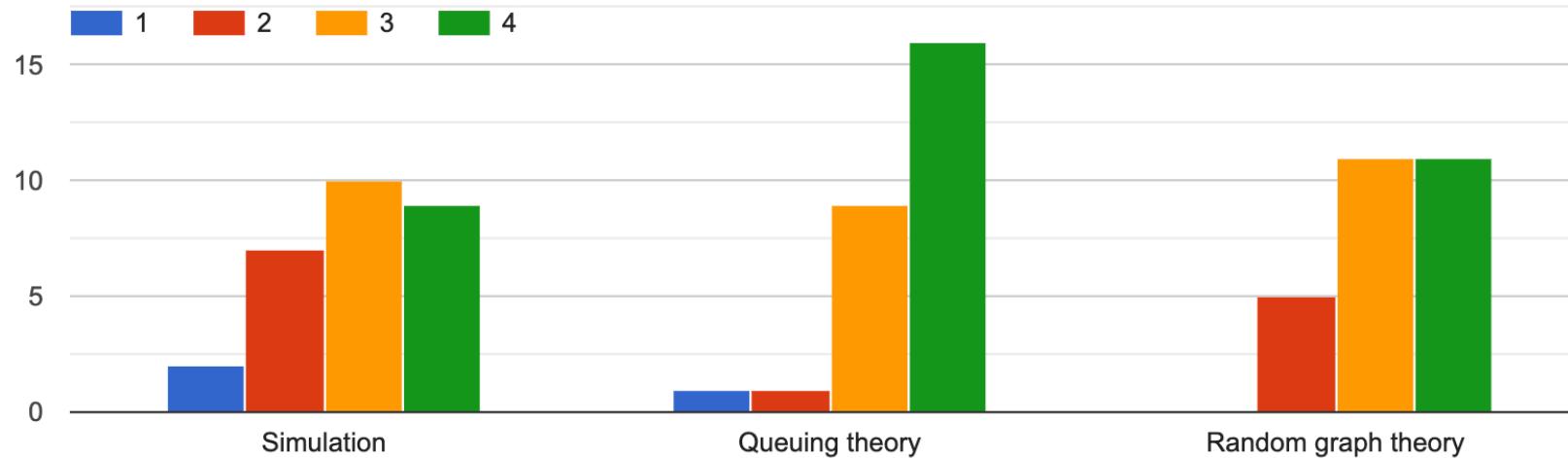
Source: S. Chang et al., "Modelling transmission and control of the COVID-19 pandemic in Australia", Nature Communications, Nov 2020

Asking to students

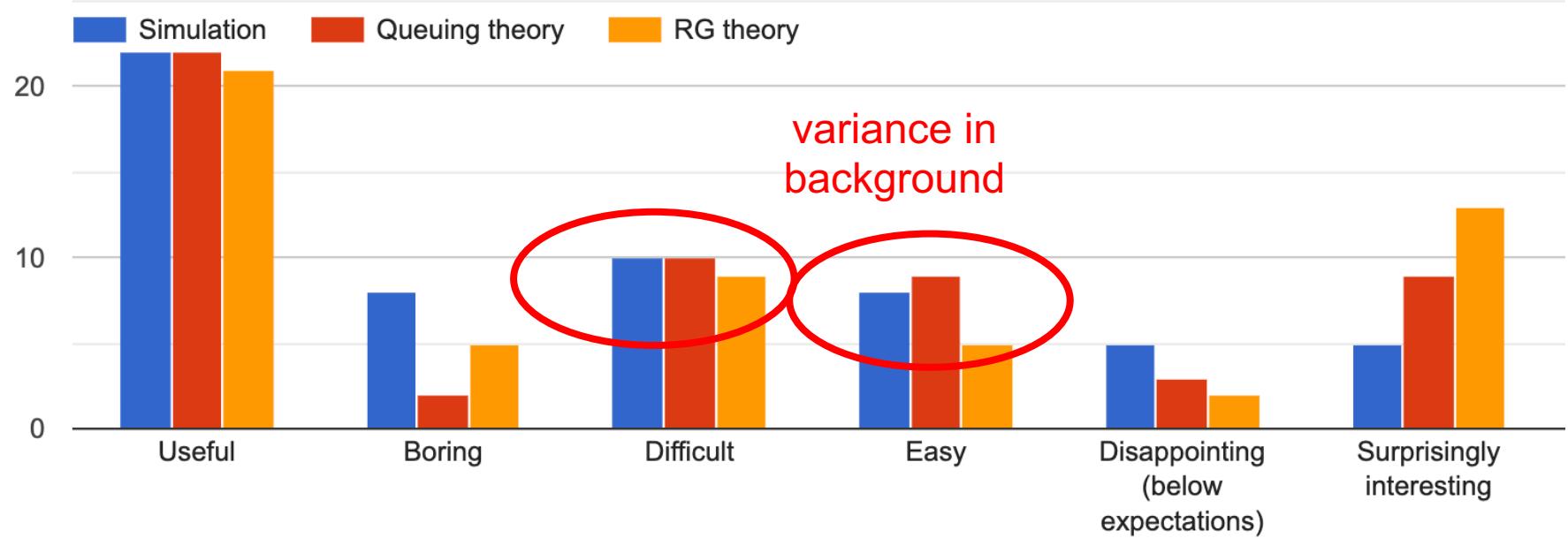
Asking to students

1. How much did you enjoy learning the following:

(1: not at all; 4: I enjoyed much)



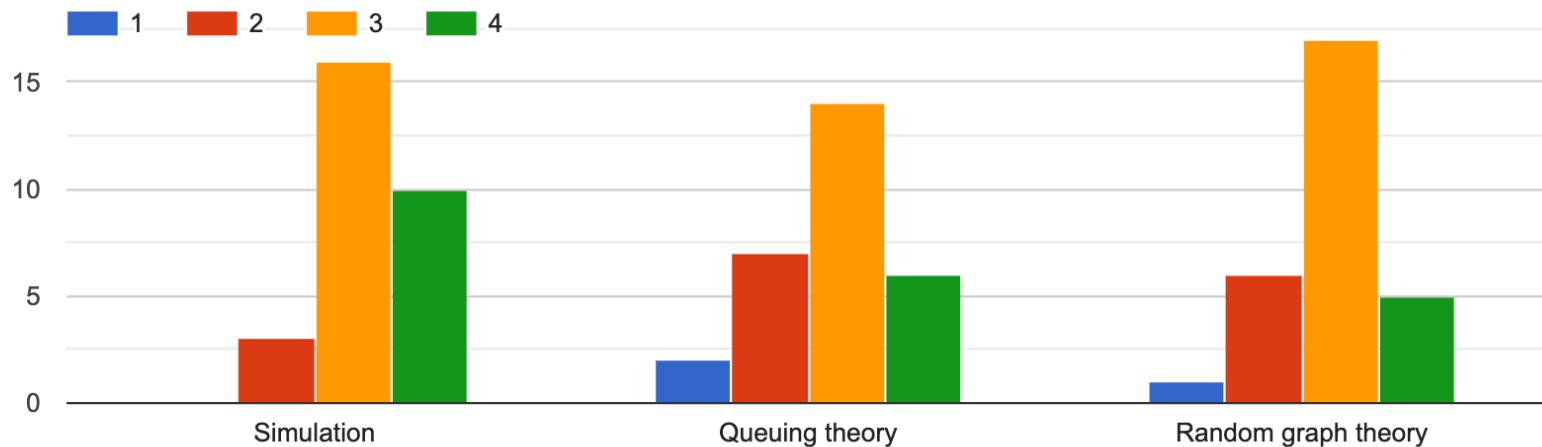
Asking to students



Asking to students

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

(1: useless; 4: very useful)



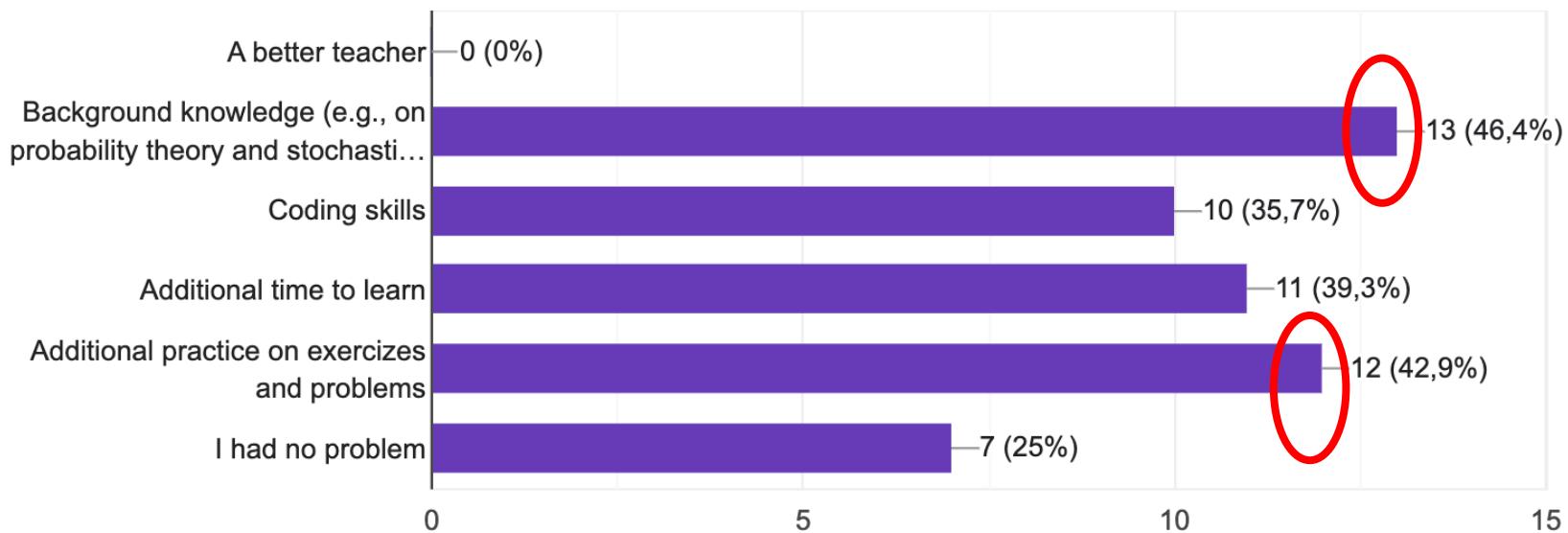
Students

- 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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