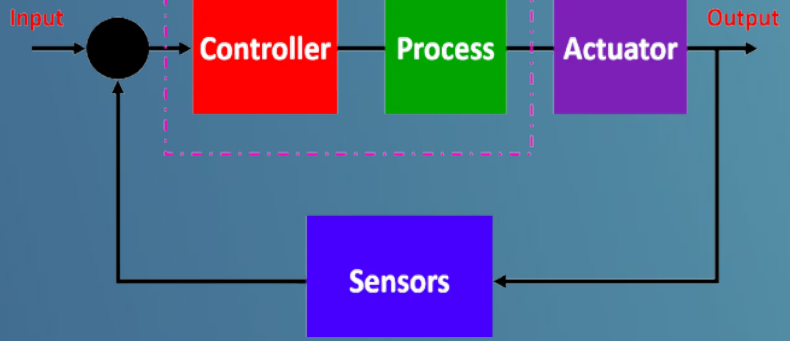
Ignazio Maria Castrignano

My Education Journey

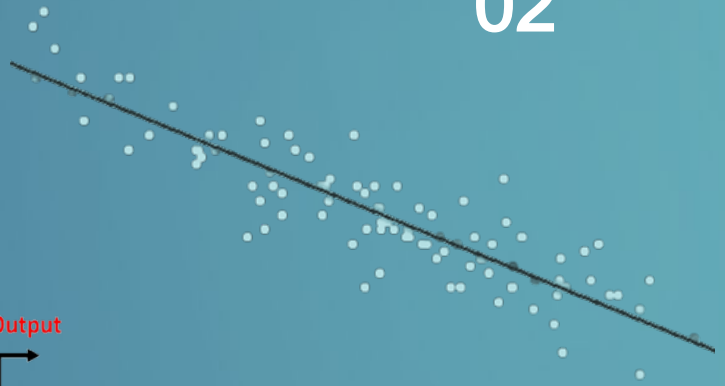
Politecnico di Milano

Control Theory 01

Feedback Control System



Artificial Intelligence 02

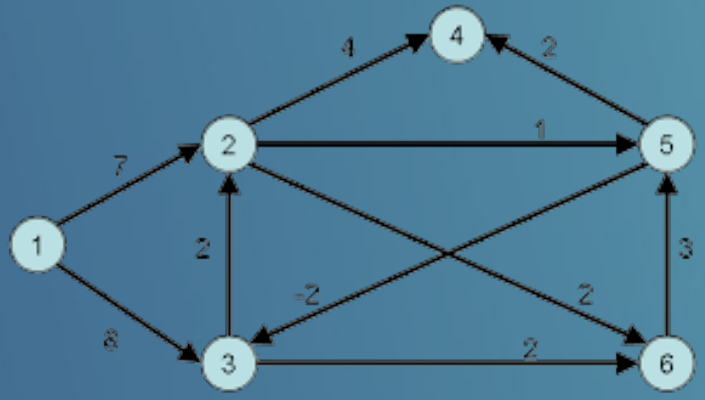


Robotics 03

Politecnico di Milano

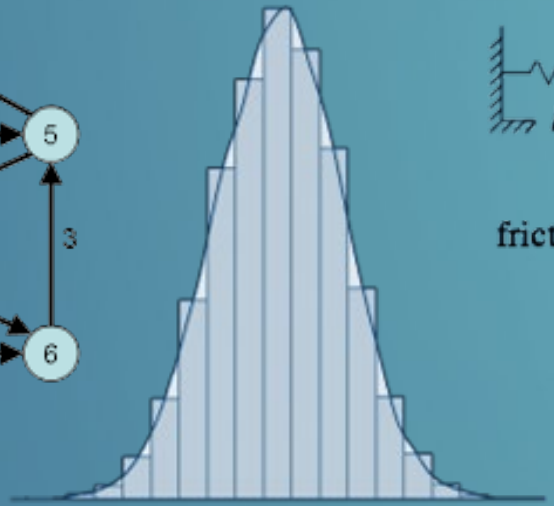
Foundations of operations research

04



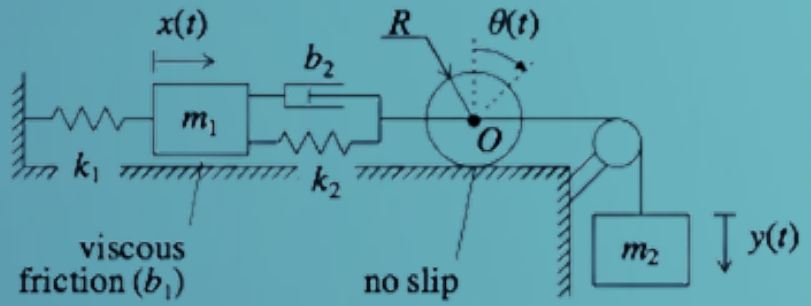
Probability and Statistics

05



Dynamics of Mechanical System

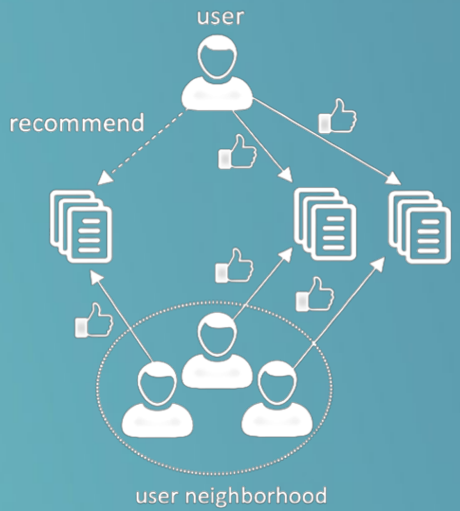
06

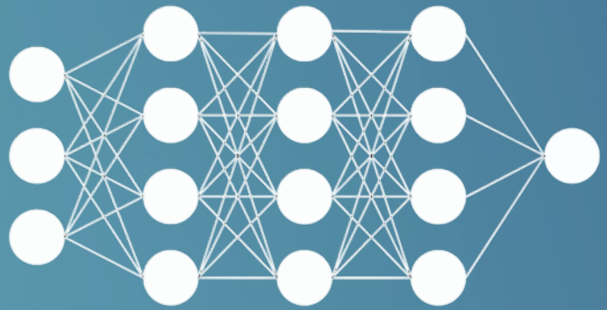


Internship in Social Thingum

social Thingum

Recommender System

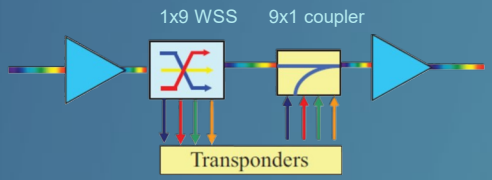




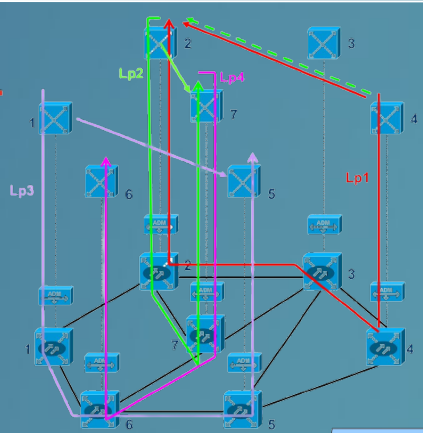
Neural Networks

Topics studied in courses with Professor Massimo Tornatore

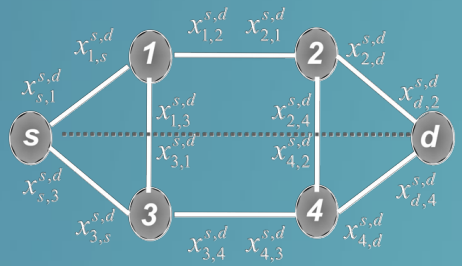
Optical devices



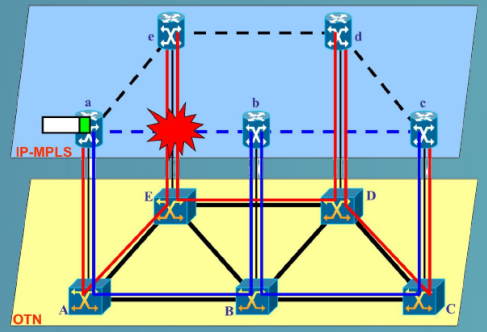
Optical Network



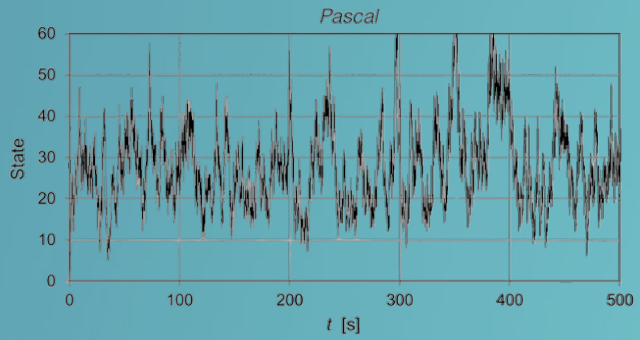
Traffic Routing



Protection Techniques



Traffic/Queueing Theory



Project 8 Hard Spectrum Partitioning

Professor: Massimo Tornatore

Nokia Supervisor: Annalisa Morea

COMMUNICATION NETWORK DESIGN

Problem Formulation

Problem

Asses overall spectral efficiency in a network with multiple channel widths, where fiber spectrum is hardly divided into two sections or not.

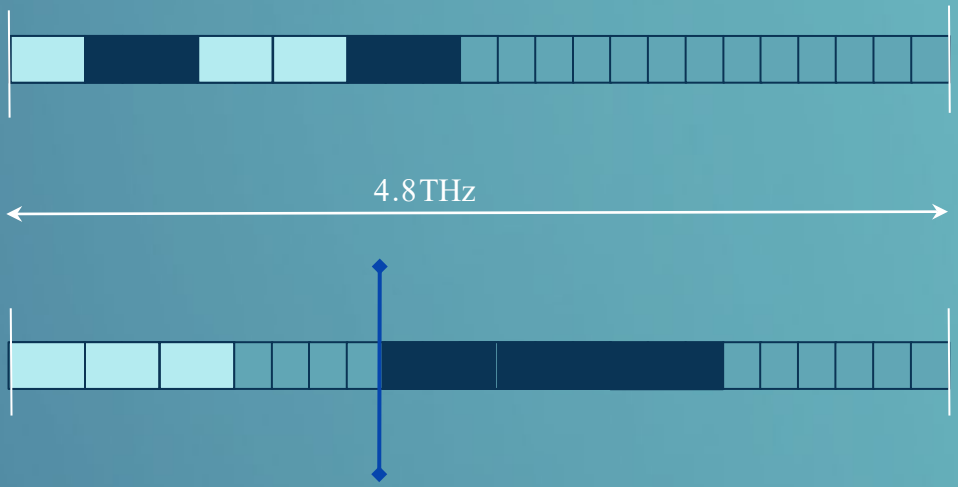
Goal

-minimize blocking probability
-minimize overall cost

Spectrum Partitioning

Soft

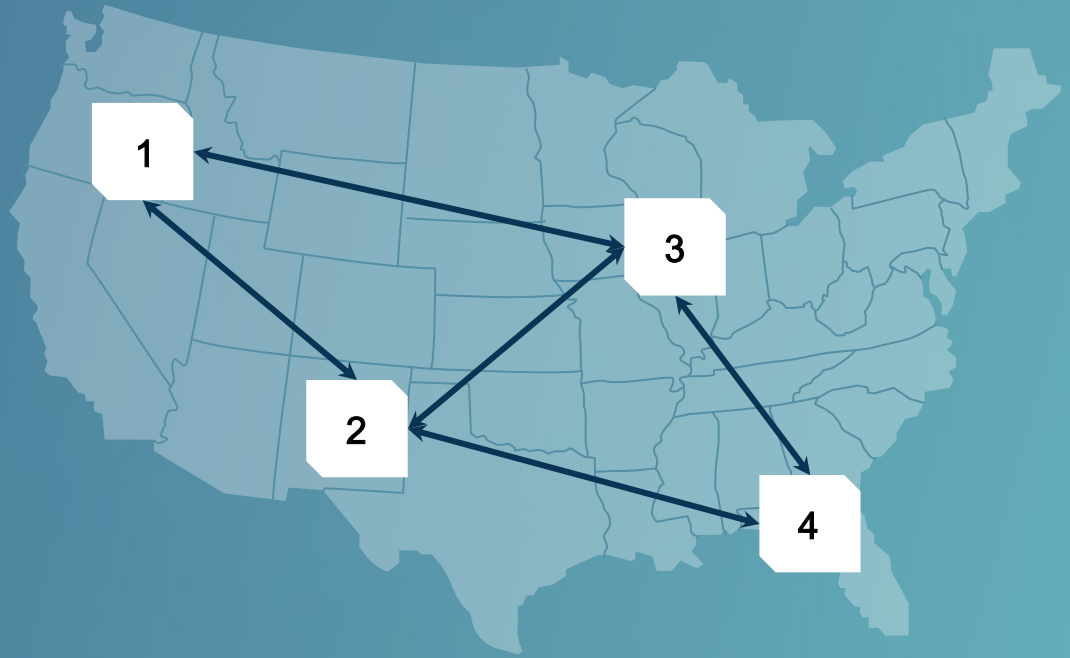
Hard



How Topology works

Source
Destination
Pair

Lenghts



K-Shortest
Path

Input parameters to generate demands

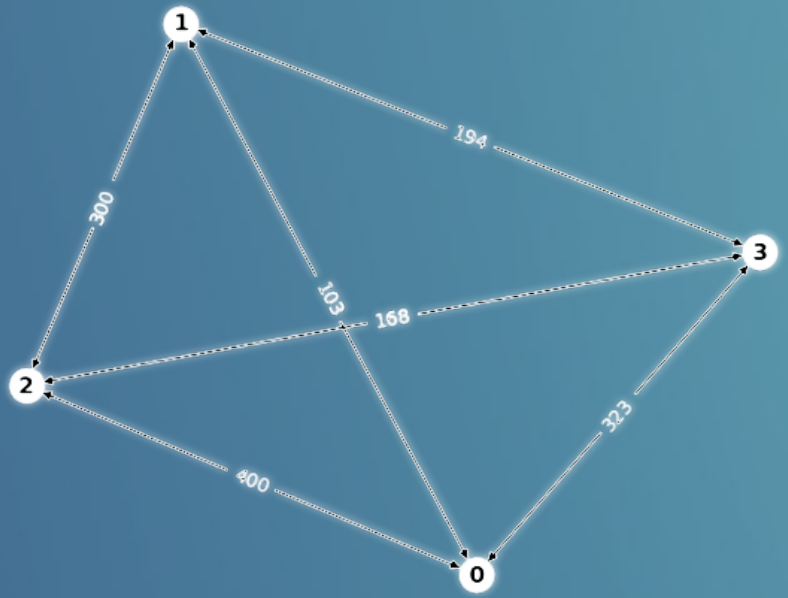
Data Rate Gb/s	Modulation Format	Bits/symbol (Gb/s)- Entropy	Channel spacing Δf (GHz)	Reach (km)
200	16 QAM	4.00	50	900
400	16 QAM	4.00	75	600

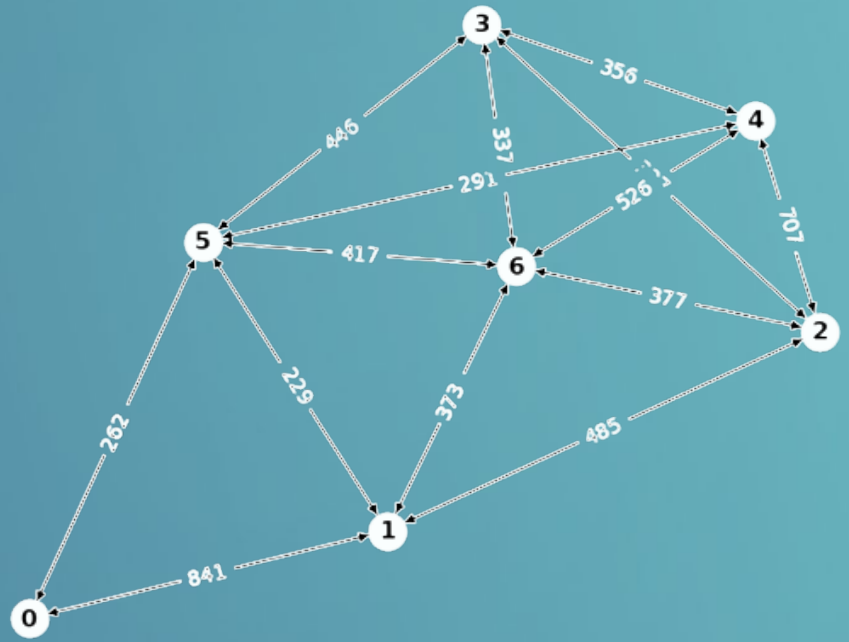
Modulation format:

-m=0 50 Ghz 2 slices of 25
-m=1 75 Ghz 3 slices of 25

OUR NATIONAL AND CONTINENTAL TOPOLOGIE

	Number of Links	Average link lenght	Max link length	Number of Nodes
National	⩽ 20 links	~ 150 km	~400 km	4
Continental	⩾ 20 links	~ 300 km	~ 1000 km	7





ALGORITHM

Integer Linear Programming

First Fit

Genetic Algorithm

ILP Constraints

Using the tool gurobipy we tried to optimize the following problem adding constraints:

Takes around 2 hours to optimize for a small network

The AP-RMSA formulation is as follows:

$$(AP - RMSA) \min \sum_{d \in D} b_d \cdot w_d \; + \alpha \cdot \sum_{d \in D} \sum_{m \in M} 2 v_{dm}$$

subject to:

$$\sum_{p \in P(d)} \sum_{c \in C(d)} x_{dpc} + w_d = 1, \;\; \forall d \in D$$

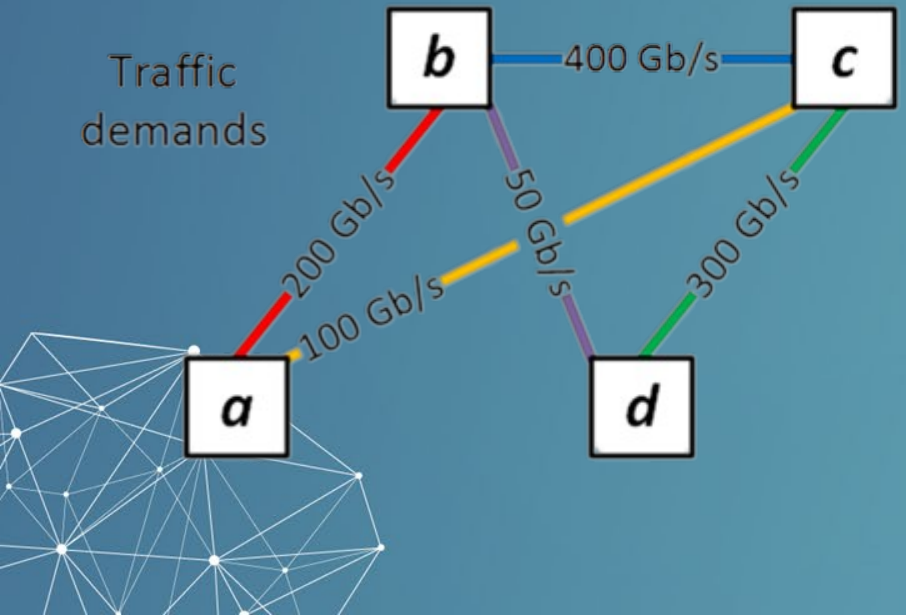
$$\sum_{p \in P(d)} \sum_{c \in C(d)} q_{cm} \cdot len(p) \cdot x_{dpc} \leq len(m) \; + v_{dm} \cdot len\,(m) \quad \begin{matrix} \forall d \in D, \\ m \in M \end{matrix}$$

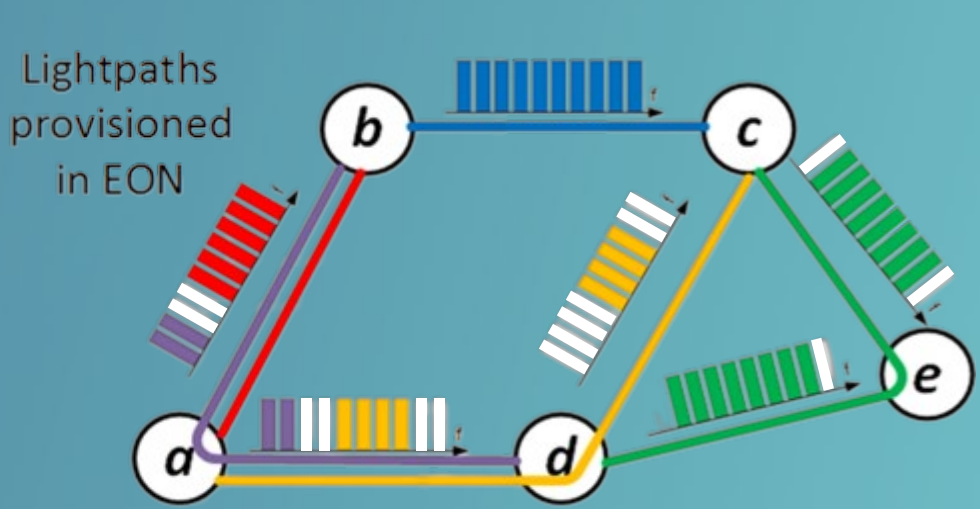
$$\sum_{d \in D} \sum_{p \in P(d)} \sum_{c \in C(d)} r_{pe} \cdot q_{cs} \cdot x_{dpc} \leq 1, \forall e \in E, s \in S$$

First Fit

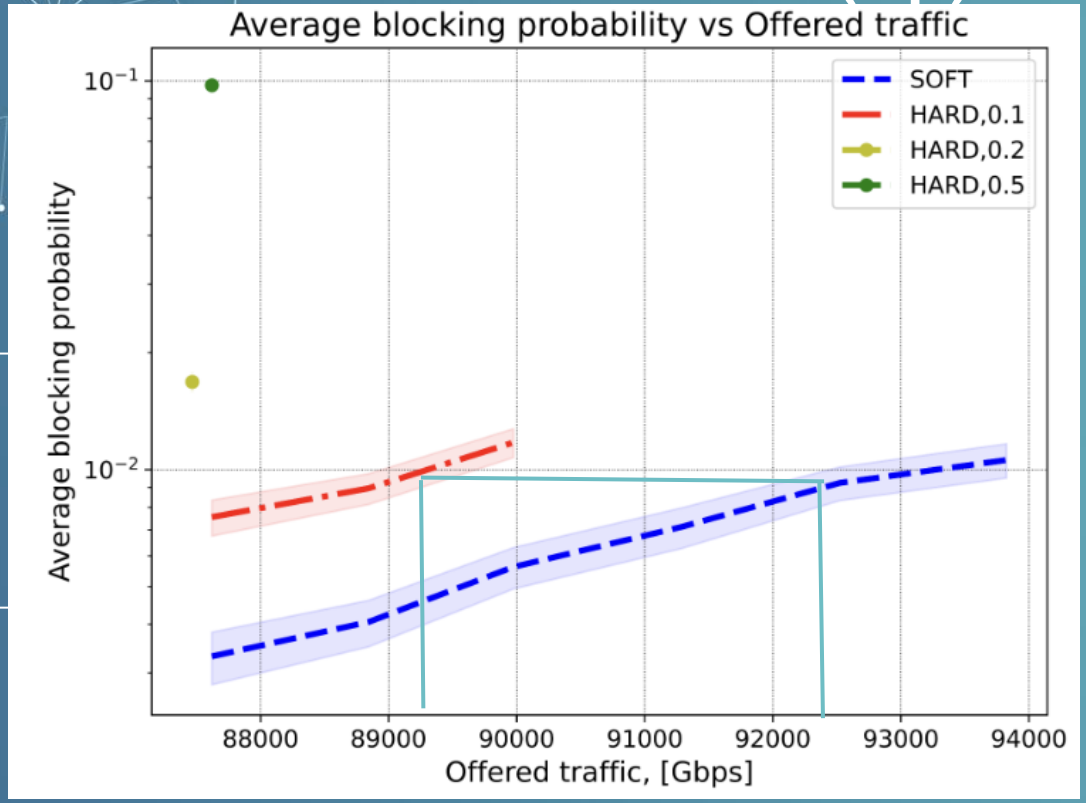
First Fit

We computes the shortest path using the K-Shortest Path.
Then take the first demand and route it in the first available shortest path, if is taken the second, and so on...





Results First Fit: National (Bp)



This is the comparison between the Soft Partitioning and the Hard Partitioning in the National Topology.

So as we can see the blocking probability using the Soft Partitioning is lower so is better for our results.

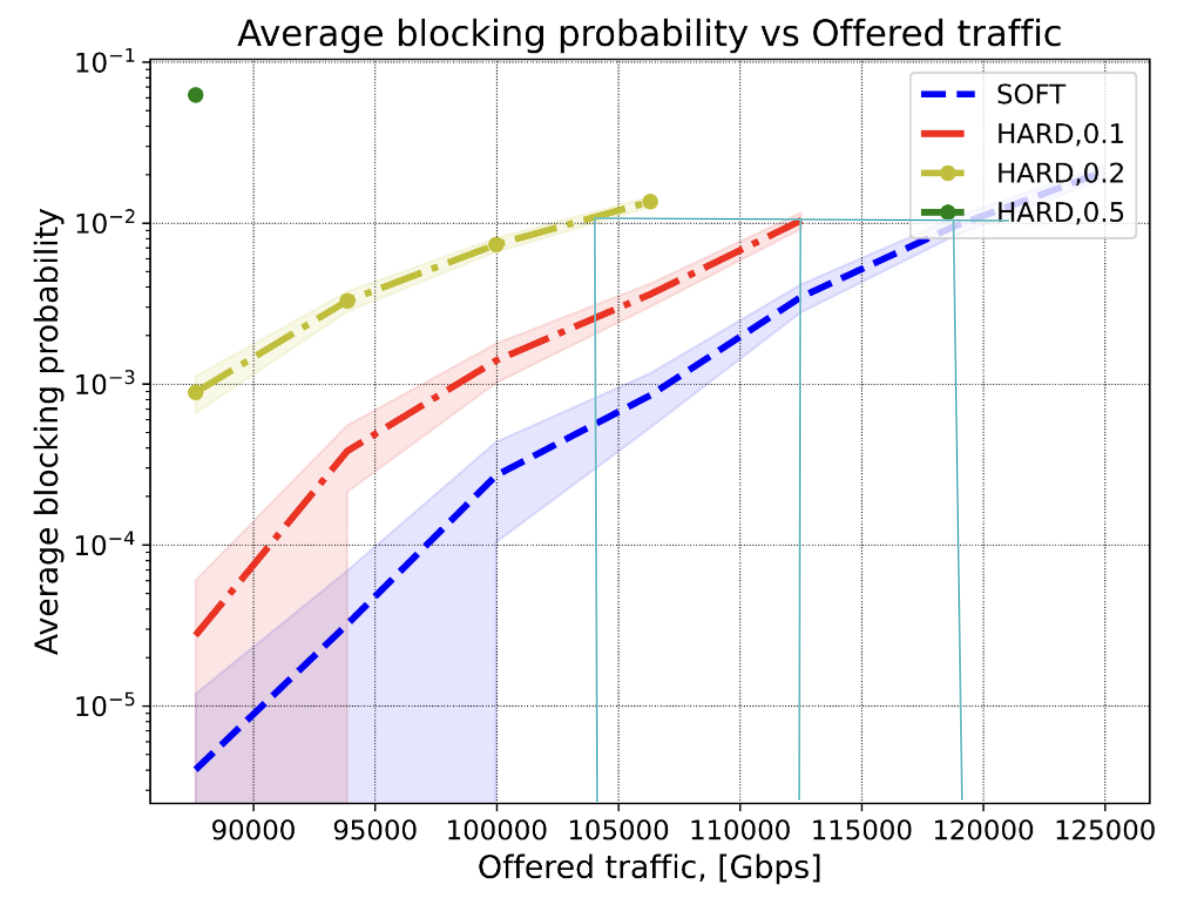
1. EX. for 89Tbps bp Soft = 2*10^-3%, bp Hard = 1%
2. EX. for 1%bp Soft we can route = 4Tbps more than with Hard

Lower Confidence Limit: $\bar{x} - 1.96\frac{\sigma}{\sqrt{n}}$

Upper Confidence Limit: $\bar{x} + 1.96\frac{\sigma}{\sqrt{n}}$

This interval of value is computed with Monte Carlo Simulation, calculating with 1000 different random demands our results 95% of times is inside this interval

Results First Fit: Continental (Bp)

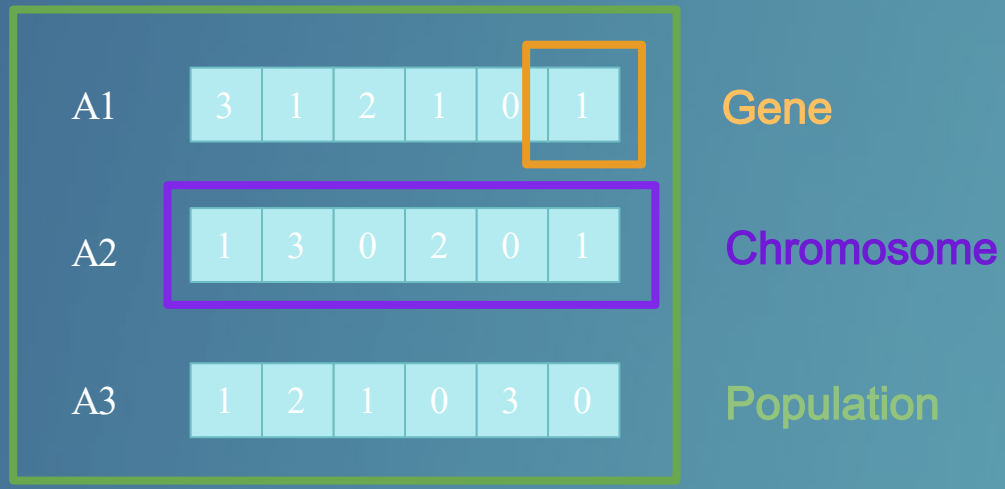


This is the comparison between the Soft Partitioning and the Hard Partitioning in the Continental Topology.

1. EX. for 95Tbps
   bp Hard,0.1 = 3,5*10^-4%
   bp Hard,0.2 = 1%
   bp Hard,0.5 = 10%

1. For the plot we can see that the lower is the border value the more traffic we can route for the same bp (not true)

Genetic Algorithm

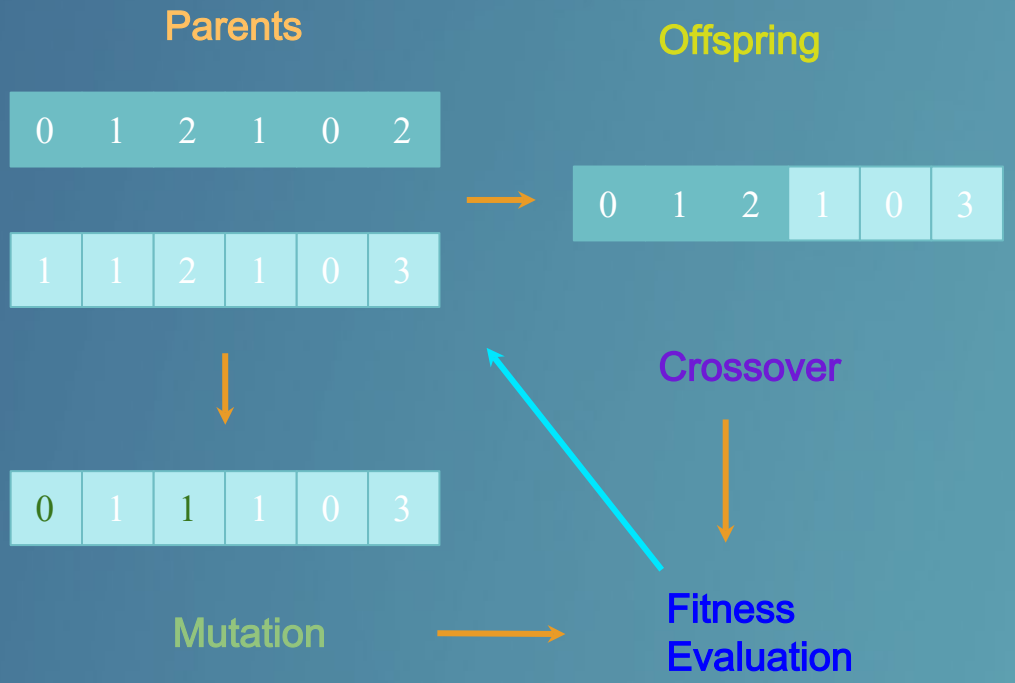


Genetic Algorithm

Is a deterministic algorithm inspired by the process of natural selection that belongs to the larger class of evolutionary algorithms (EA).

One candidate solution in Genetic Algorithm is called Chromosome.

One value of the Chromosome is called Gene.
All the calculated Chromosome are called Population.



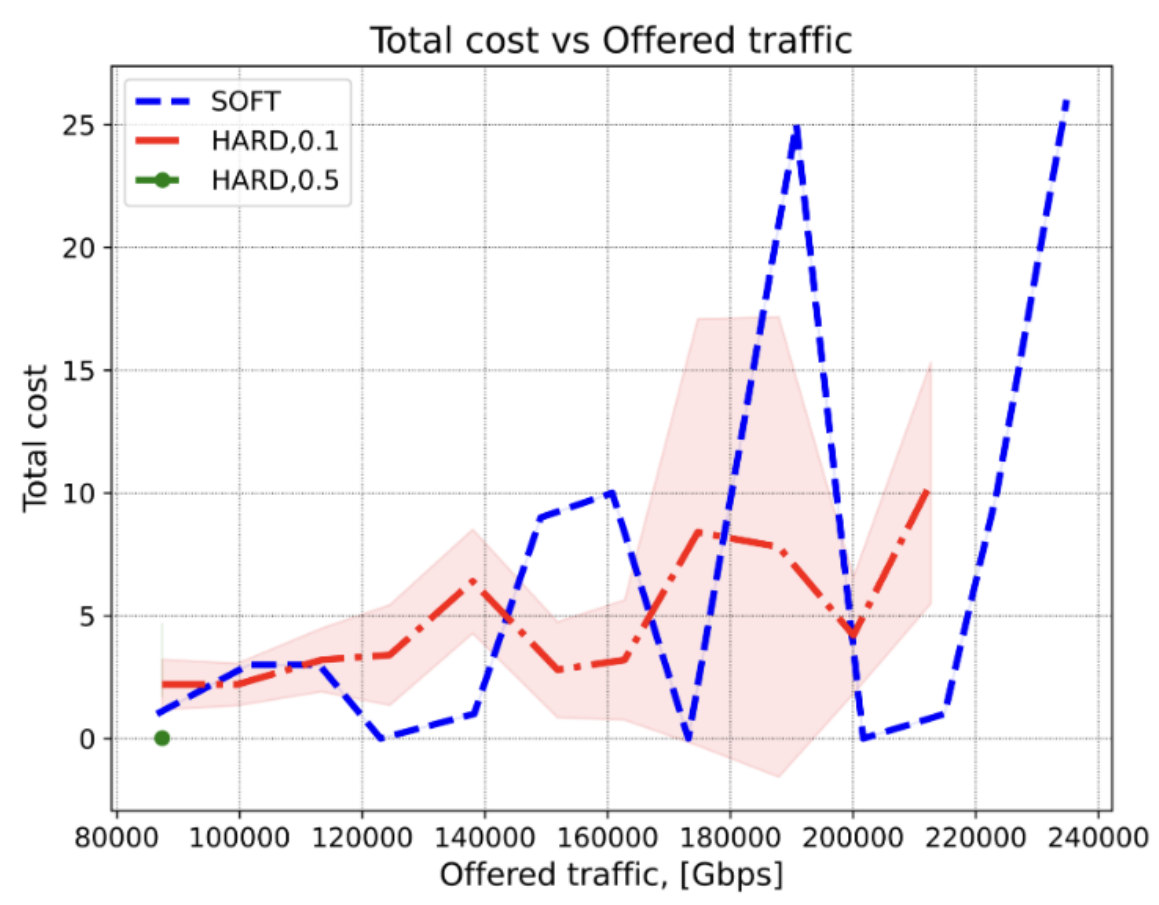
Genetic Algorithm

Genetic Algorithm take the solution using First Fit algorithm and than makes Crossover and Mutation Function.

Crossover mixes different solutions creating new candidates.
Mutation randomly changes several genes in order to adds stochasticity.

At the end evaluate the candidates and take the best ones and restart the process till the end of the tree.

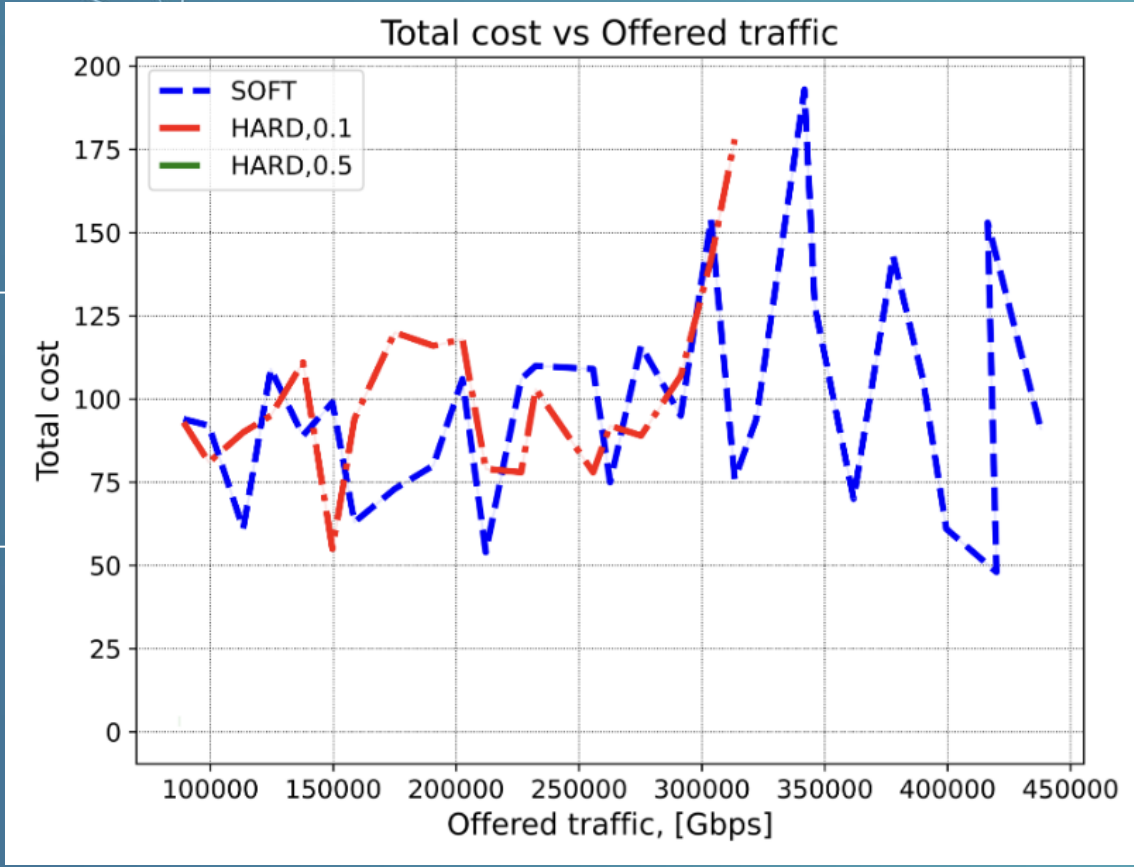
Results Genetic Algorithm : National (Cost)



This is the comparison between the Soft Partitioning and the Hard Partitioning in the National Topology.

So we can take the points as the maximum offered traffic that can be routed

Results Genetic Algorithm : Continental (Cost)



This is the comparison between the Soft Partitioning and the Hard Partitioning in the Continental Topology.

So we can take the points as the maximum offered traffic that can be routed

CONCLUSION

1. For large number of demands ILP is not computational efficient solution.
2. Hard partitioning does not influence the cost.
3. Genetic algorithm is more effective than k -SP First Fit but it requires larger amount of time to compute.
4. (~ 2 min per demand for 1000 MC vs ~ 15 min of demands for 5 MC).
5. Soft Partitioning may serve as a lower bound for the performance.
6. Finding best border values requires hyper -paramer search

POLITECNICO
MILANO 1863

UCDAVIS
COLLEGE OF ENGINEERING

THANK YOU FOR THE OPPORTUNITY

Ignazio Maria Castrignano