Automatic Analysis, Decomposition and Parallel Optimization of Large Homogeneous Networks

D. Ignatov, A. Filippov, A. Ignatov, X. Zhang

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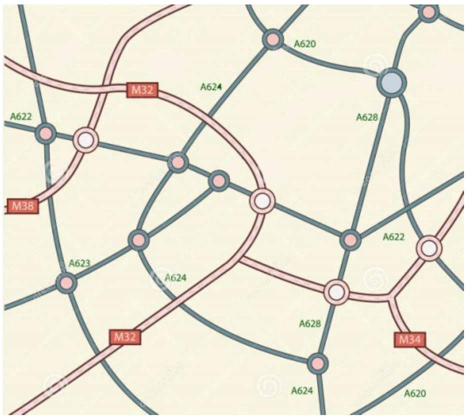
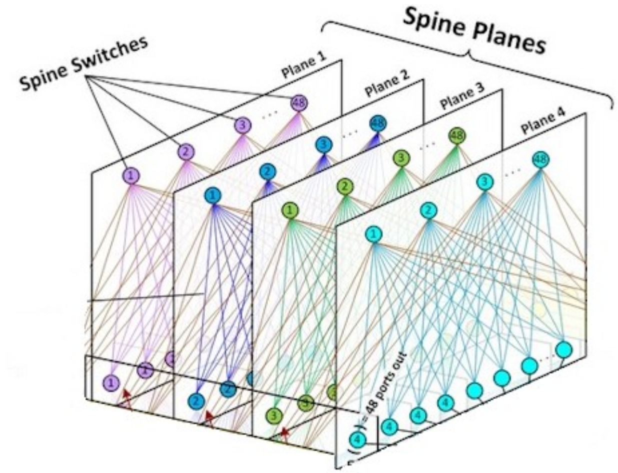
Homogeneous Networks

Communication Networks

Road network

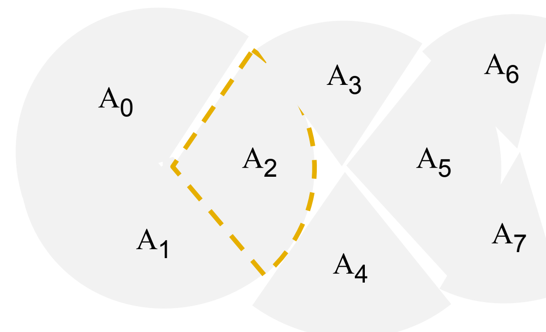


Wired



Wireless

Signals of sector antennas A_0 – A_7



Element	Crossroad	Switch	Antenna
Optimized integral index	Average speed of traffic		Average power of prevalent radio signal
Correlation formula for 2 elements	1 / (1 + [elements quantity on the shortest path])		1 / (distance between antennas)

Background: Sector Planning with full optimization

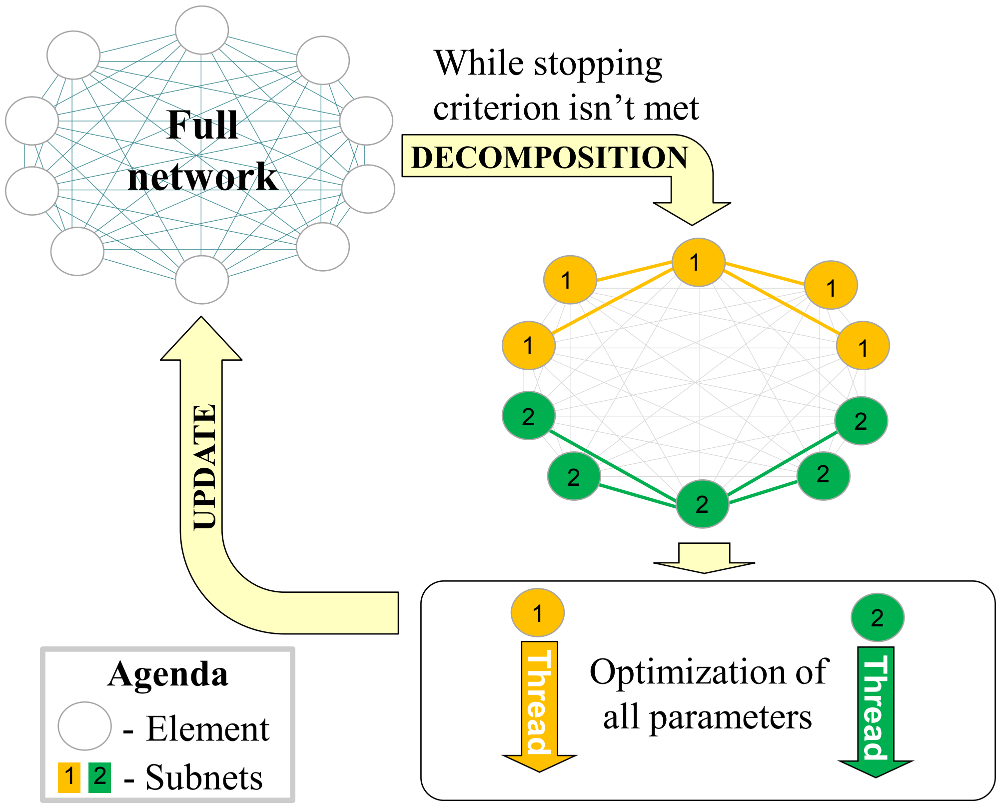
Graph-based representation

Homogeneous network is represented as a weighted complete graph, where

- each vertex corresponds to network element
- each edge has weight equals to correlation between correspondent elements

Optimization loop:

1. Decomposition of network into subnets by the rule of minimal sum of crossing edges weights
2. Parallel optimization of subnets
3. Update of network parameters

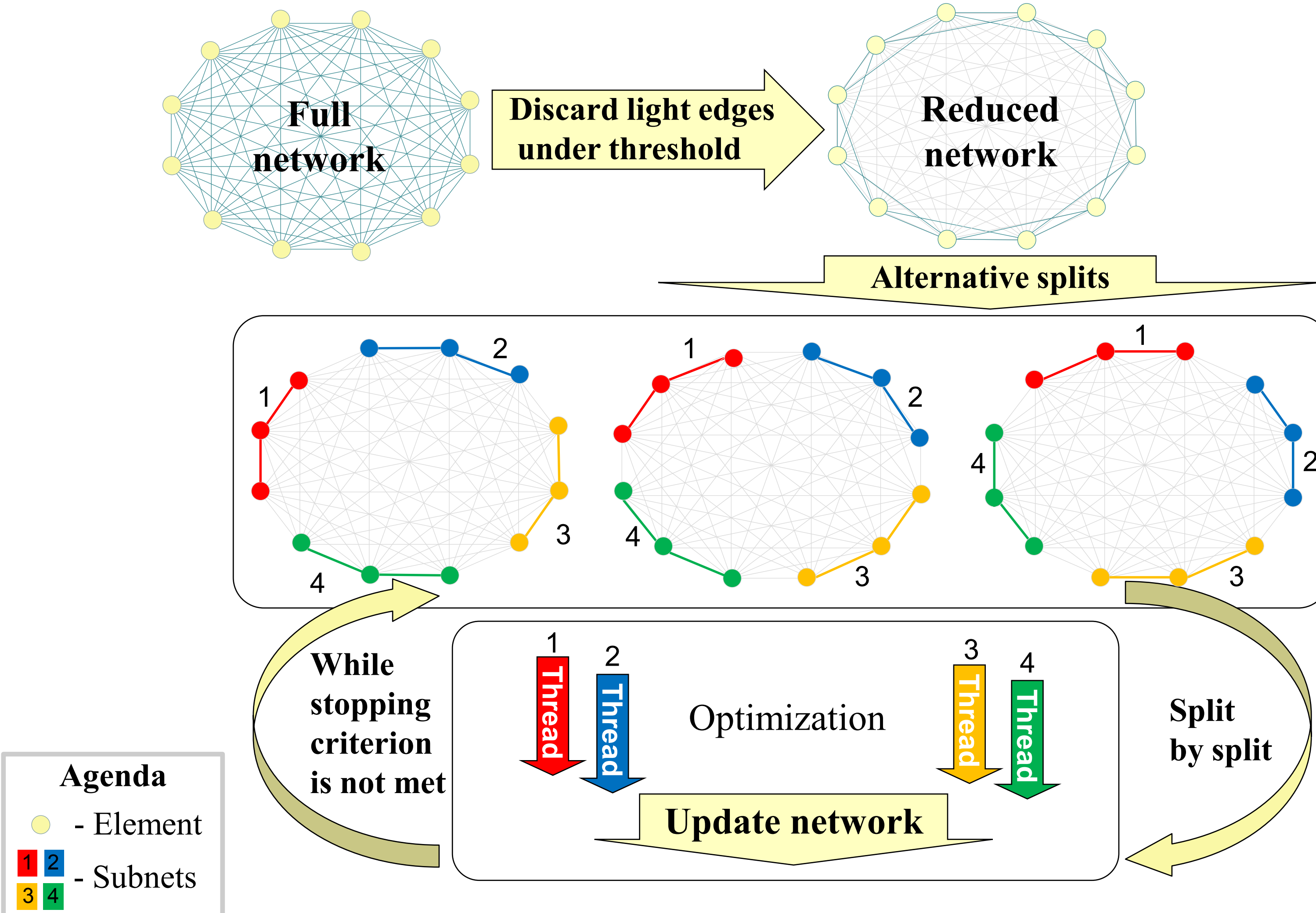


Main drawback:

Crossing edges are ignored

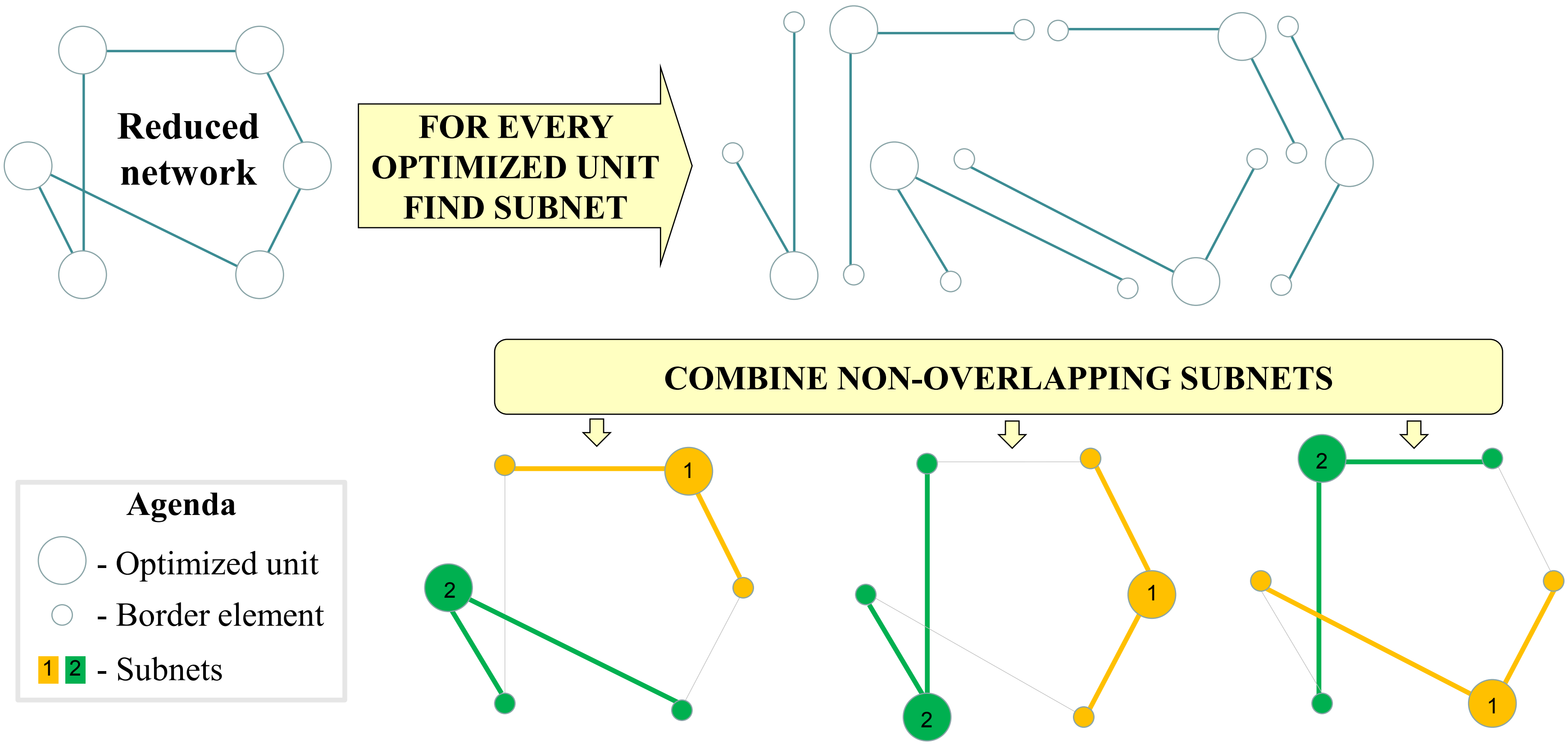
=> poor accuracy

Idea 1: Alternative splitting



Advantage: All crossing edges are taken into account

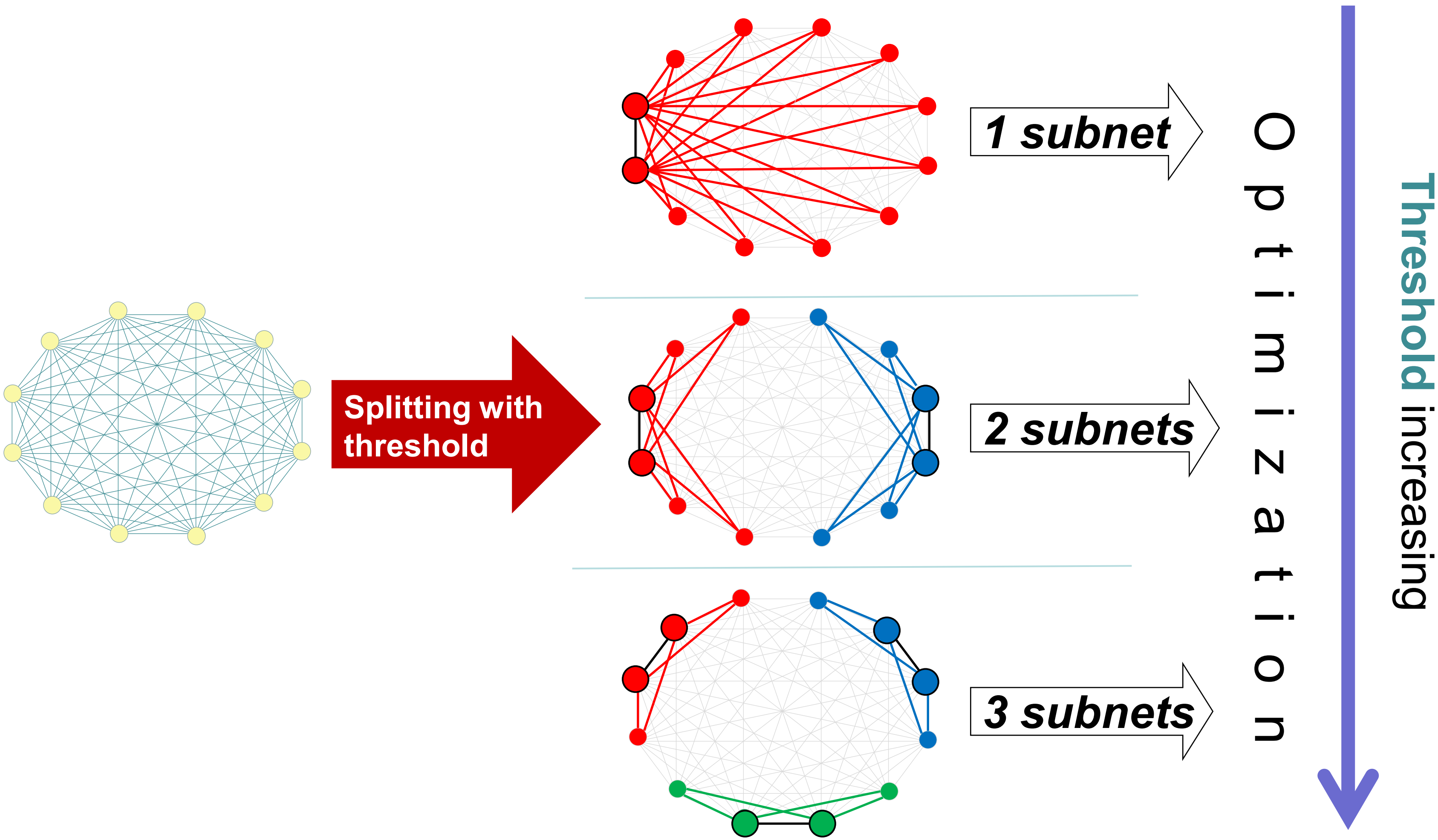
Idea 2: Independent optimization



Advantage: Parallel optimization of the fully independent elements

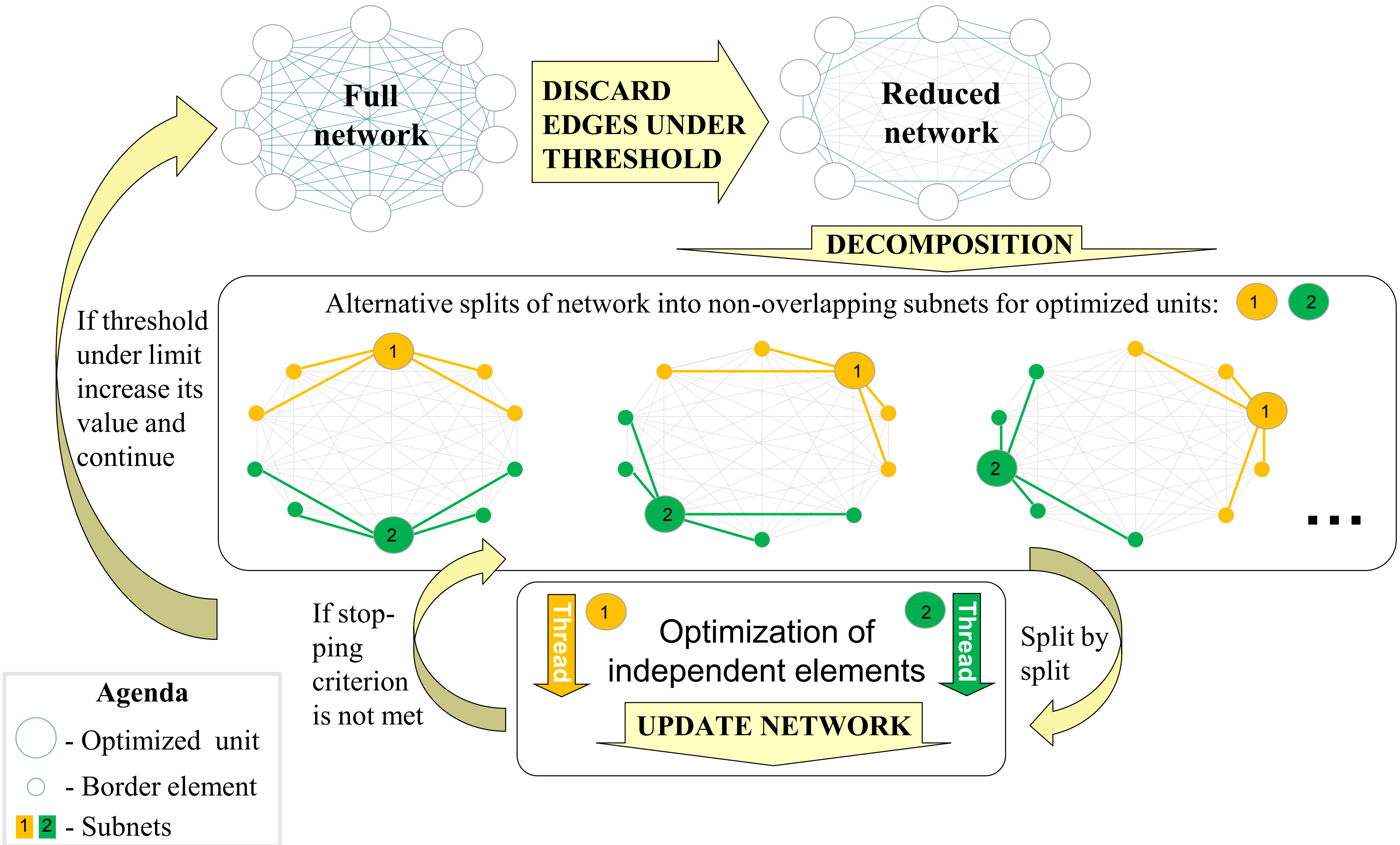
Idea 3: Regulation of threshold

Optimized unit = 2 elements (one split)

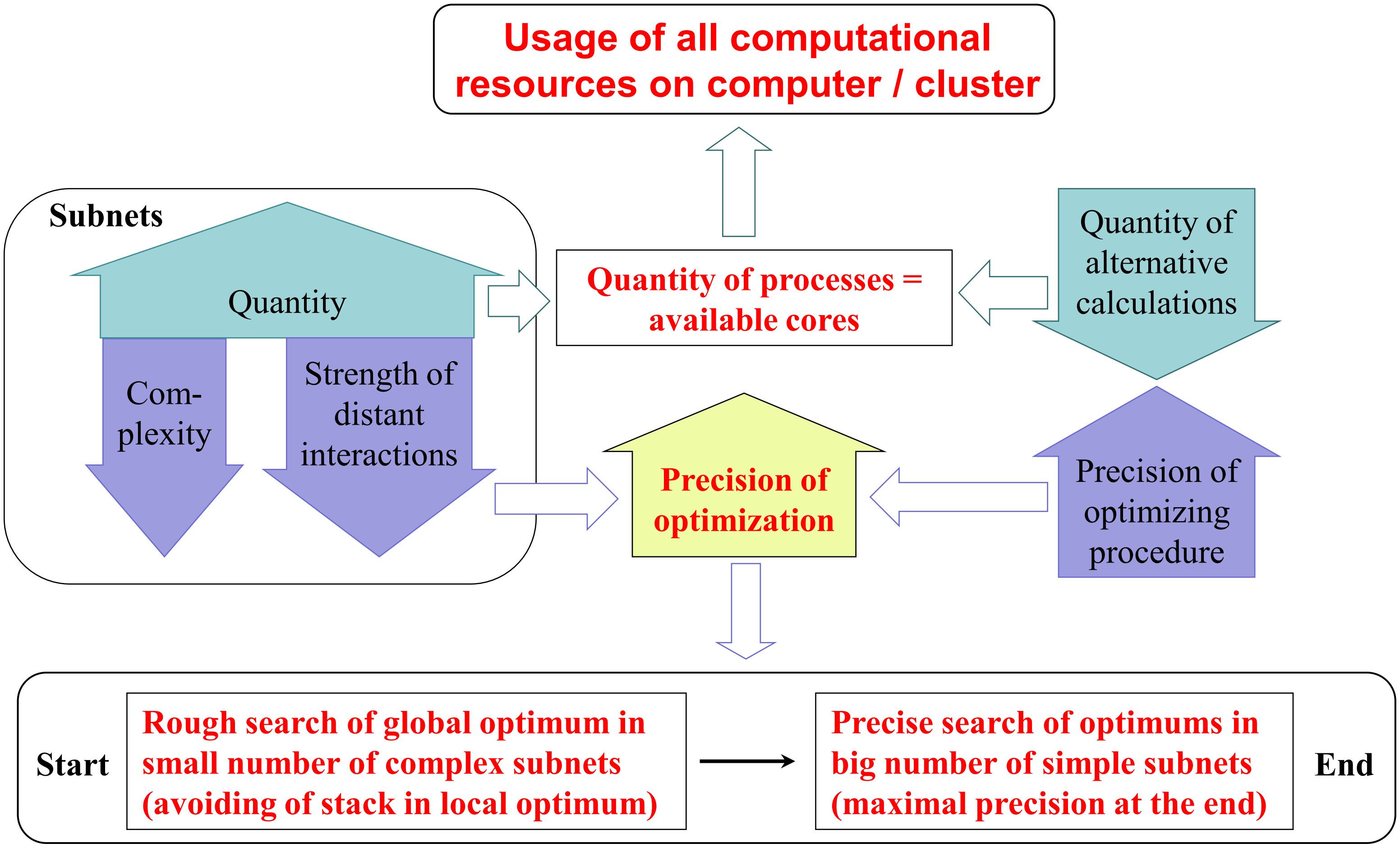


Advantage: Optimization process is regulated by threshold

Full cycle of alternative splitting with regulated threshold

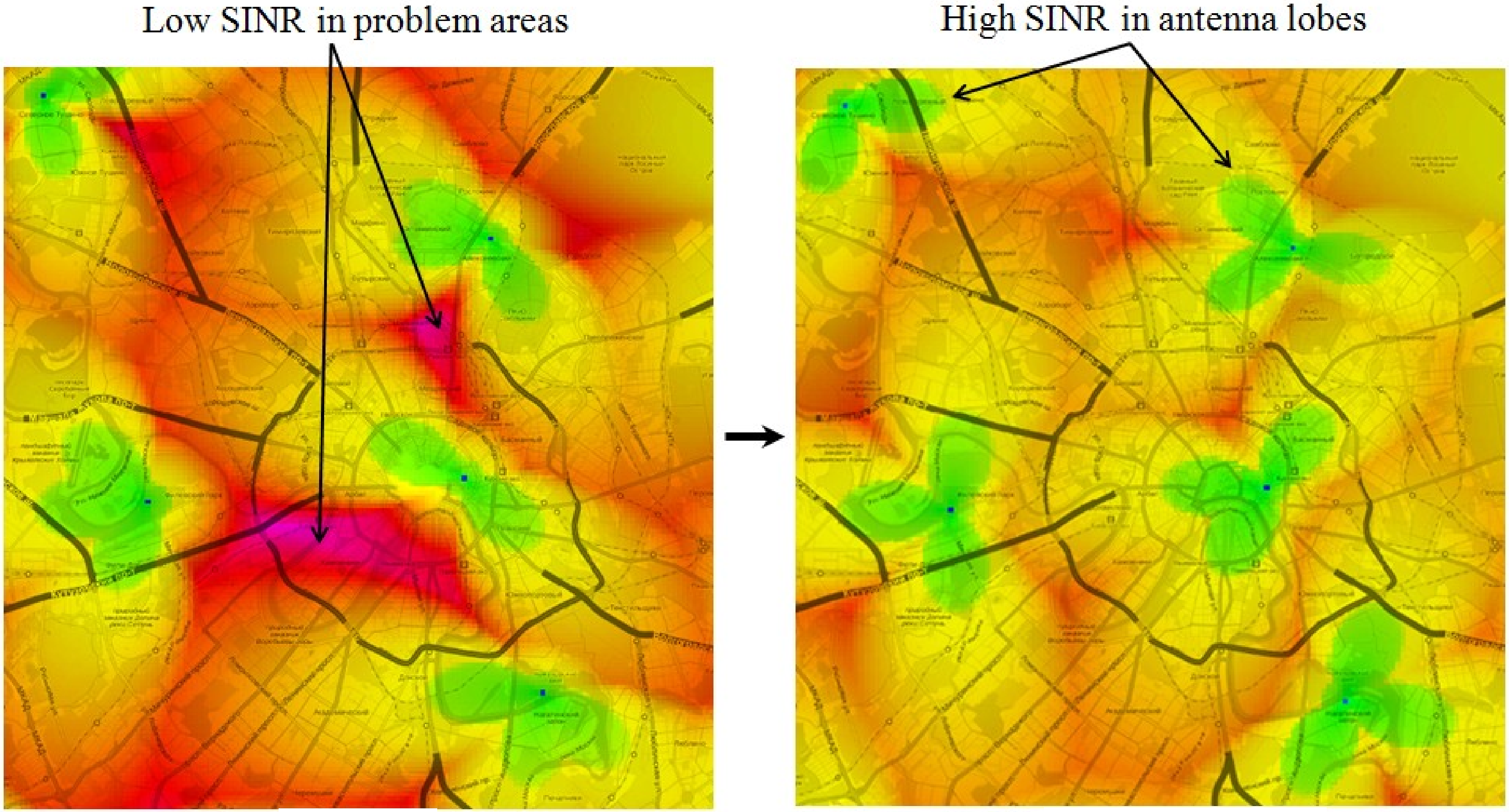


Optimization process regulation



Vertical colored (■ ■ ■) arrows – increase (up) or decrease (down) of parameter value
Empty arrows – impact on optimization process

Optimization of mobile network coverage and quality



Initial

Optimized

Regulated parameters of sector antenna: power, height, tilt, azimuth

High optimization complexity: 300 antennas * 4 parameters, n states of parameter => n^{1200} states

Alternative splitting vs. Sector planning

Optimized integral index – average Signal to Interference plus Noise Ratio:

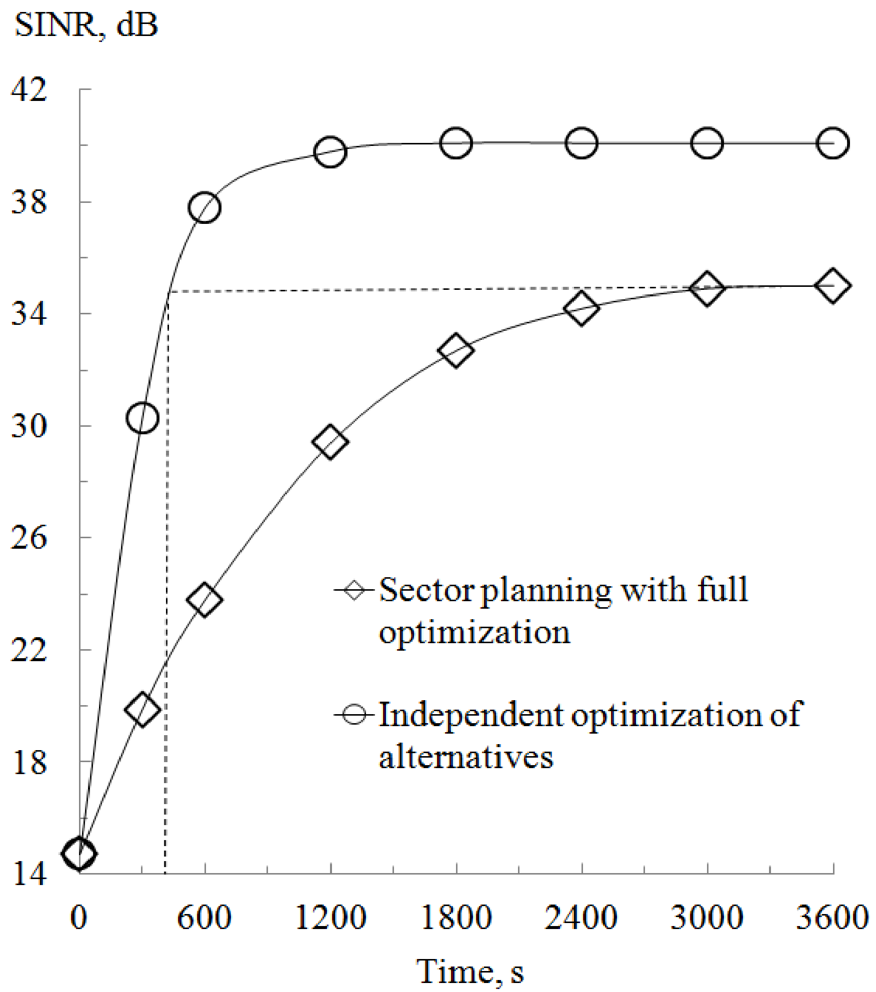
$$SINR = \log\left(\frac{1}{n}\sum_{i=1}^{n}\frac{P}{I+N}\right)$$

n – number of optimized areas in network
P – the power of the prevalent signal
I – the power of the other (interfering) signals
N – other noise

Optimizing procedure – modified Simulated Annealing:

procedure optimize(S_0, **precision**) {
  $S_{new} := S_0$
  step := **maxStep** * (1 – **precision**)
  S_{gen} := random neighbor of S_0 within **step**
  t := T (1 – **precision**)
  if $A(E(S_0), E(S_{gen}), t) \geq$ random(0, 1) then $S_{new} := S_{gen}$
  Output: state S_{new}
}

S_0, S_{gen}, S_{new} – current, generated, new states of subnet
maxStep – maximal value of step
T, E, A – temperature, energy, acceptance functions



9 times faster

1 hour – SINR 15 % higher ($p < 0.01$)

Benefits of Independent optimization of alternatives

- Faster optimization due to reduction of optimization complexity and efficient usage of all computational resources

- Better quality of optimization due to progressive shift of optimization strategy from rough search of global optimum at the beginning of optimization process to precise search of optimum at the end of optimization

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