Genetic & Evolutionary Algorithms:
Real-World Examples

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Contents

- **Real-World Applications**
  - Time-Series Forecasting
  - Resource Allocation
  - Traveling Salesman Problem
  - Shortest Path Routing
  - Network Coding

Some Real-World Applications

Time-Series Forecasting

What Is It?

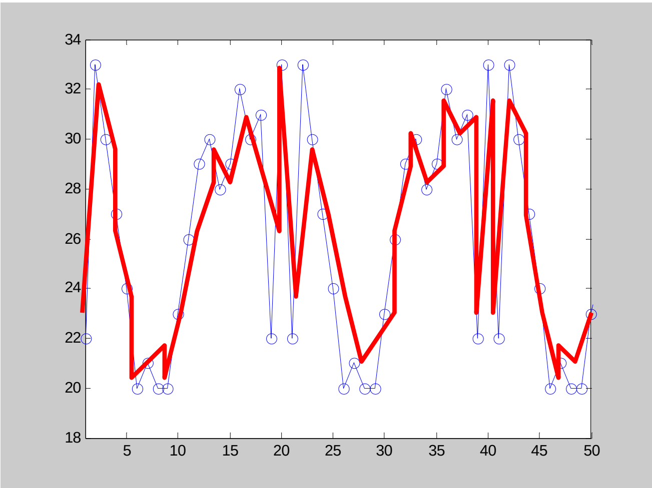
- Predicting some future outcomes from a set of historical events
- Stock prediction, Weather forecasting, Passenger prediction, etc.

Many Classical Methods Exist!

- Linear model approach: exp. smoothin… MA
- Non-linear model approach: Threshold, …

Not so efficient!

Actually, it is not like this in real-coded domain!



GAs: linear model

GA Approach:

- Using a linear-type function: i.e., Future can be represented by a linear combination of past data.

$$x_{t+1} = \alpha_t x_t + \alpha_{t-1} x_{t-1} + \alpha_{t-2} x_{t-2} + \cdots + \alpha_{t-6} x_{t-6} = \sum_{k=0}^{6} \alpha_{t-k} x_{t-k}$$

Encoding

α_t	α_{t-1}	α_{t-2}	α_{t-3}	α_{t-4}	α_{t-5}	α_{t-6}
0.83	0.57	0.25	0.92	0.23	0.41	0.55
0.51	0.13	0.46	0.19	0.88	0.76	0.83

Crossover

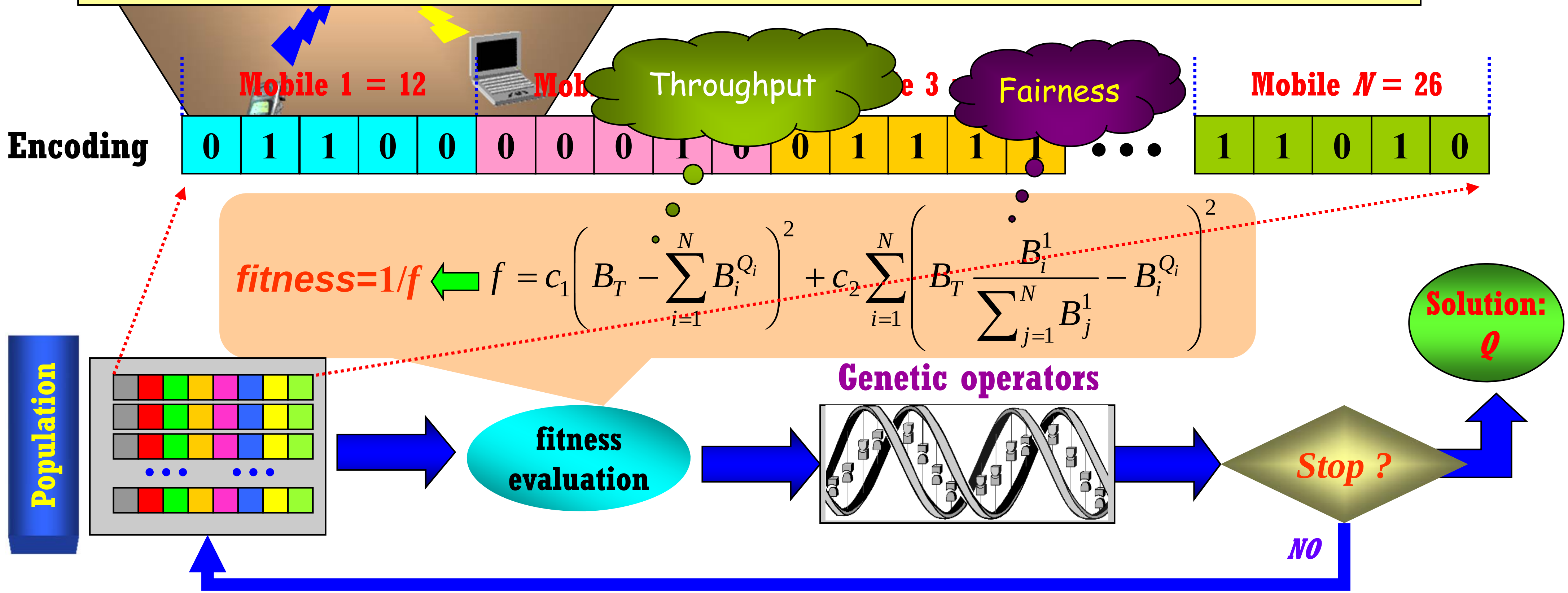
0.83	0.57	0.46	0.19	0.88	0.76	0.55
0.51	0.13	0.25	0.92	0.23	0.41	0.83

Mutation

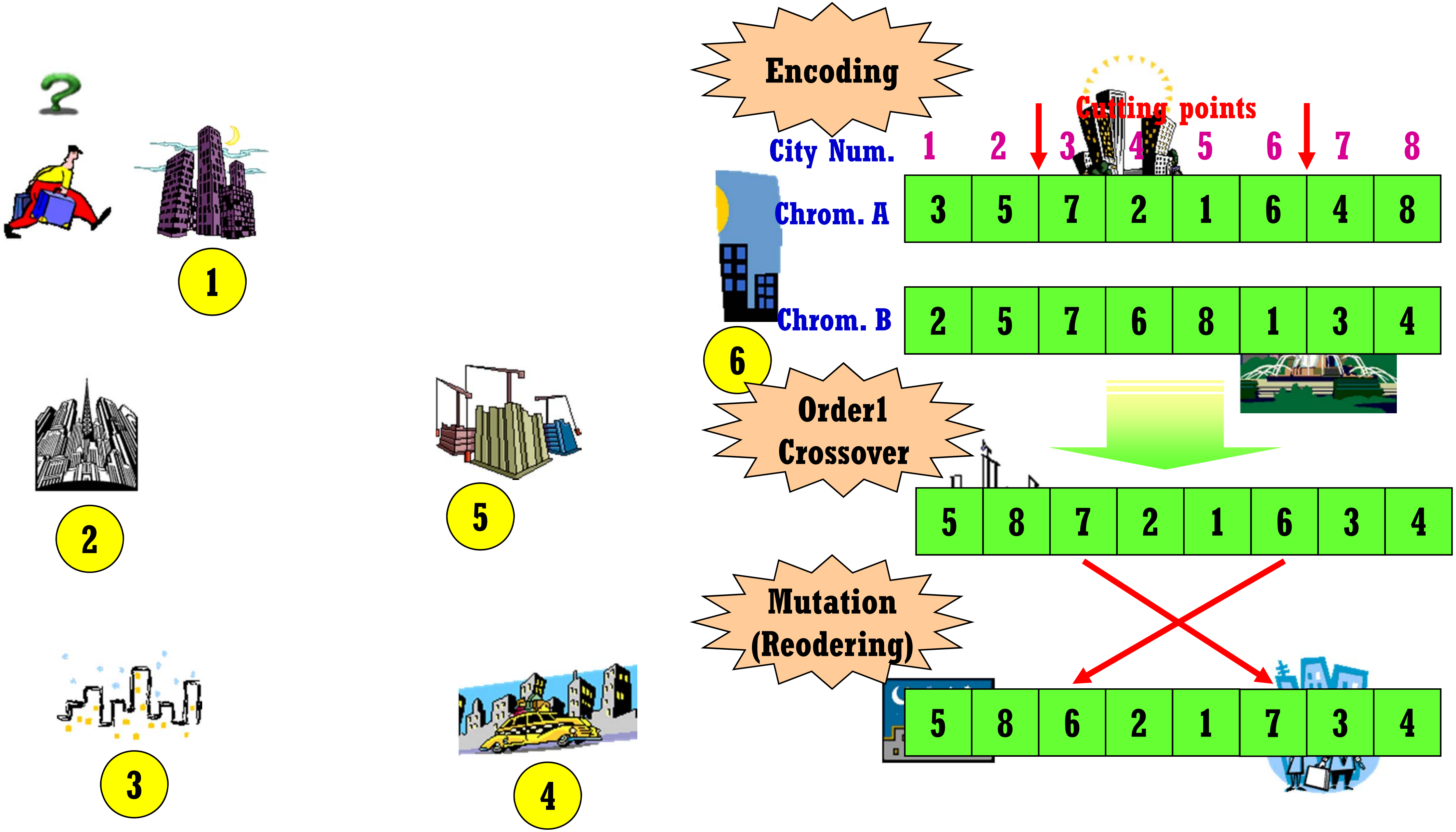
0.51	0.13	0.25	0.92	0.16	0.41	0.83

Resource Allocation

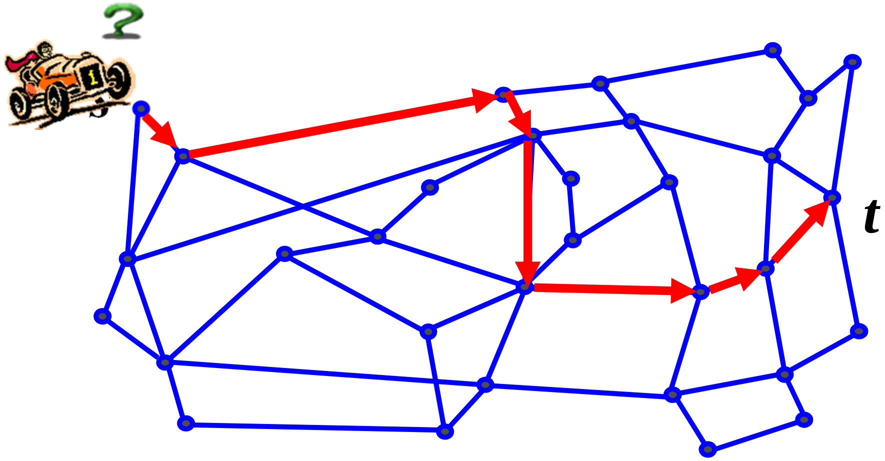
QoS Index	1	2	…	14	15	…	26	27
Video	High	High	…	Mid.	Mid.	…	Low	Low
Audio	High	High	…	Mid.	Mid.	…	Low	Low
Data	High	Mid.	…	Mid.	Low	…	Mid.	Low



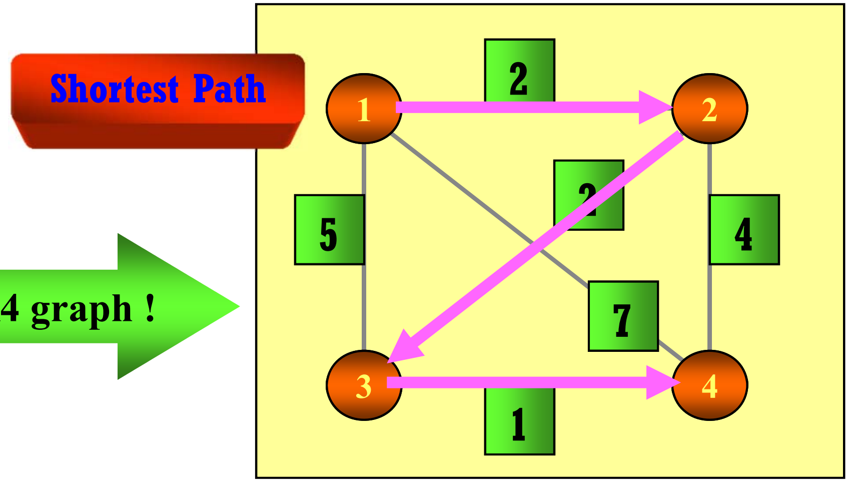
Traveling Salesman Problem

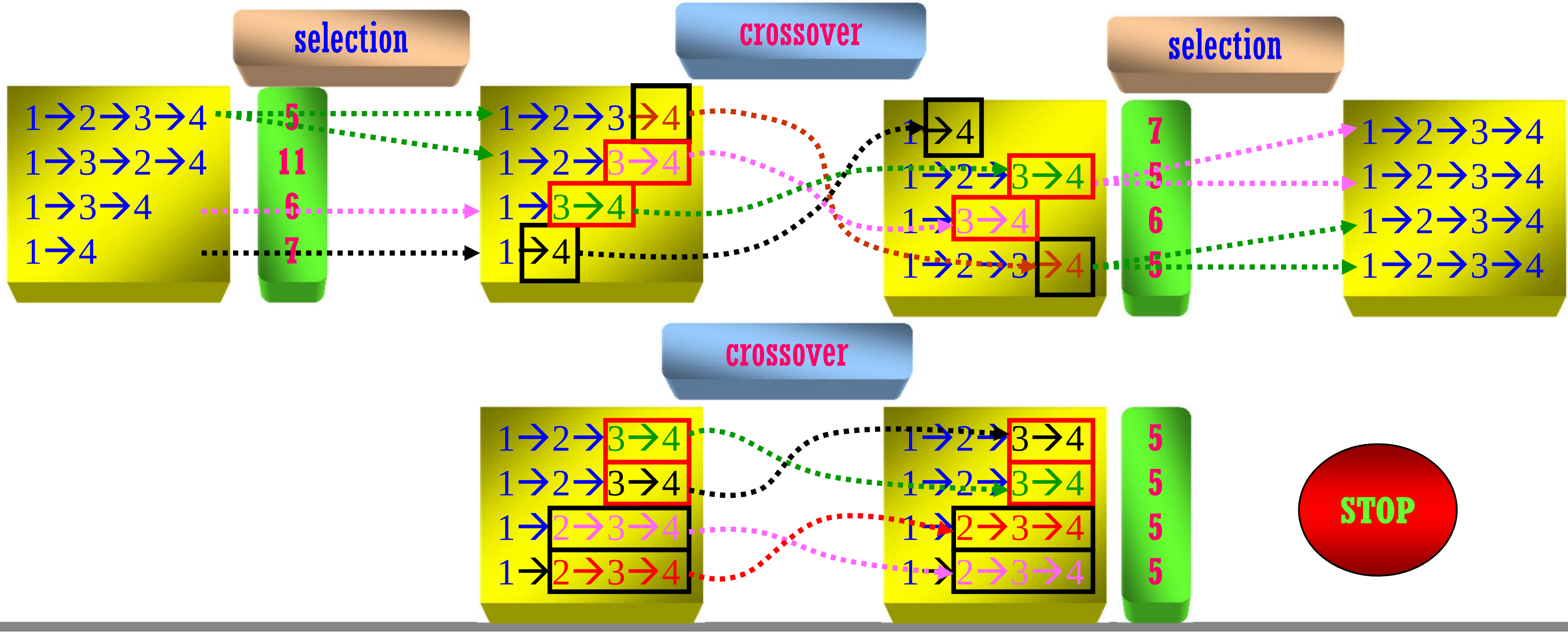


Shortest Path Routing



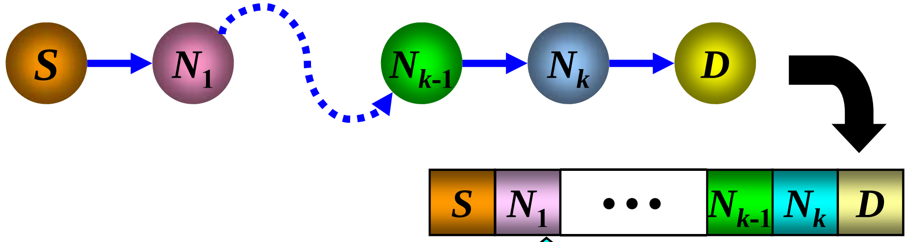
Consider a K4 graph !



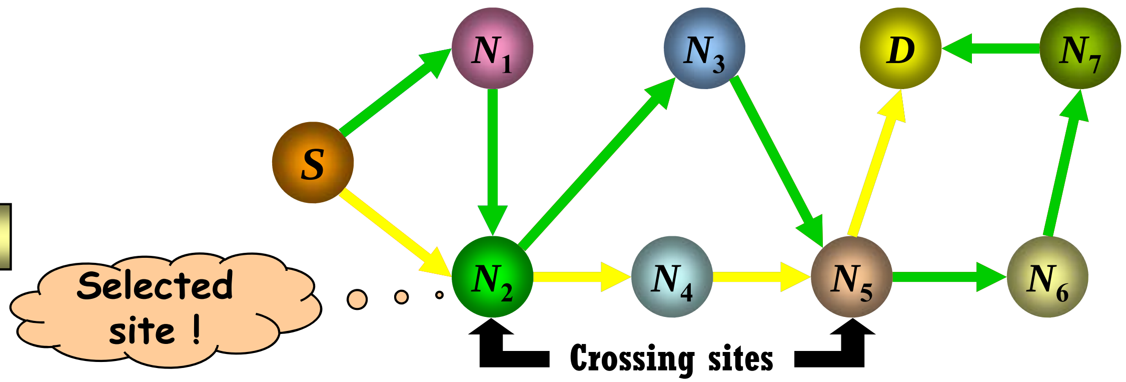


Unicast Routing

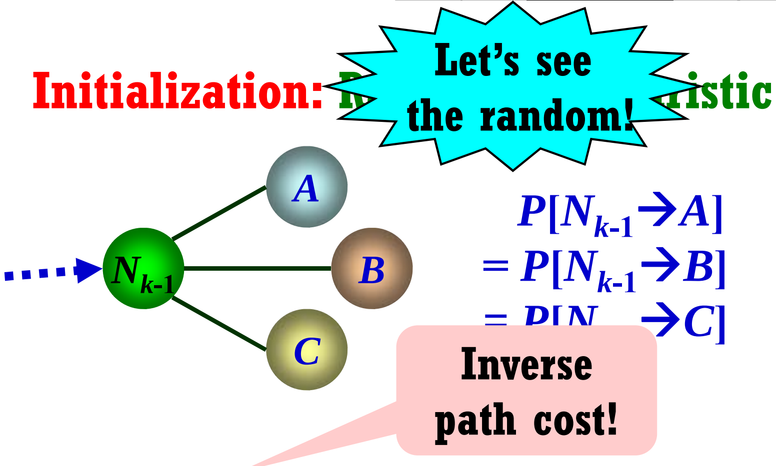
Representation: X-ary encoding



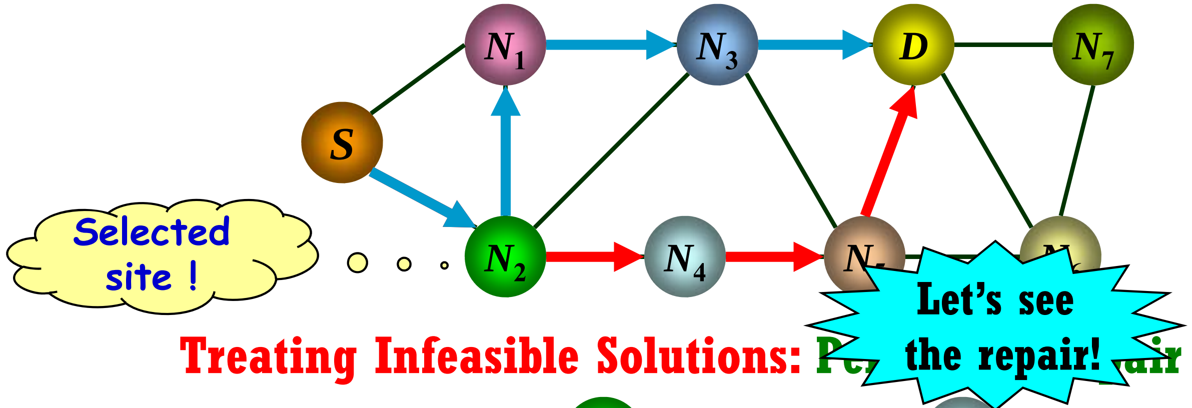
Crossover: Single-point



Initialization: **istic**



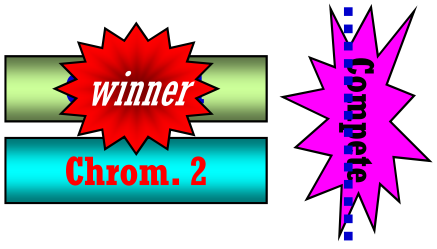
Mutation: Perturbation

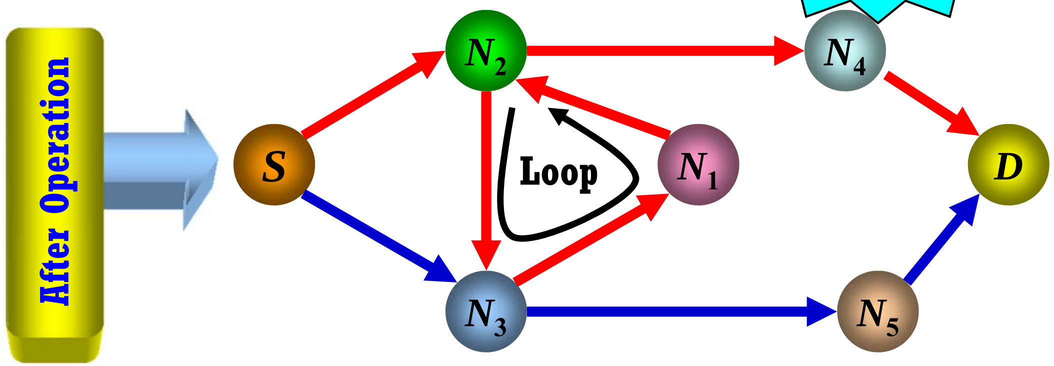


Fitness $F_i=[\sum C(g_i(j),g_i(j+1))]^{-1}$

Treating Infeasible Solutions: Re ir

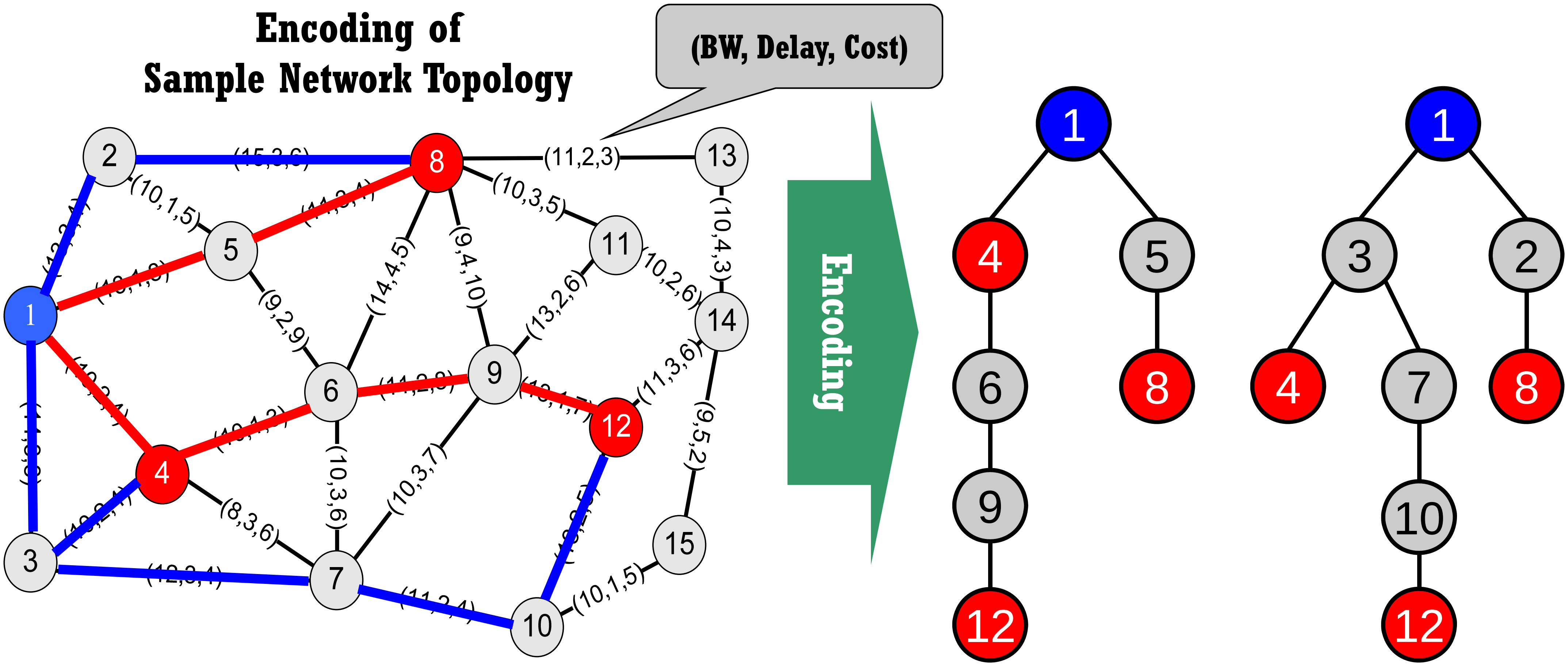
Selection: Tournament Selection





Multicast Routing (1/3)

Encoding of Sample Network Topology



minimize a multicast tree cost
s.t. B_{req}=10 for each link
& D_{req}=10 for each path

Path	D_T
1→4	2
1 →5 →8	4
1 →4 →6 →9 →12	6

Path	D_T
1→3 →4	5
1 →2 →8	6
1 →3 →7 →10 →12	10

Multicast Routing (2/3)

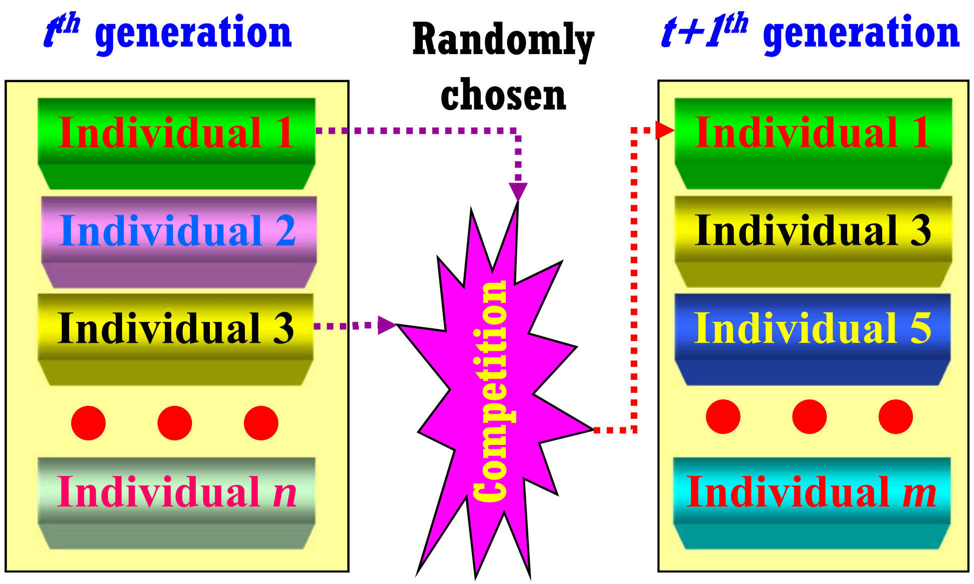
- **Fitness Function**

$$F(h_k) = [C_{T_k}]^{-1} = \left[\sum_{\{i,j|e_{ij} \in T_k\}} C_{ij} \right]^{-1}$$

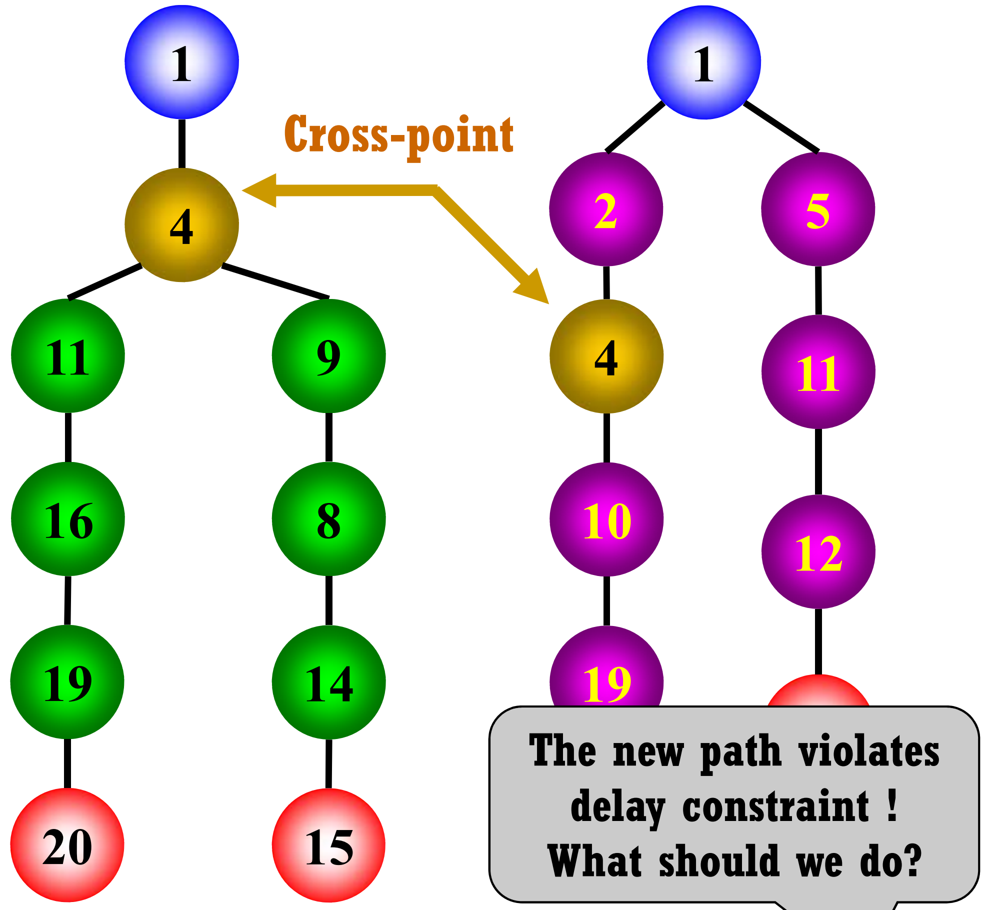
h_k : *Chromosome* $\quad$ T_k : *Multicast Tree*

C_{T_k} : *Sum of link cost of* T_k

- **Tournament Selection**



- **Crossover: Partial-tree exchange**

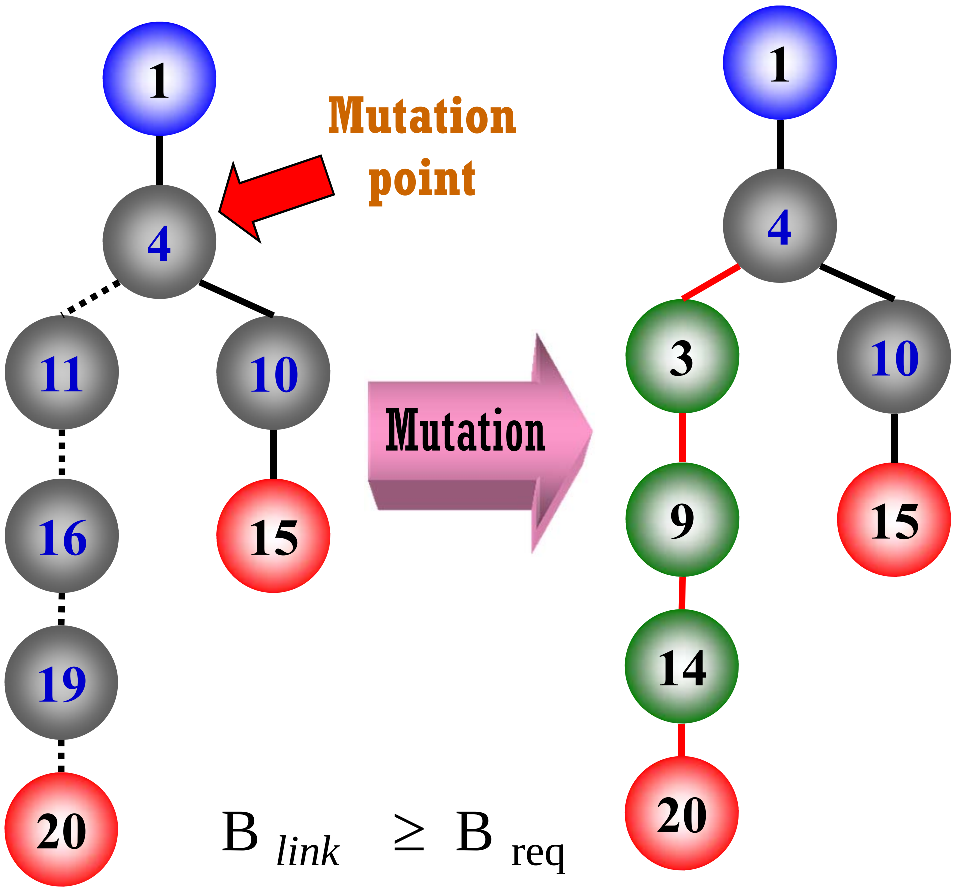


Paths	Sub_D_T
1→4	2
4 →11 →16 →19 →20	8

Paths	Sub_D_T
1→2 → 4	4
4 →10 →19 →20	6

Multicast Routing (3/3)

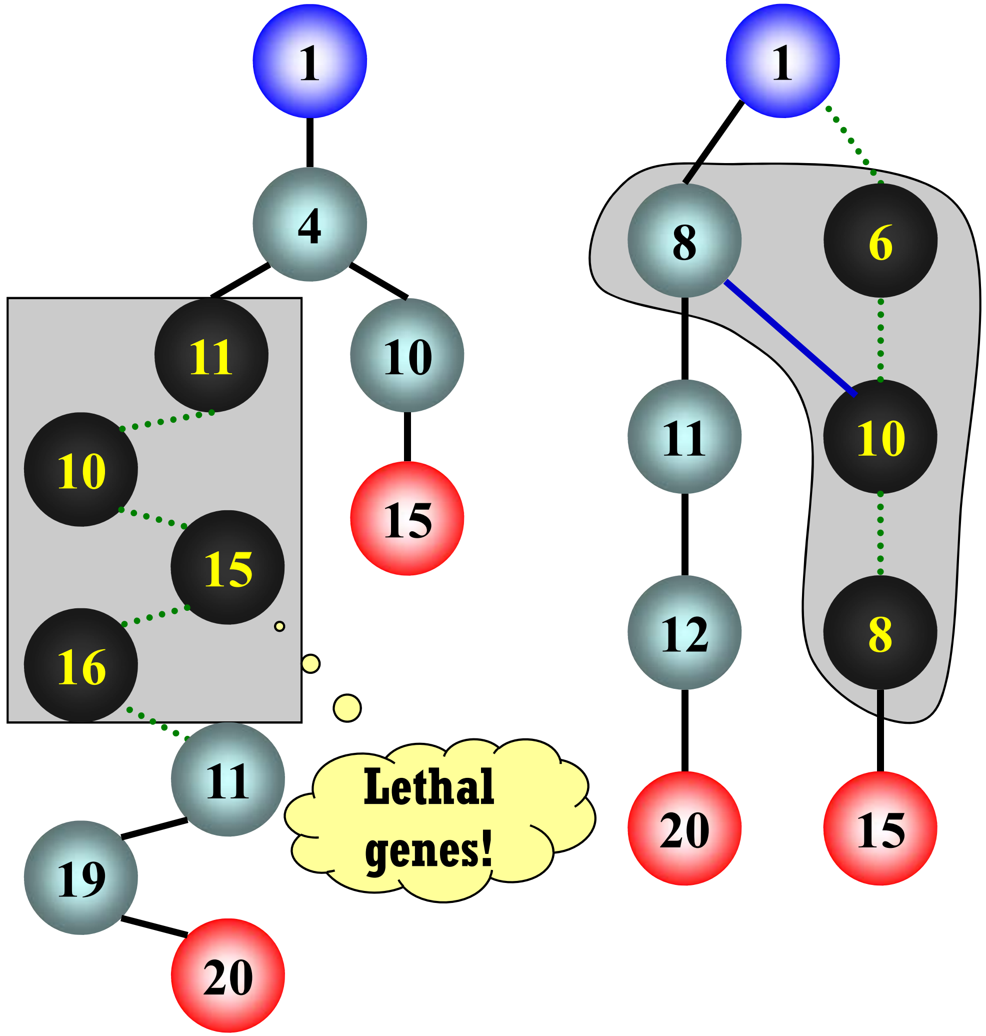
- **Mutation:**
  - New partial-tree replacement



$$B_{link} \geq B_{req}$$

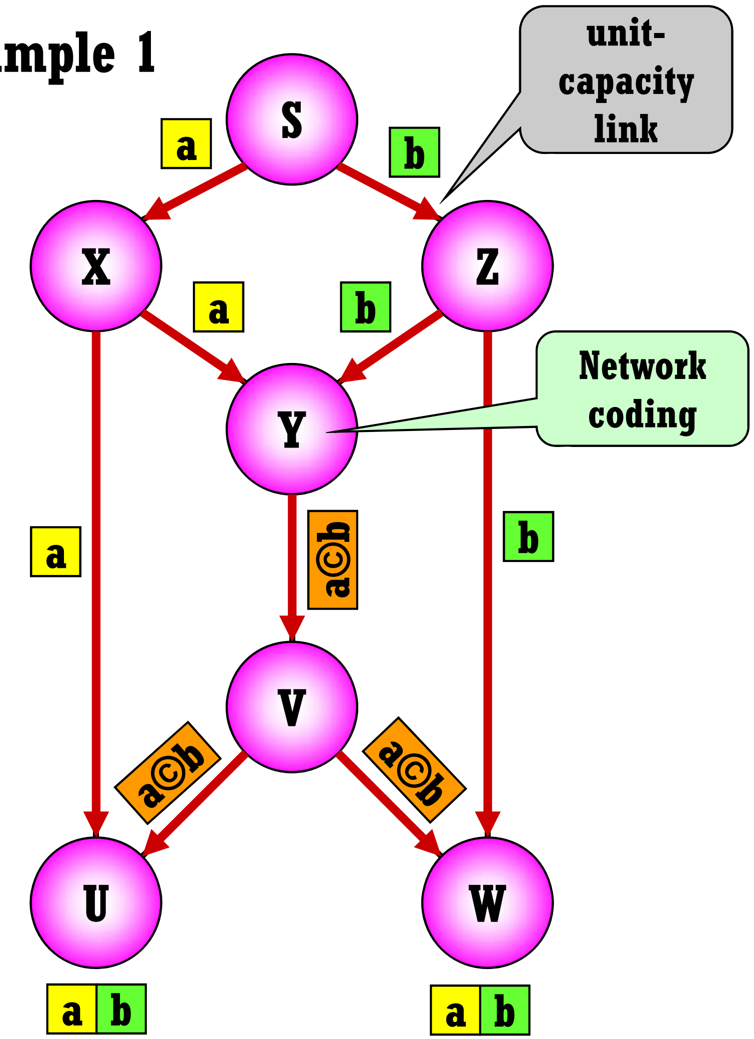
$$D_T \leq D_{req}$$

- **Repair Function**
  - Lethal genes are cured.



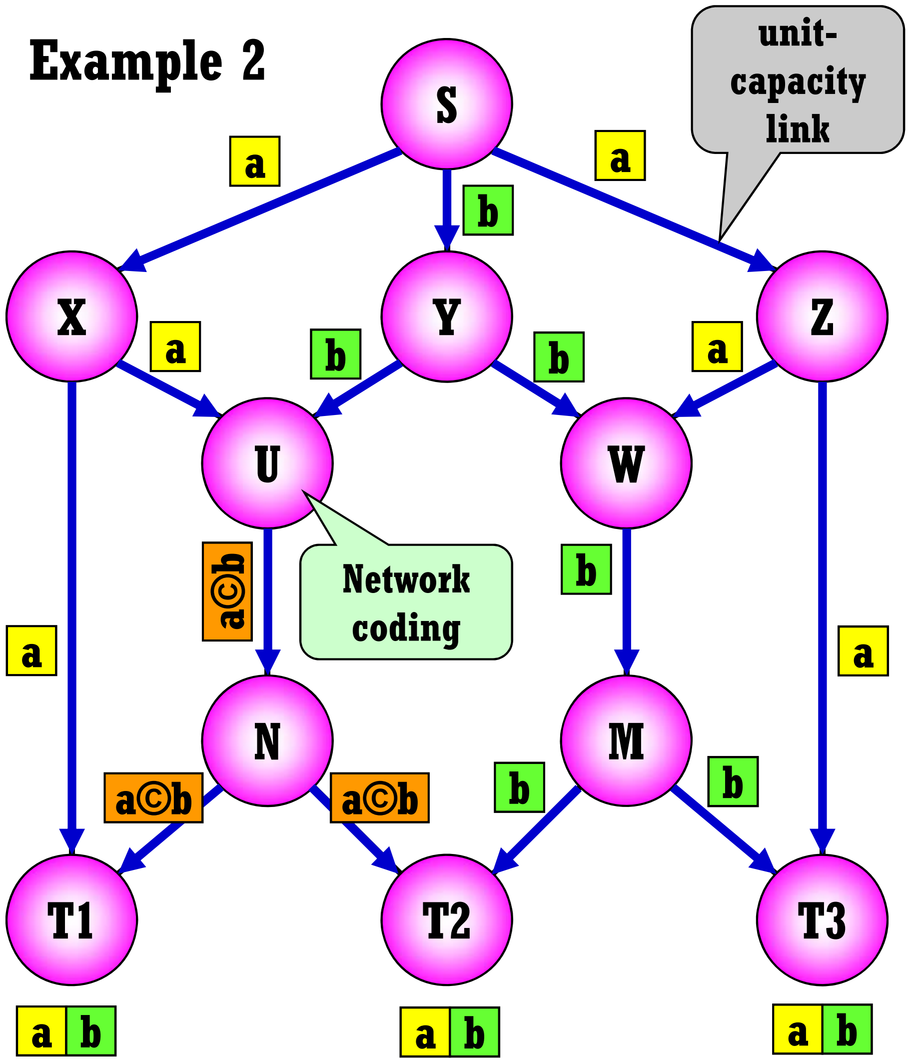
Network Coding: Examples

Example 1



- Sink nodes U and W receive data at rate 2 with a certain operation at node Y!
- It is impossible by conventional routing schemes.

Example 2



- Every sinks receive data at rate 2 by network coding!
- But, it is impossible by extant broadcasting scheme.

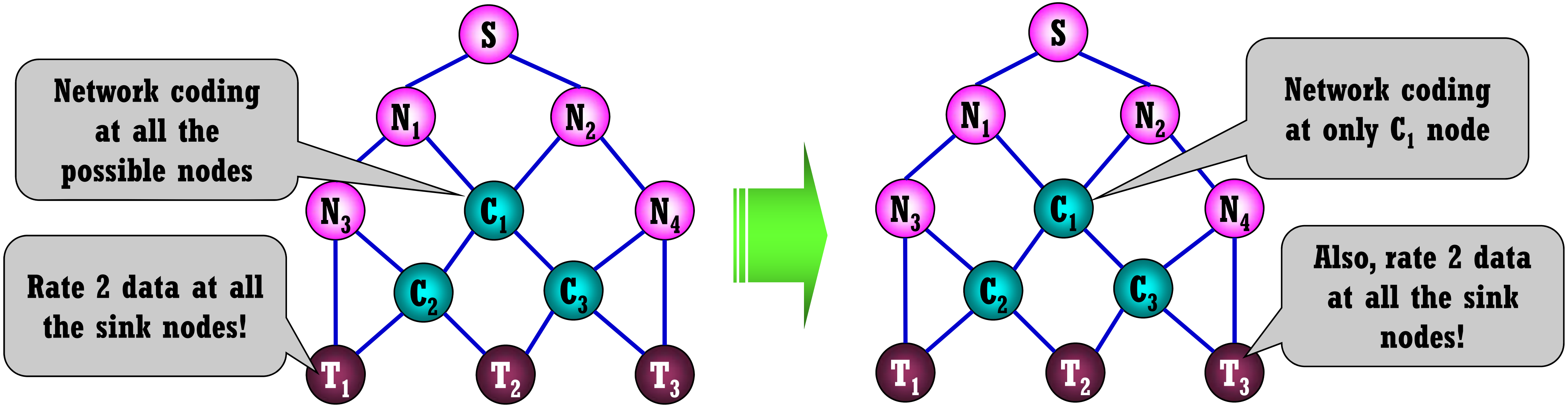
➔ Network coding would be very important quite soon!

Network Coding: Formulation

- **Observation**
  1. Generally, network coding is done at all possible nodes
  2. But, possible to achieve the target throughput by coding only at a subset
     - Save computational cost or Reduce the number of routers

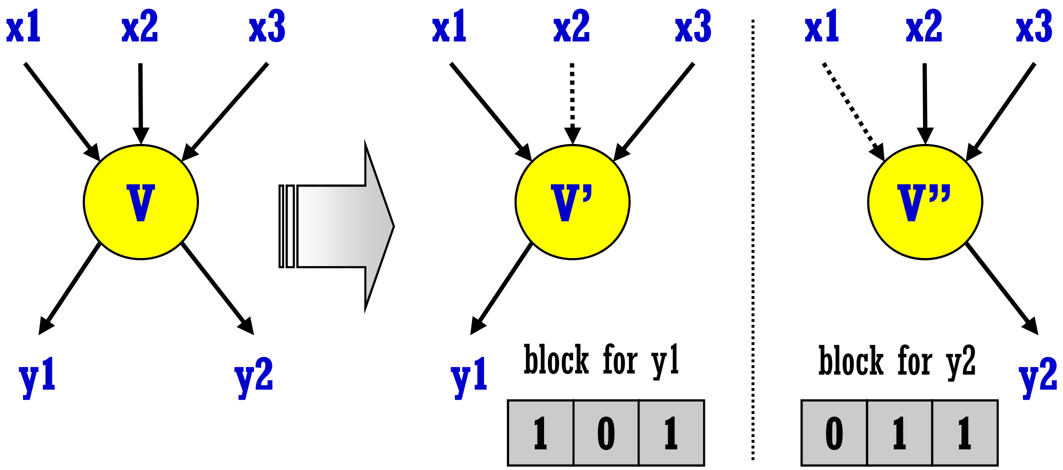
- **Formulation**
  1. Task: Determining the minimal set of coding nodes ➔ NP-hard
  2. Basically, network coding is done at outgoing links of nodes
  3. Objective: Minimizing the number of coding links

     Subject to: Transmitting data at the target rate from a source to a set of sinks



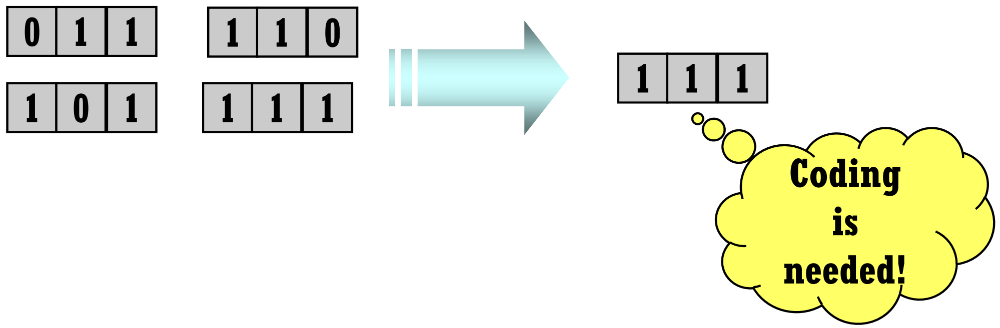
Network Coding: GA Approach

Encoding: active/inactive link → '1'/'0'



Search space reduction:

- Tow or more '1' means that network coding is required

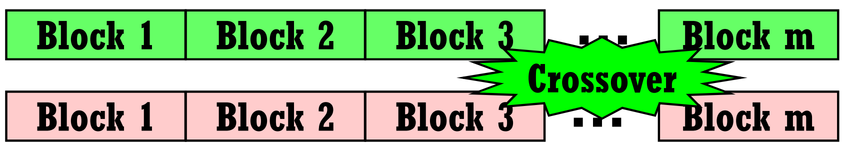


Fitness: Assigned by a simple method

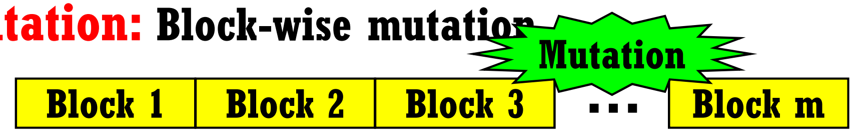
- with the number of coding links which means the number of all '1' blocks

$$f(X) = \begin{cases} \#\textit{coding links}, & \text{if } X \text{ is feasible} \\ \infty, & \text{if } X \text{ is infeasible} \end{cases}$$

Crossover: Block-wise crossover



Mutation: Block-wise mutation



Critical Points (from the simple fitness rule)

1. A large tournament size is necessary.
   (But, it is not properly decided in advance)
2. A single initial feasible solution is required.
   (It isn't a big deal, but very important here!)