

# Development of Software for Modelling Decentralized Intelligent Systems for Security Monitoring and Control in Power Systems

Программная реализация интеллектуальной  
системы для предотвращения крупных аварий в  
энергосистемах

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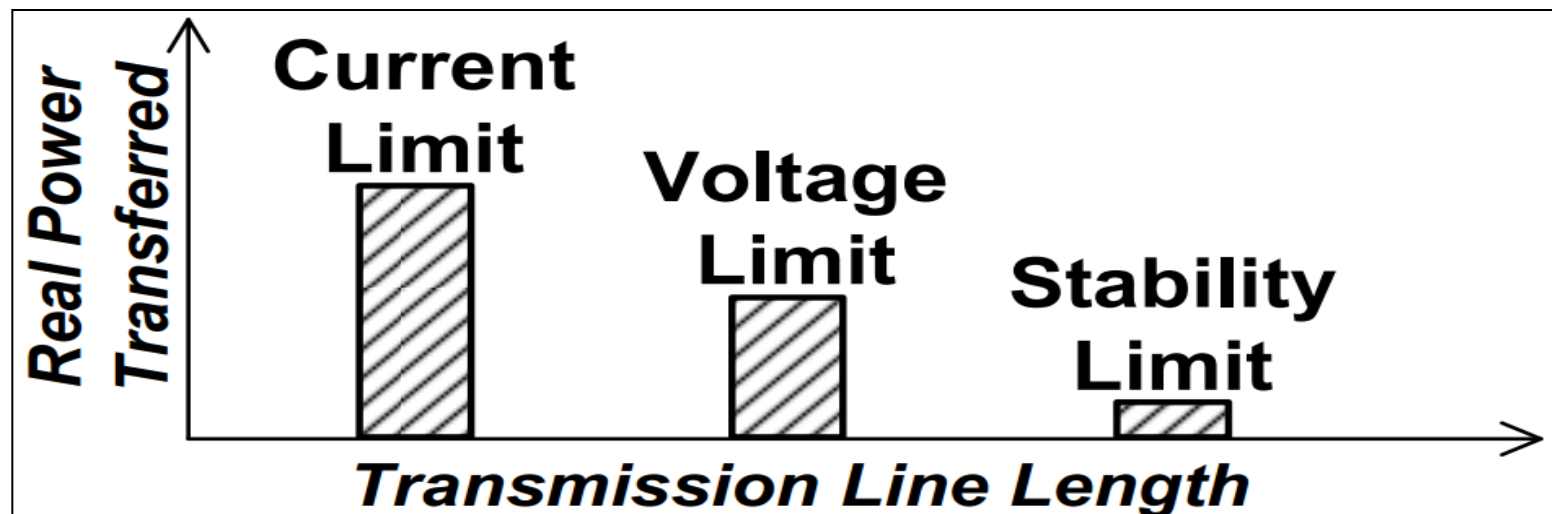
## New challenges

Software for Modelling Decentralized Intelligent Systems for Security Monitoring and Control in Power Systems

Why do we need **decentralized intelligent systems** for security monitoring and **control** in power systems? For instance, in EPS of Russia?

# Limits and structural features of EPS

- The predominance of a particular restriction is directly related to the structural features of the considered EPS.
- The current limit and voltage limit are crucial in systems with complex multi-loop structure with average length lines (industrial centers, megacities, EPS in many developing countries, **western EPS**).
- Angular stability (parallel operation) is the main limiting factor for extended EPS with long length lines (**EPS of Russia**).



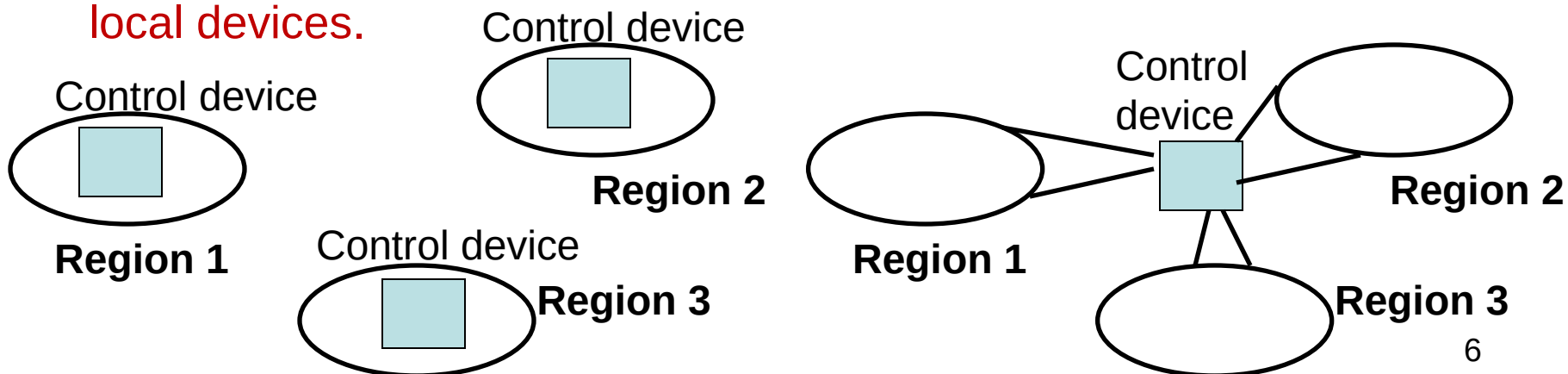


# Possible future of the EPS of Russia

- The development of the Russian economy leads to the formation of large industrial and business centers with complex multi-loop structure with average length lines (**voltage and current limits**).
- We can expect that in the near future the emergencies in the EPS of megacities and large industrial centers of Russia will be on scenario where **the determining factors are voltage stability and current limits but not angular stability**.
- **Our monitoring and emergency control systems must be prepared.** But what exactly they (monitoring and emergency control systems) must be prepared?
- To answer this question it is necessary to understand what disadvantages of western emergency control systems caused most blackouts during the last several decades.
- Further in this report we will analyze in detail only emergency control systems, it is because the disadvantages of monitoring systems are more obvious.

# Disadvantages of emergency control

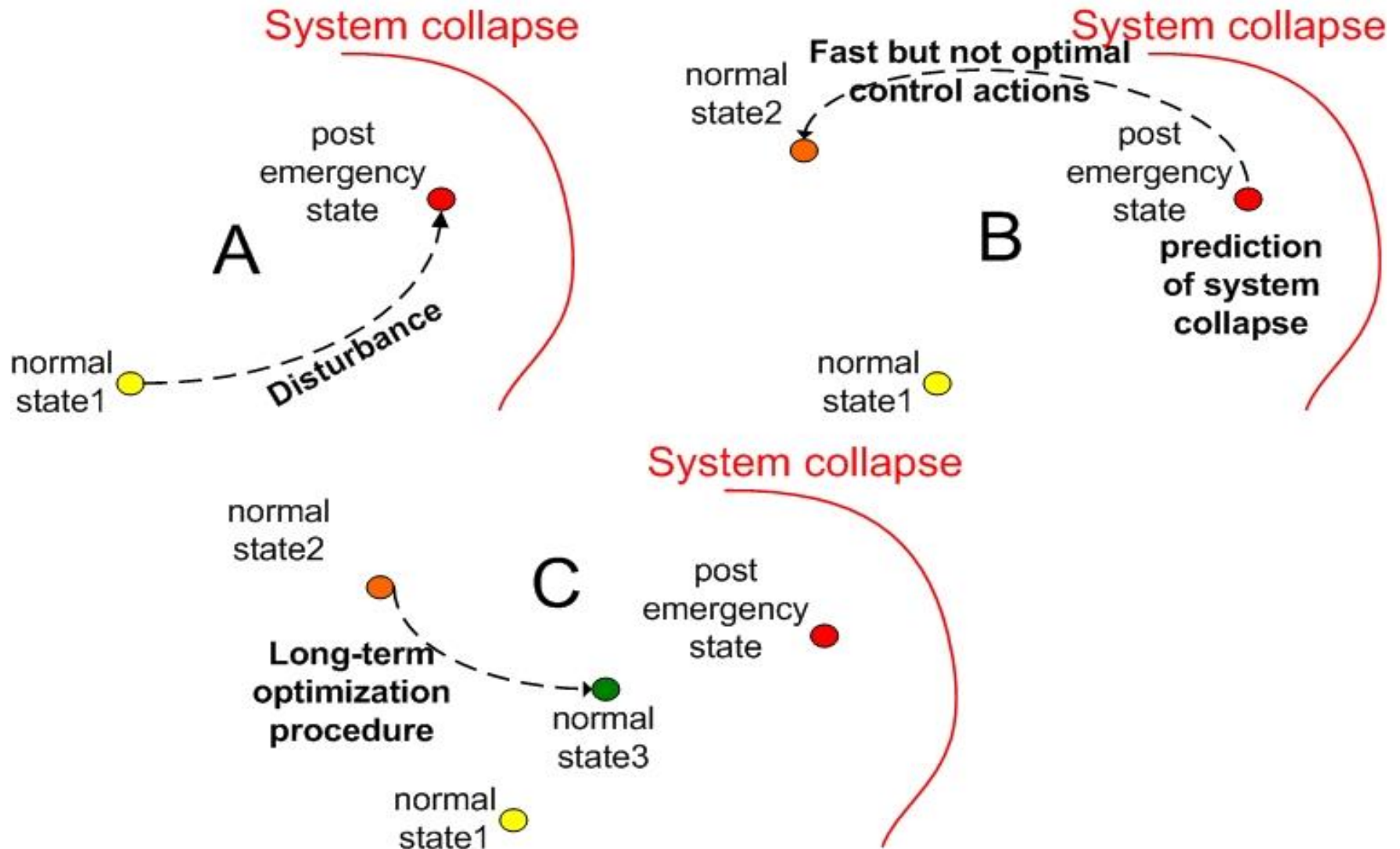
- A low level fault-tolerant of elements and lack of local devices coordination (adaptability) are the two main disadvantages of modern emergency control systems, which cause large-scale blackouts.
- So, what to do? At first sight, greater centralization (избыточная централизация) of control systems and higher redundancy level (N-2, N-3) (избыточное резервирование) could help to handle these significant problems.
- However, excessive redundancy and centralization can lead to a cost increase and reliability decrease of emergency control systems due to improving structural complexity of systems elements.
- A more promising solution is to use of decentralized adaptive control systems with simultaneous increase of the intelligent level of the local devices.



# A new approach to EPS emergency control

- We need a kind of adaptive decentralized automation which will be able to provide voltage/reactive power control by means of coordination of local devices.
- This automation must «predict» the emergency situation, but not just operate after the emergency situation has occurred already. The prediction can be provided by analyzing some parameters that usually precede the collapse of the system (rotor and stator currents, bus voltages and etc.)
- Control actions, generated by the automation should not be optimal, but they should provide the redundant control, which will prevent a sharp increase in losses of reactive power in post emergency state, and provide sufficient time for implementation of a long-term optimization procedure

# A new approach to EPS emergency control

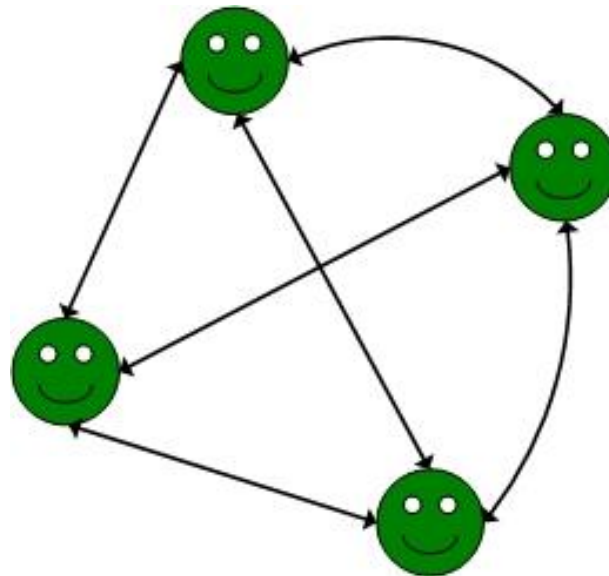


## From words to action

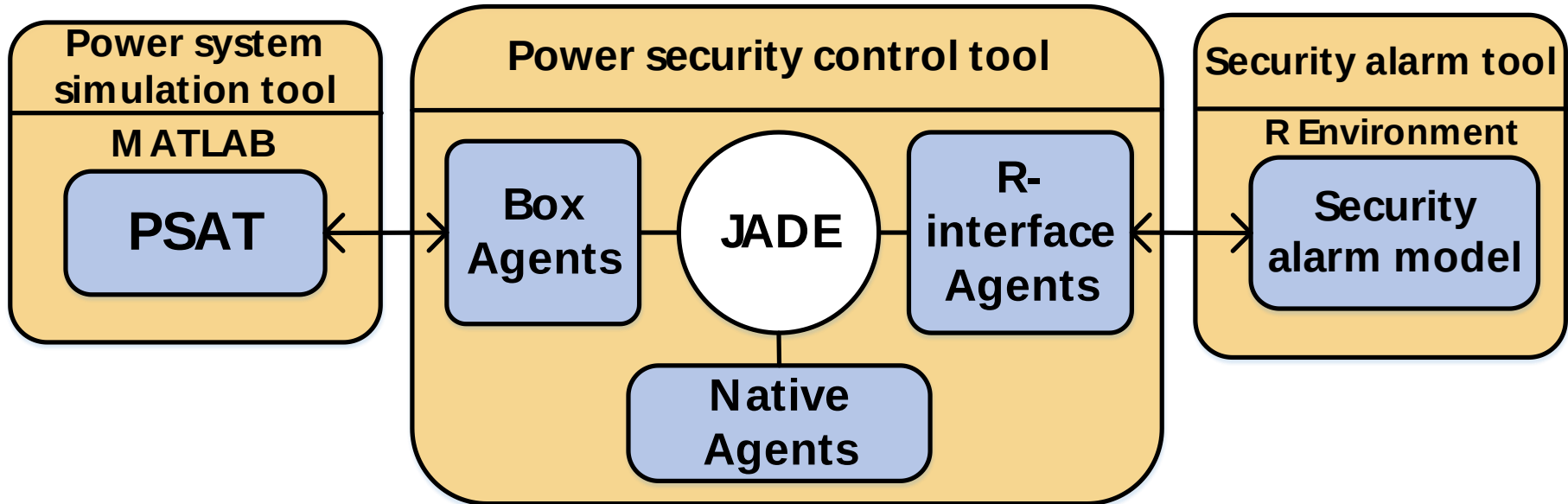
- The development of a new algorithm or approach to operational or emergency control includes the following set of steps:
  - *Step 1. Theoretical justification (conducting research, writing articles, etc.);*
  - *Step 2. Development of the software required to validate the proposed algorithm (approach);*
  - *Step 3. Implementation on prototypes (for example, the creation of hardware and software complexes);*
  - *Step 4. Implementation of the algorithm (approach) in operation.*

# Software implementation

- The final hardware implementation of an emergency control system that uses some distributed algorithms should be a set of independently operating devices with possibility of asynchronous transmission and reception of messages within an information environment – many computers at different substations connected through communication channels, this is distributed computing.
- To simulate the behavior of this automation (software to validate the proposed algorithm) one must create a software system that consists of a set of special agents working in parallel; with the possibility of asynchronous messaging, this is parallel computing.



# Software implementation

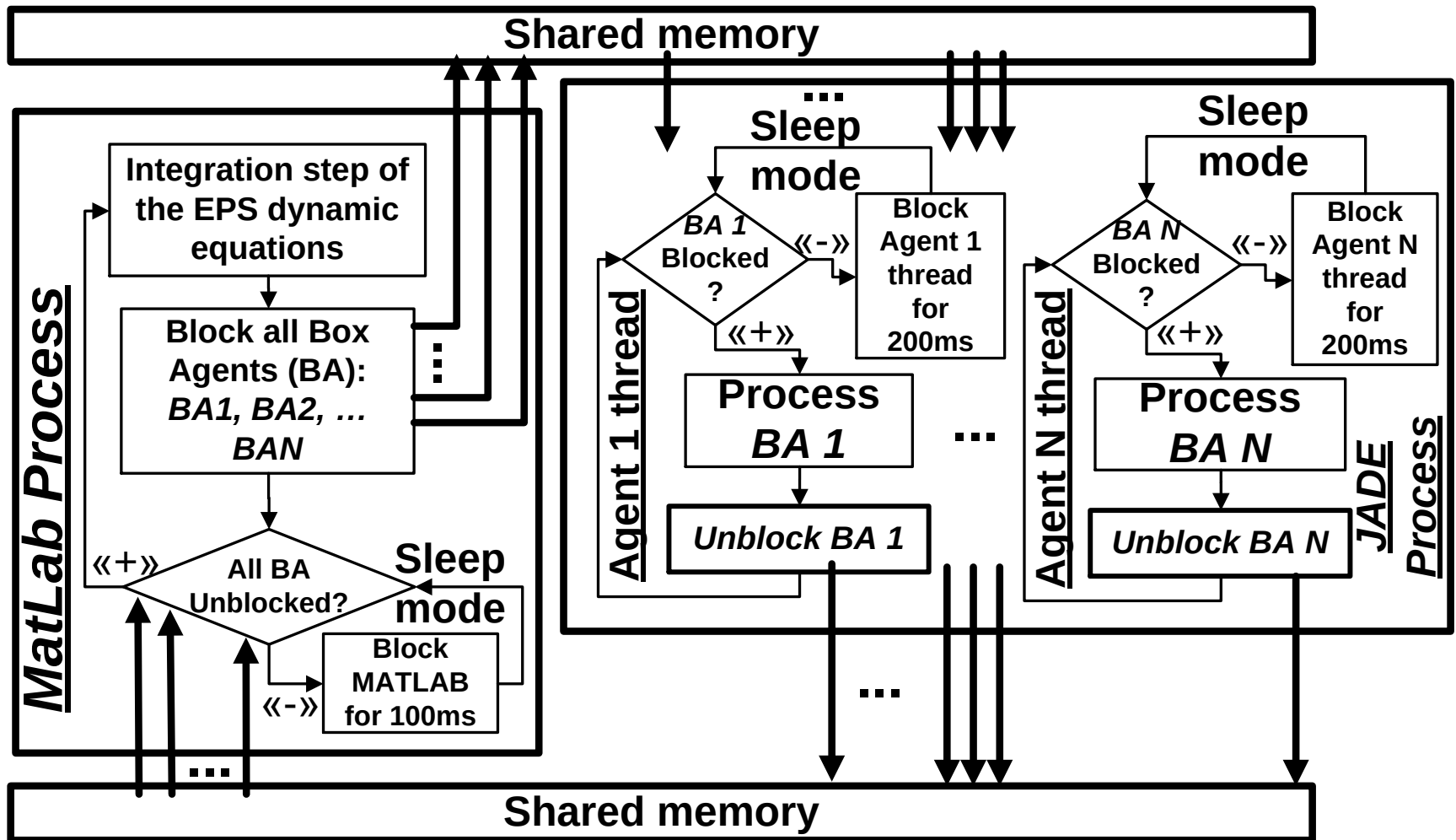


Power System Model  
Static Dynamic

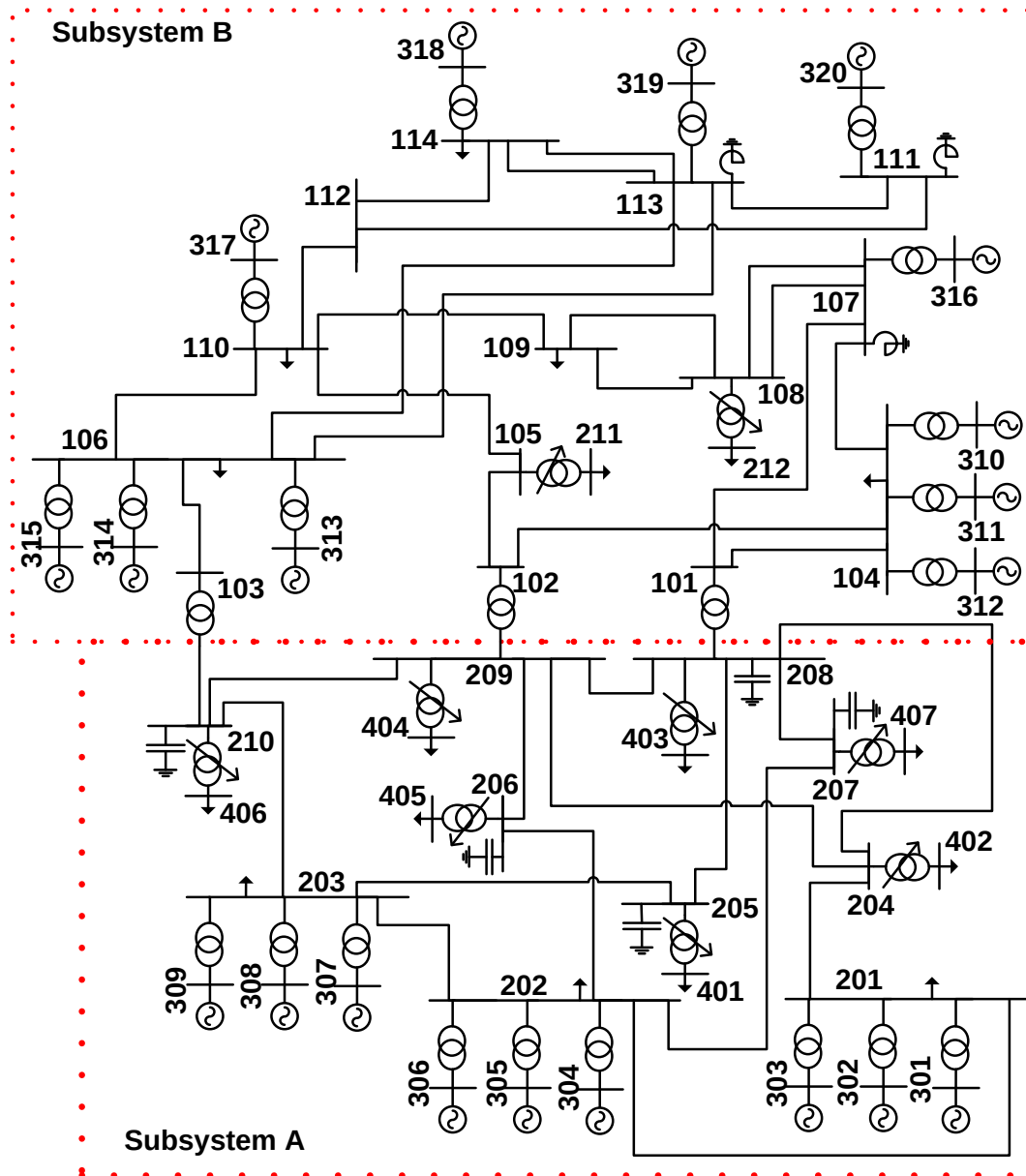
Multi-agent distributed automation  
(agent behavior + automation algorithms)

Monitoring

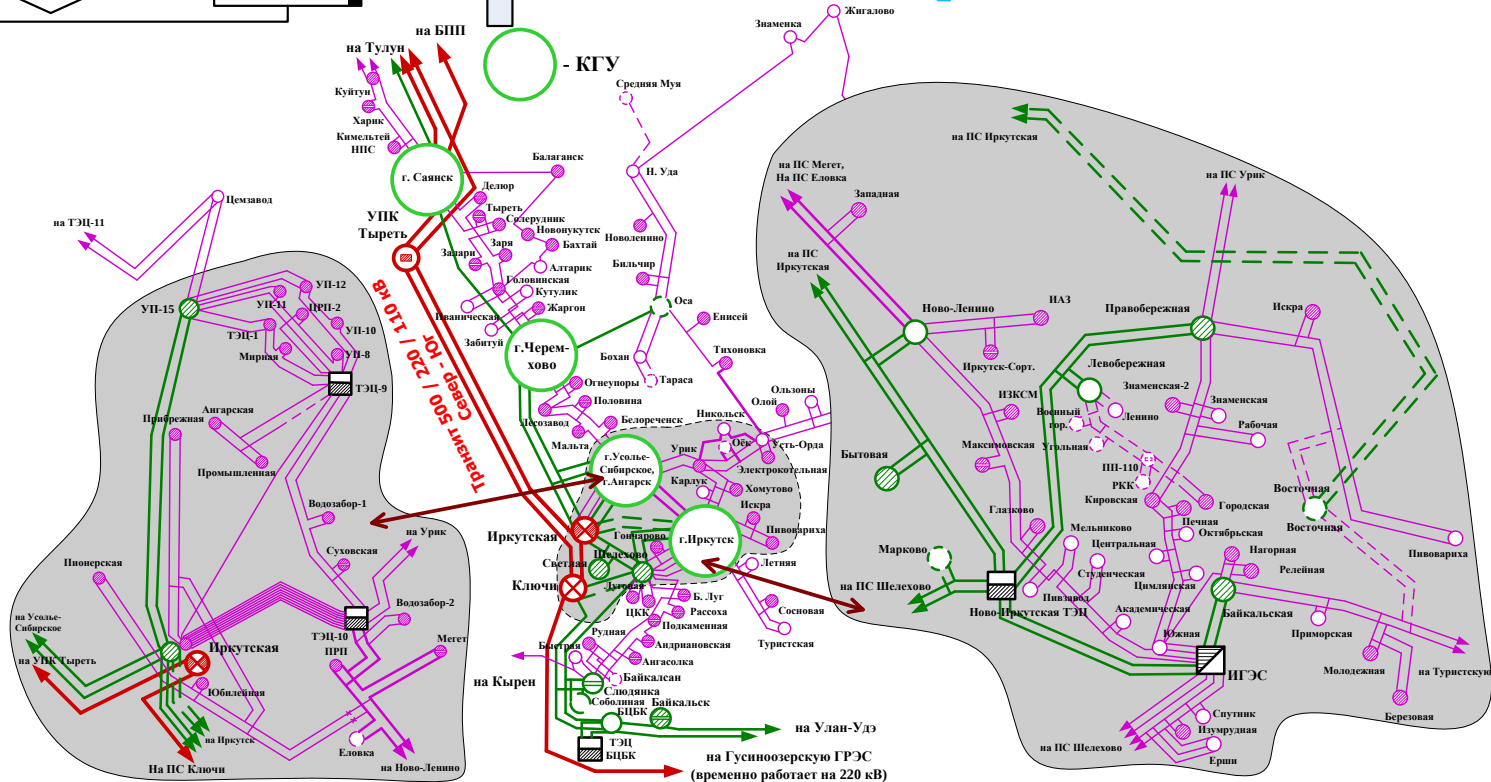
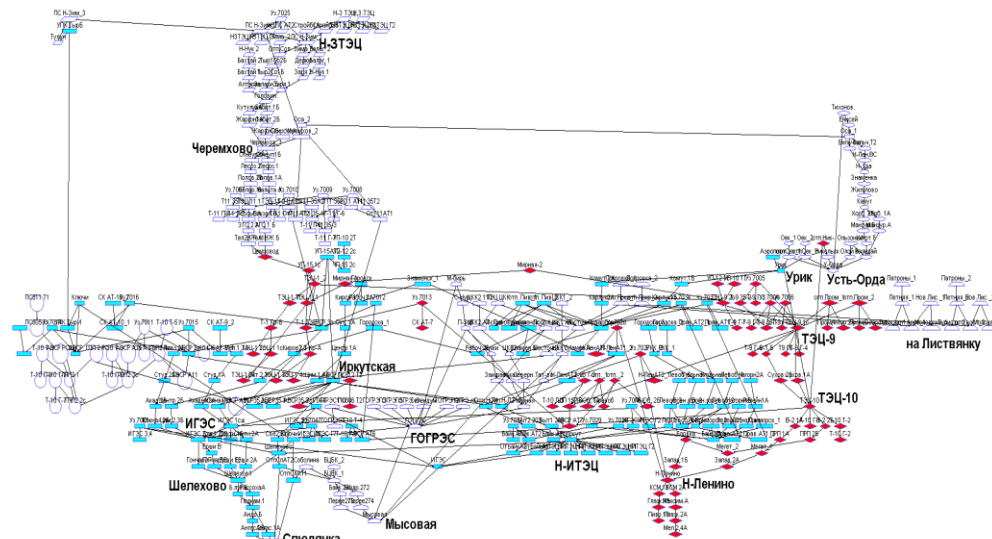
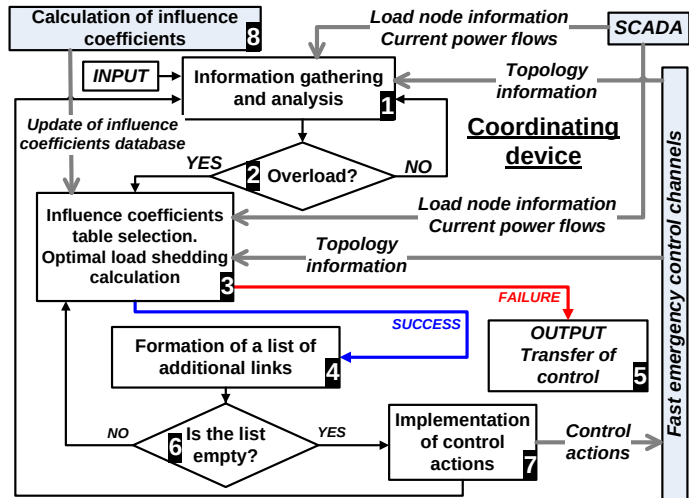
# Synchronization mechanism



# Voltage stability control system



## Overload (current) control



**СПАСИБО ЗА ВНИМАНИЕ**