MESA

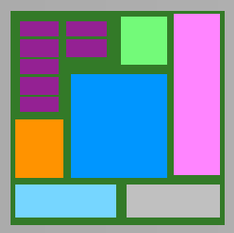
Merged Environments for Simulation and Analysis: Building an Extensible Framework for Testing New Engineering Concepts

Dr. Mark Bryden

Increasing energy use

Increasing impact on the environment

Increasing resource scarcity



Fuel flexibility

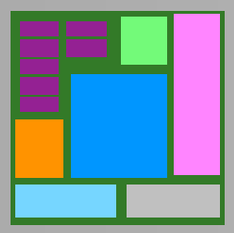
Reduced emissions

Efficiency

Availability

Economics

Carbon footprint



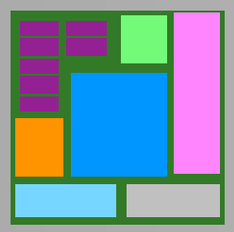
Advanced power systems

Require advanced sensor and control systems

Increasingly complex energy systems

Sensors are rapidly becoming ubiquitous and inexpensive

Computers are become ubiquitous and “free”

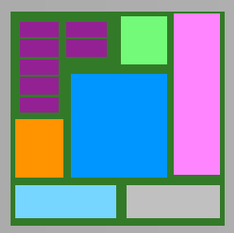


Opportunity space

Current top-down methods of controls will not work with the coming flood of data

Self organization appears to offer flexibility, scalability, and robustness for sensor network controls of complex systems

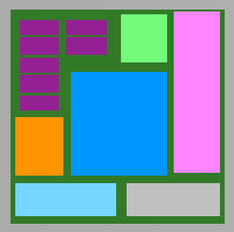
Stigmergy provides a low level rule set for self organization



Increasing complexity between systems and subsystems

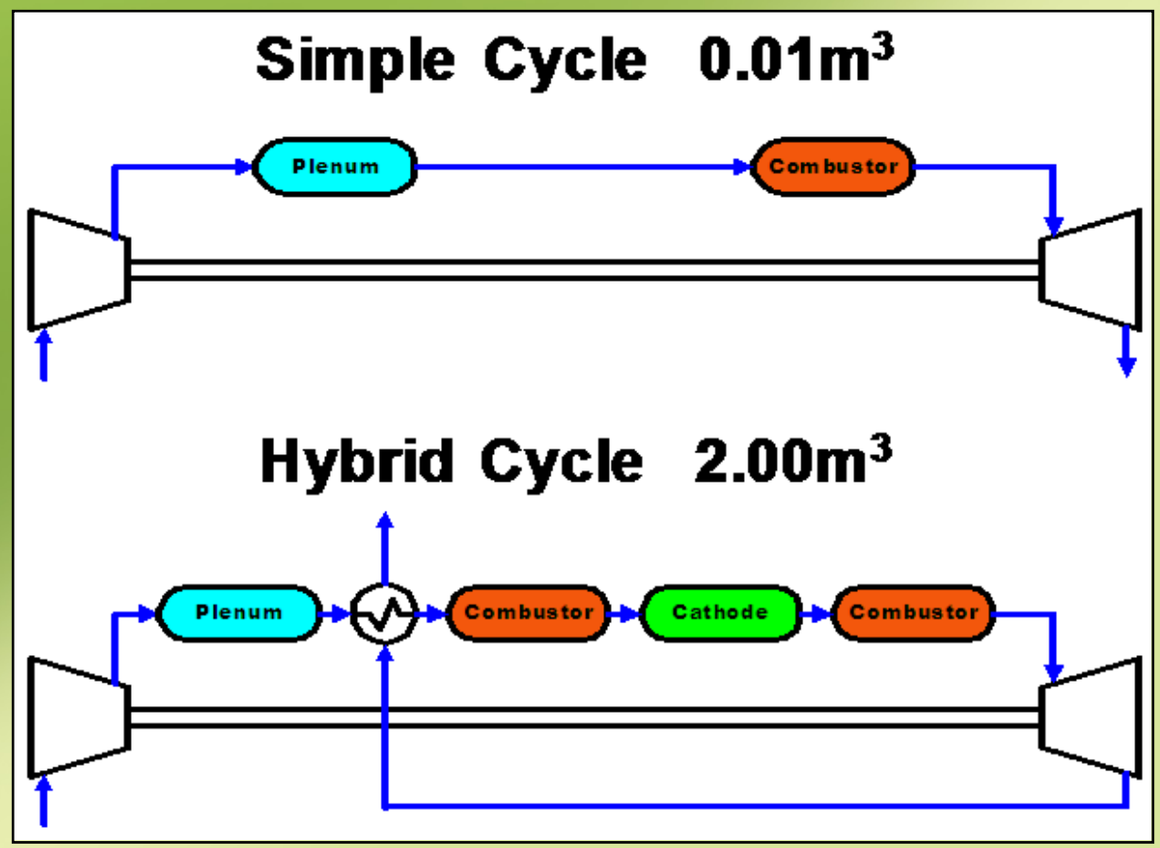
No algorithmic structure or research on self organization control of process systems

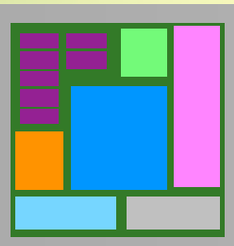
No stigmergy-based sensor framework available



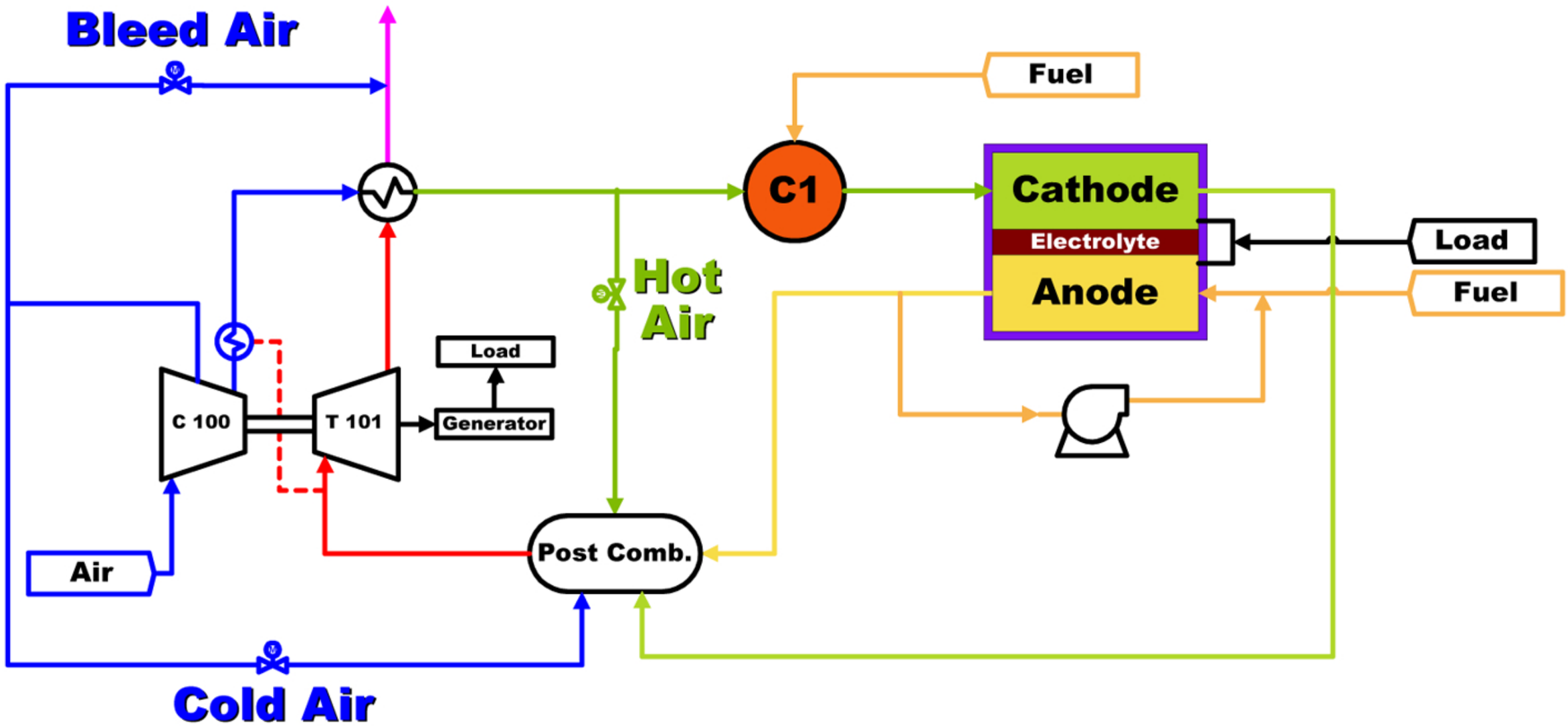
Challenges

- Hybrid fuel cell and gas turbine system
- Can test dynamic performance of any advanced power system based on a gas turbine recuperated cycle



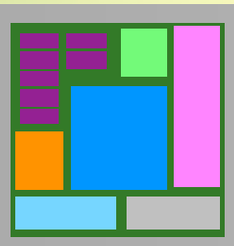


Hyper facility



Pilot scale plant for testing control strategies

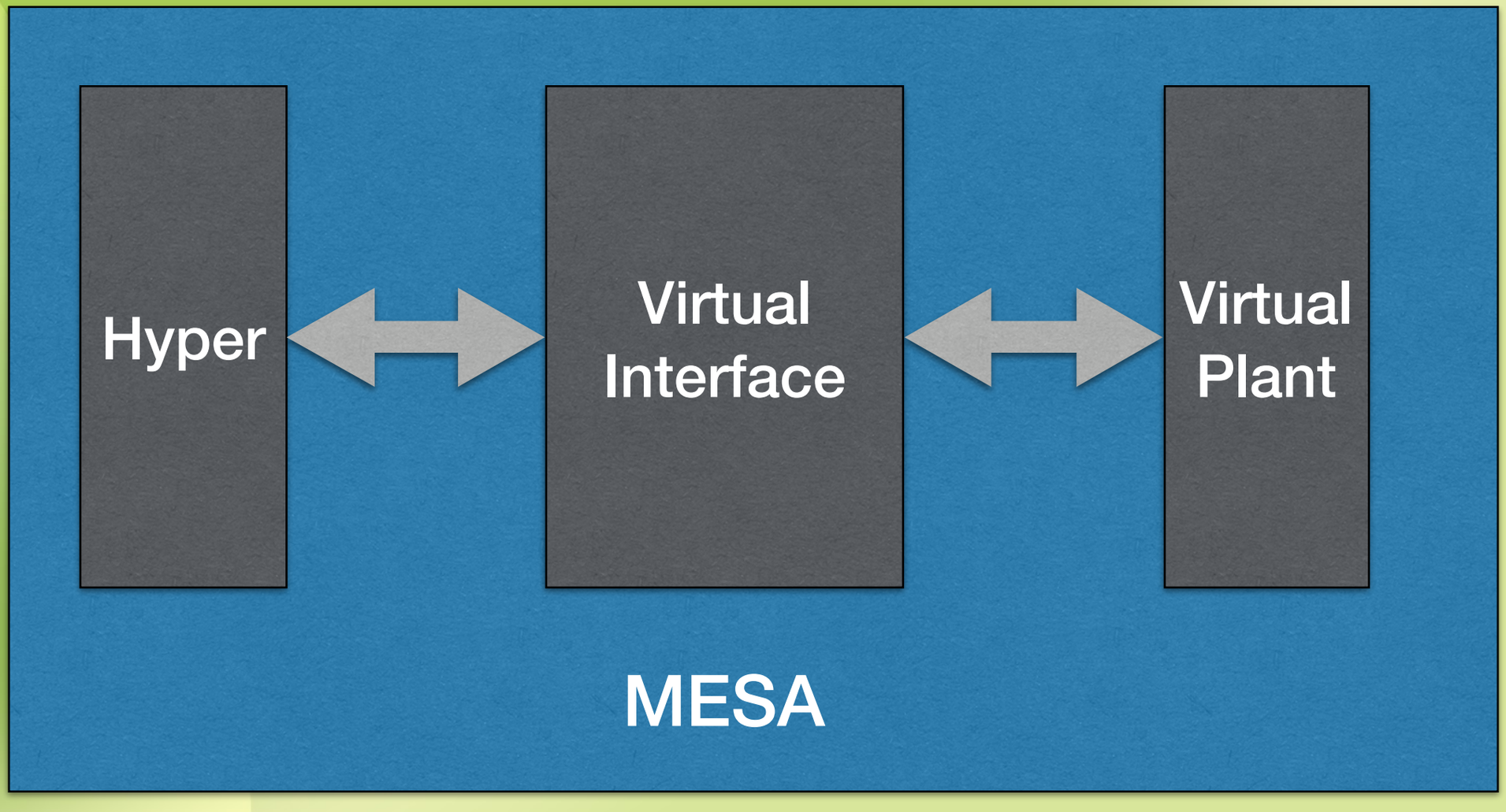
- Testing time is expensive
- Facility reconfiguration takes time
- An extensible testing interface is needed

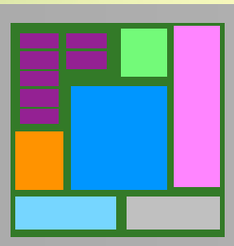


Using Hyper

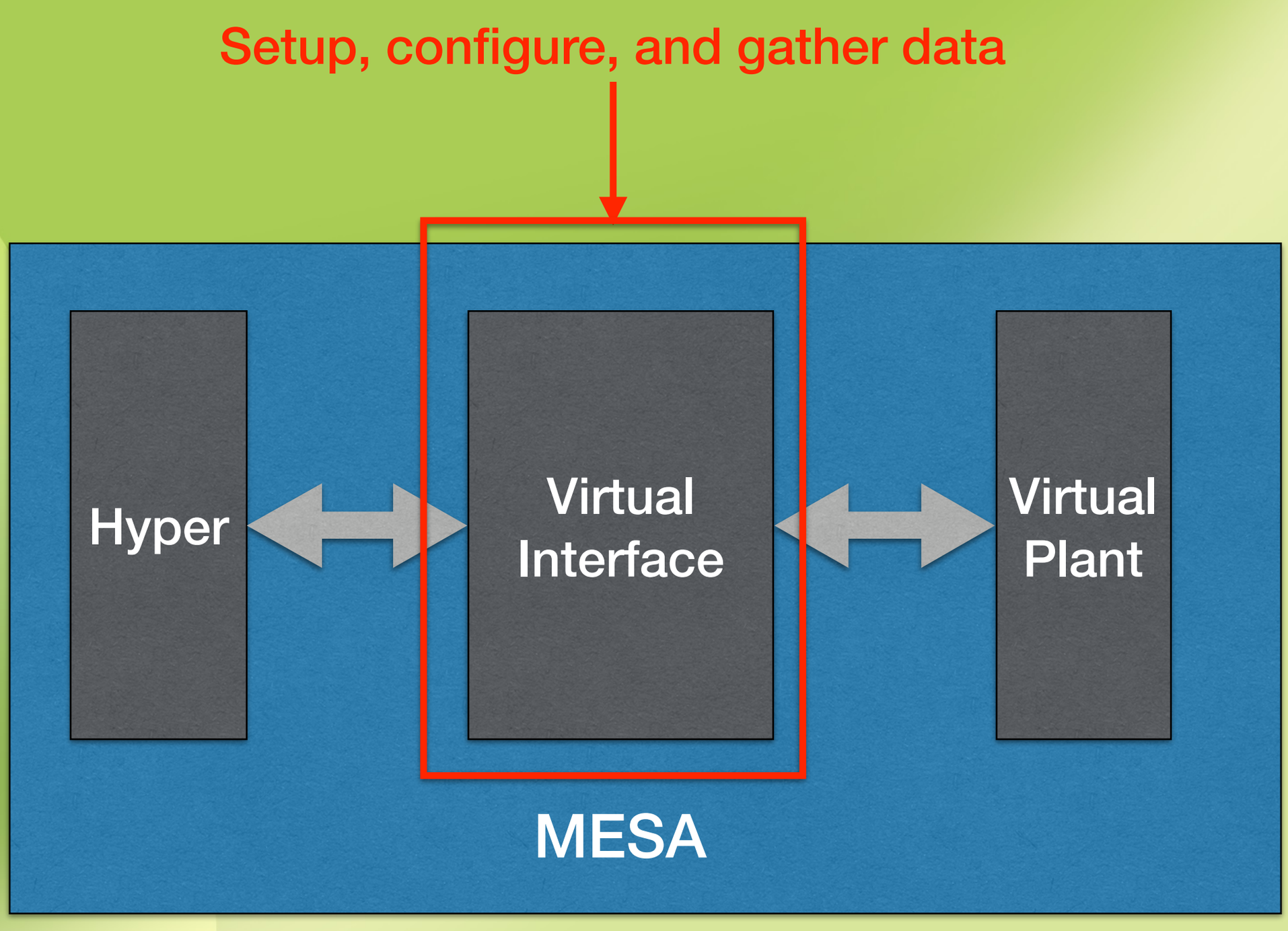
Merged Environment for Simulation and Analysis

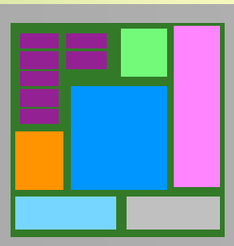
- Cyber-physical hybrid
- Separable virtual interface for offline interaction
- Extensible to maintenance, training, and test design



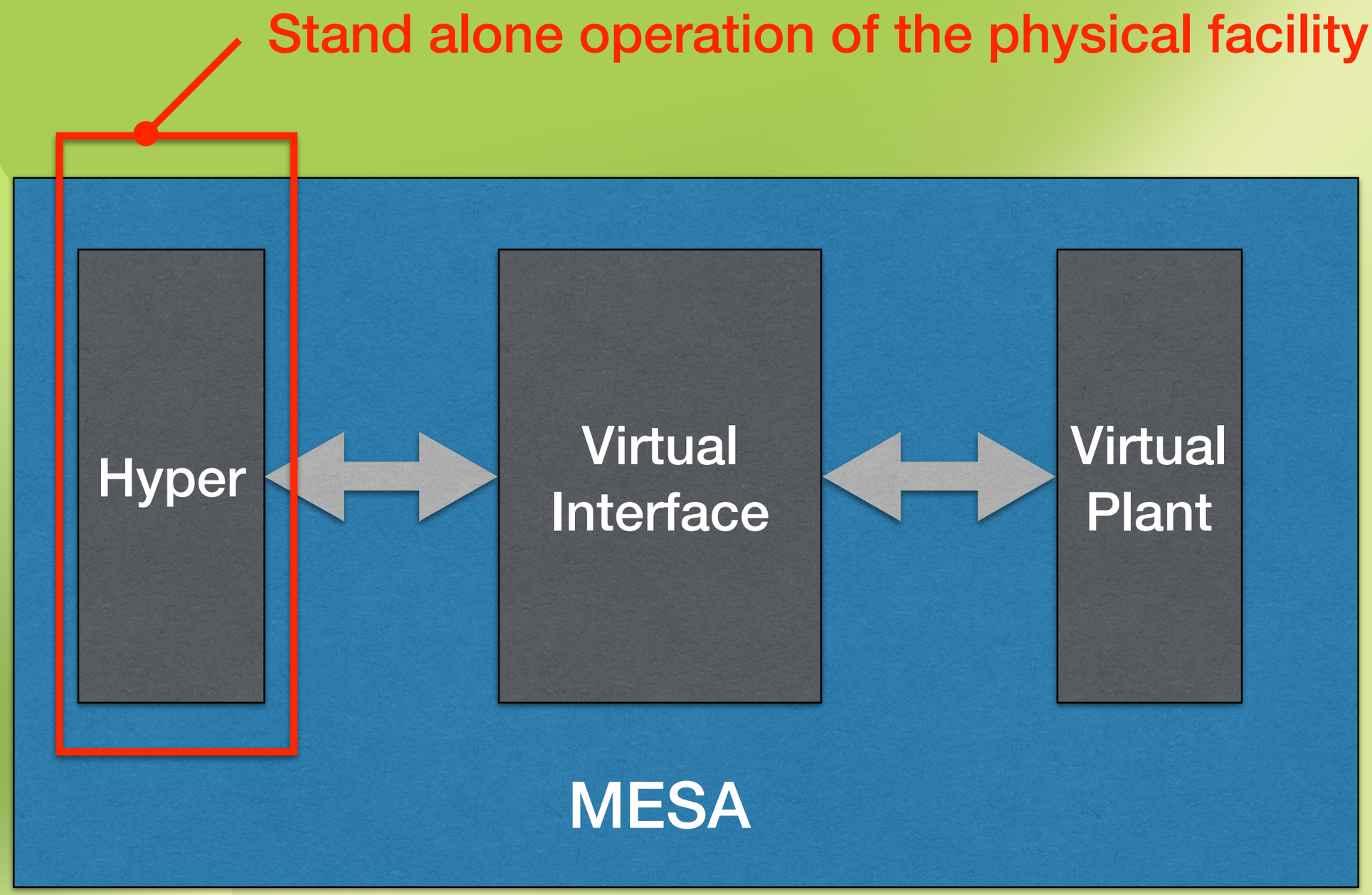


Overview

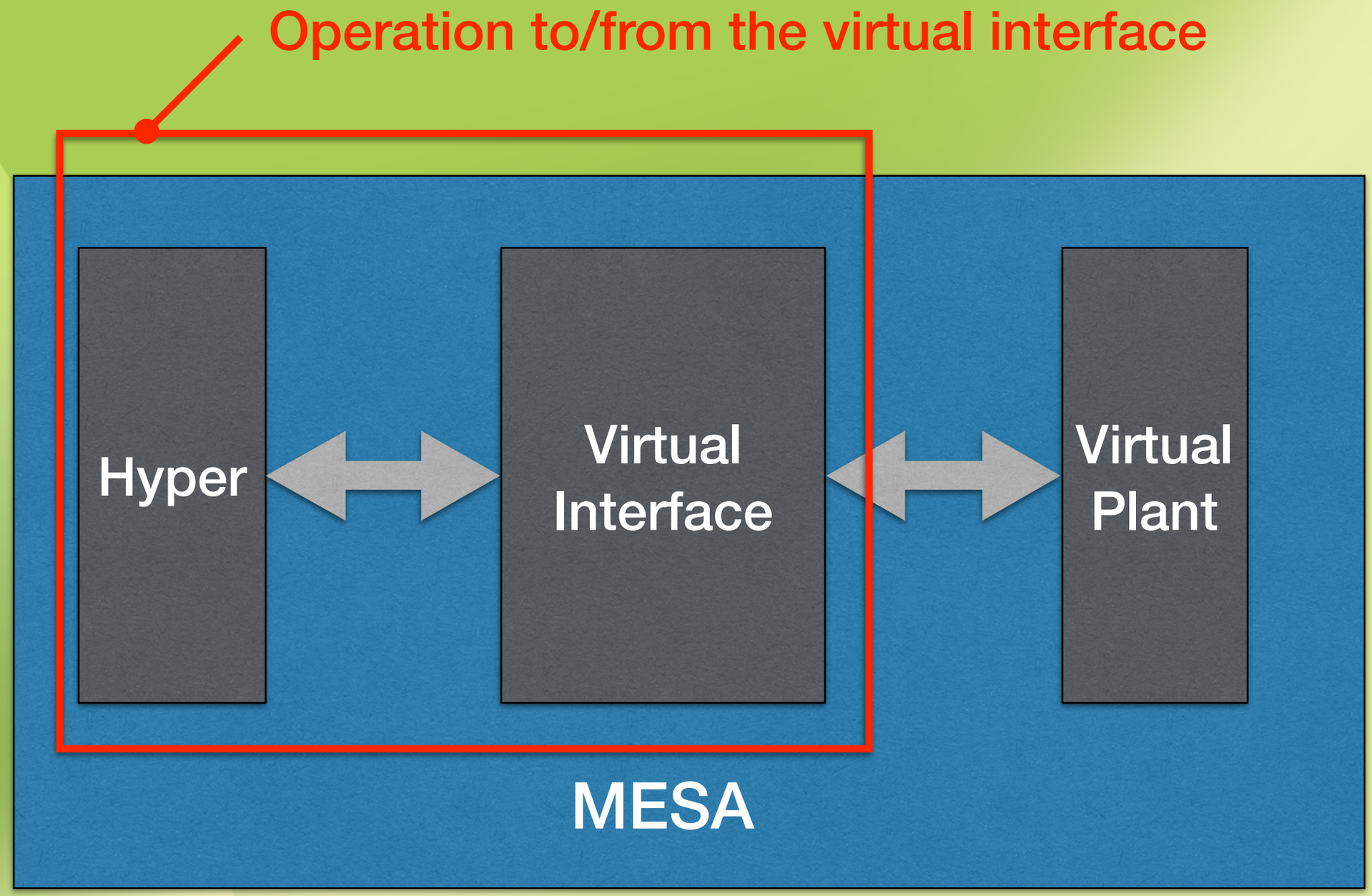

Setup, configure, and gather data
Hyper
Virtual
Interface
Virtual
Plant
MESA

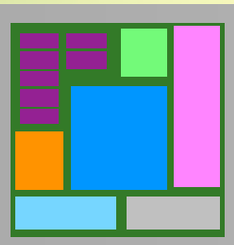


Overview

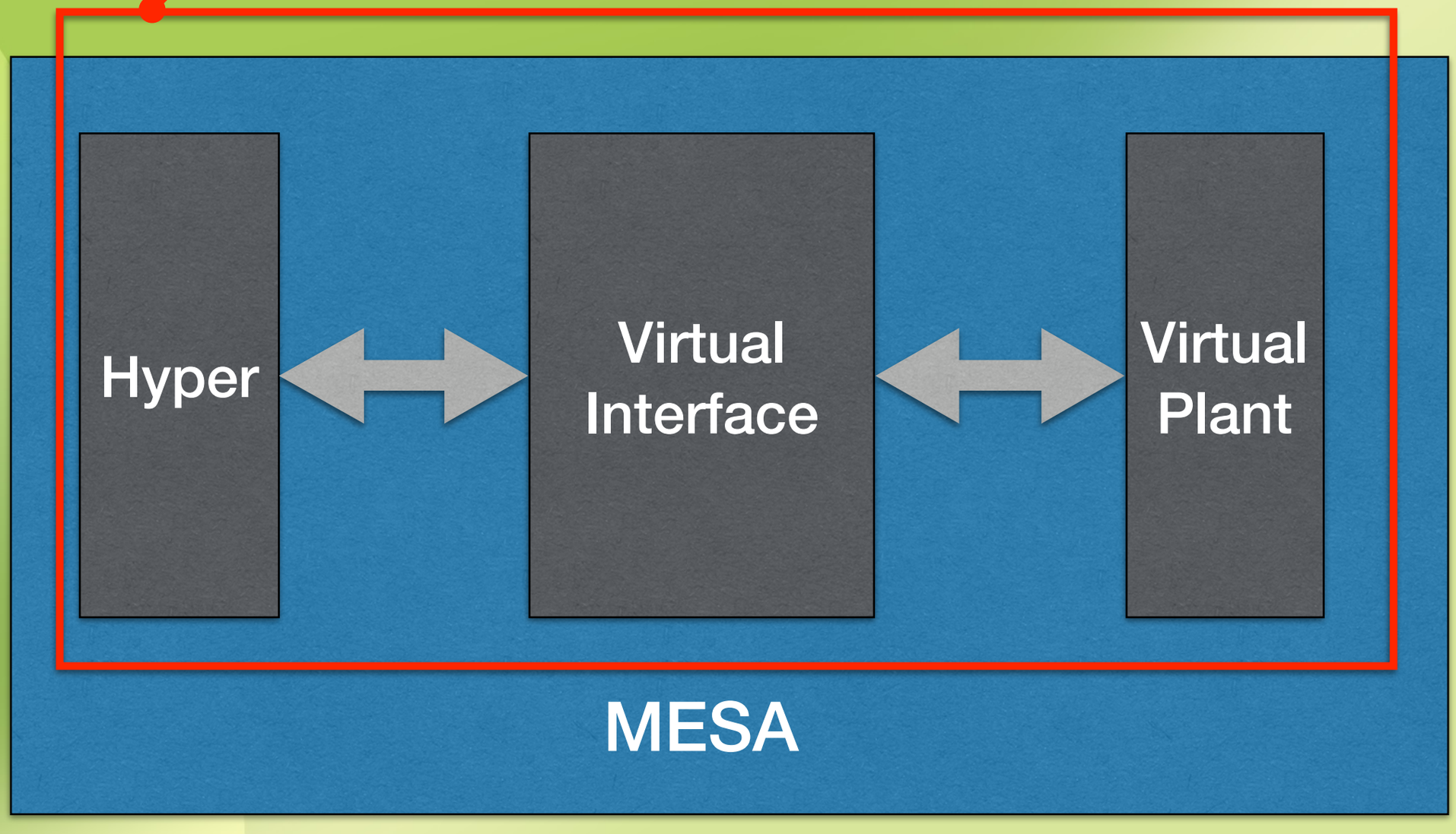


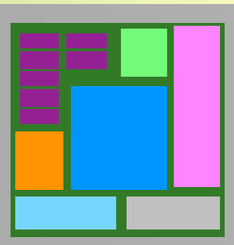
Modes of operation



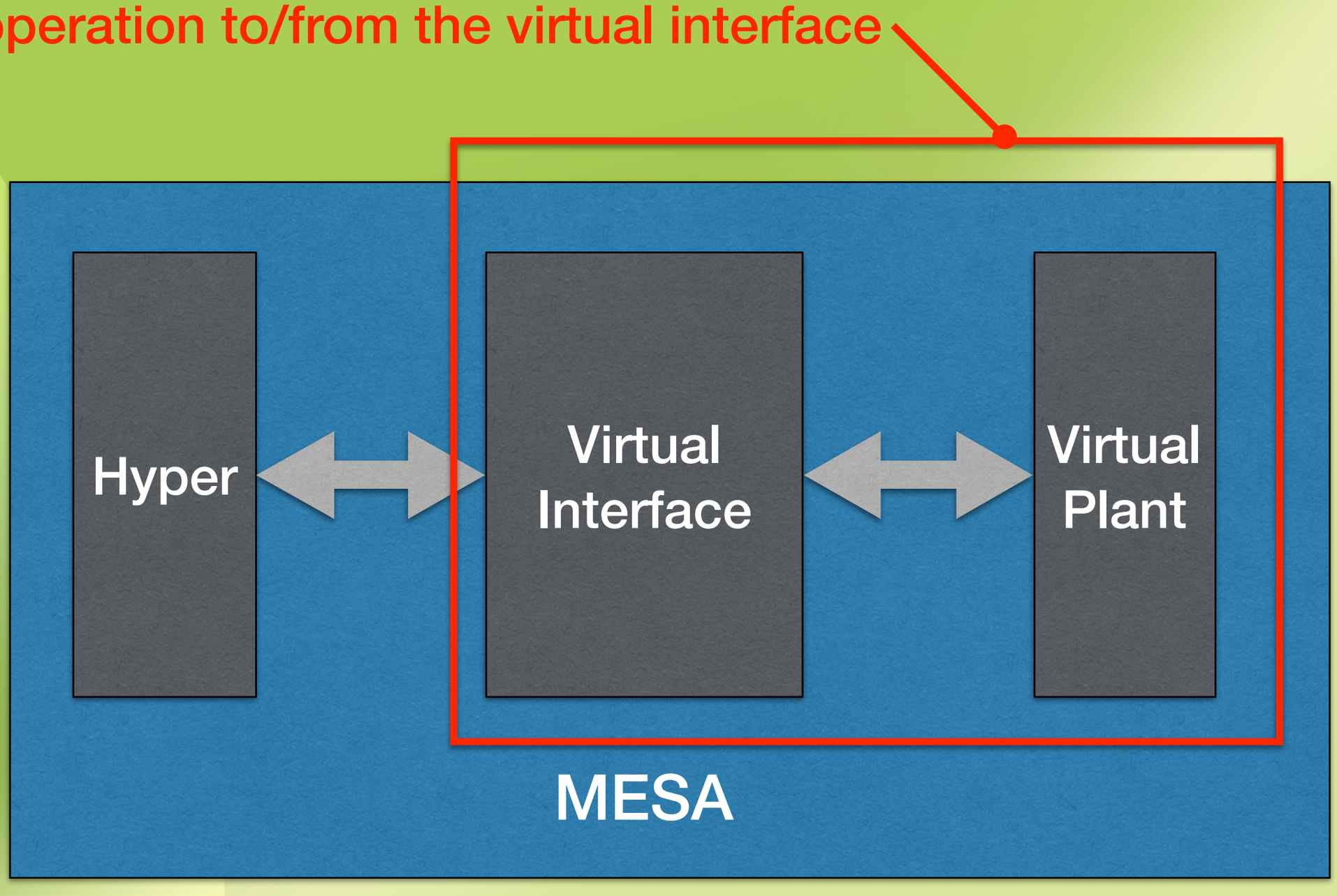


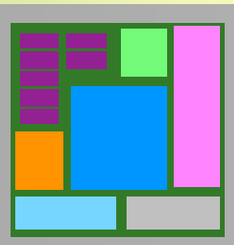
Modes of operation





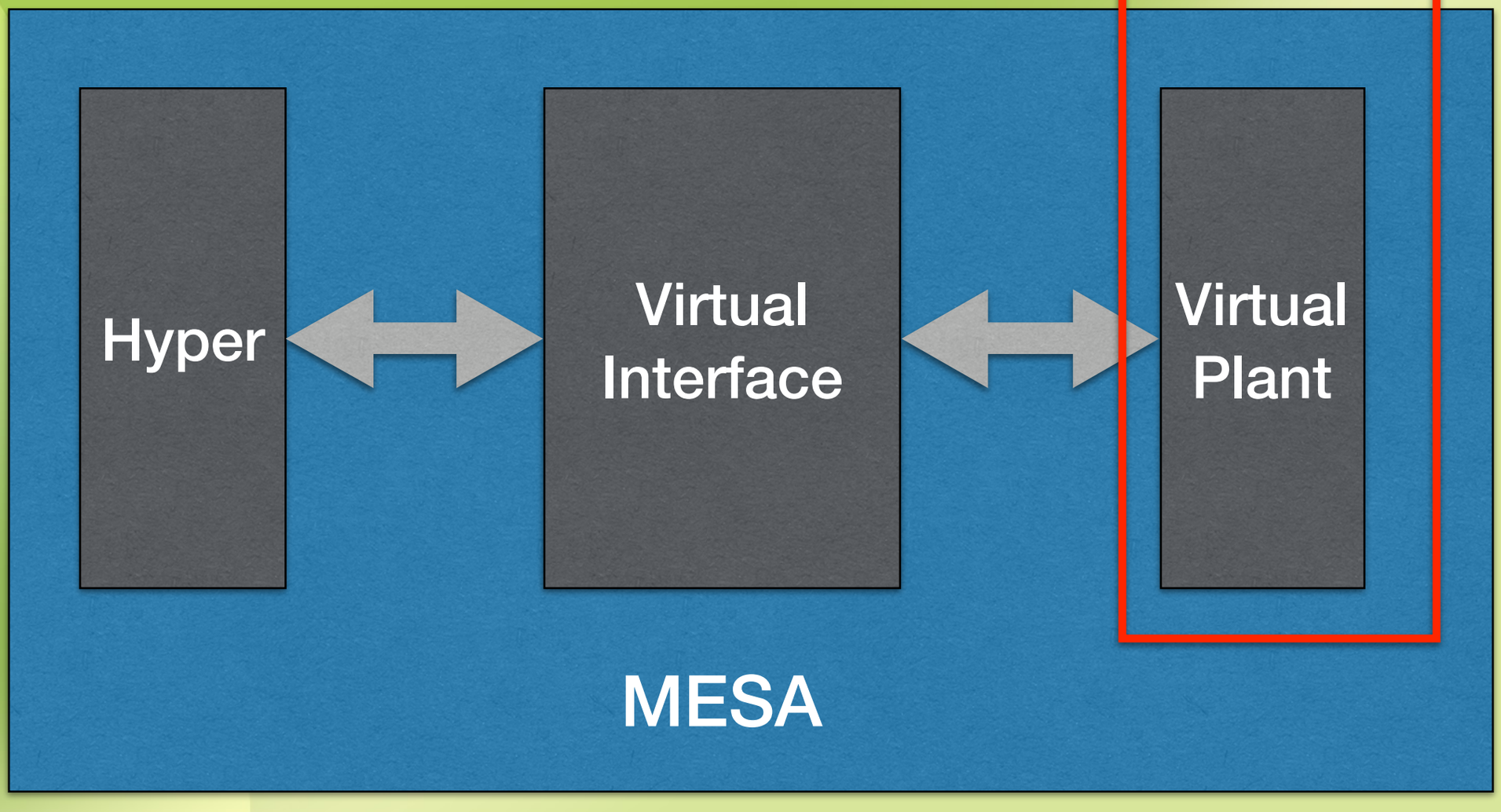
Modes of operation

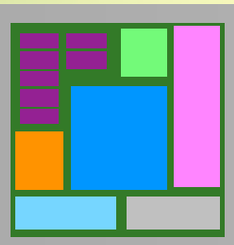




Modes of operation

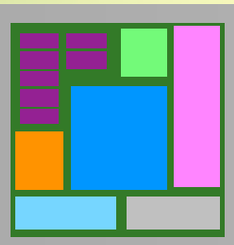
Stand alone operation of the virtual plant





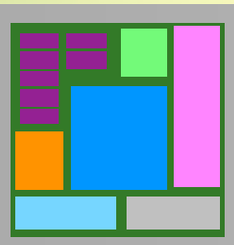
Modes of operation

1. Test advanced control algorithms
2. Develop stigmergic and other distributed controls algorithms
3. Develop tools for human-computer interaction with complex engineered systems

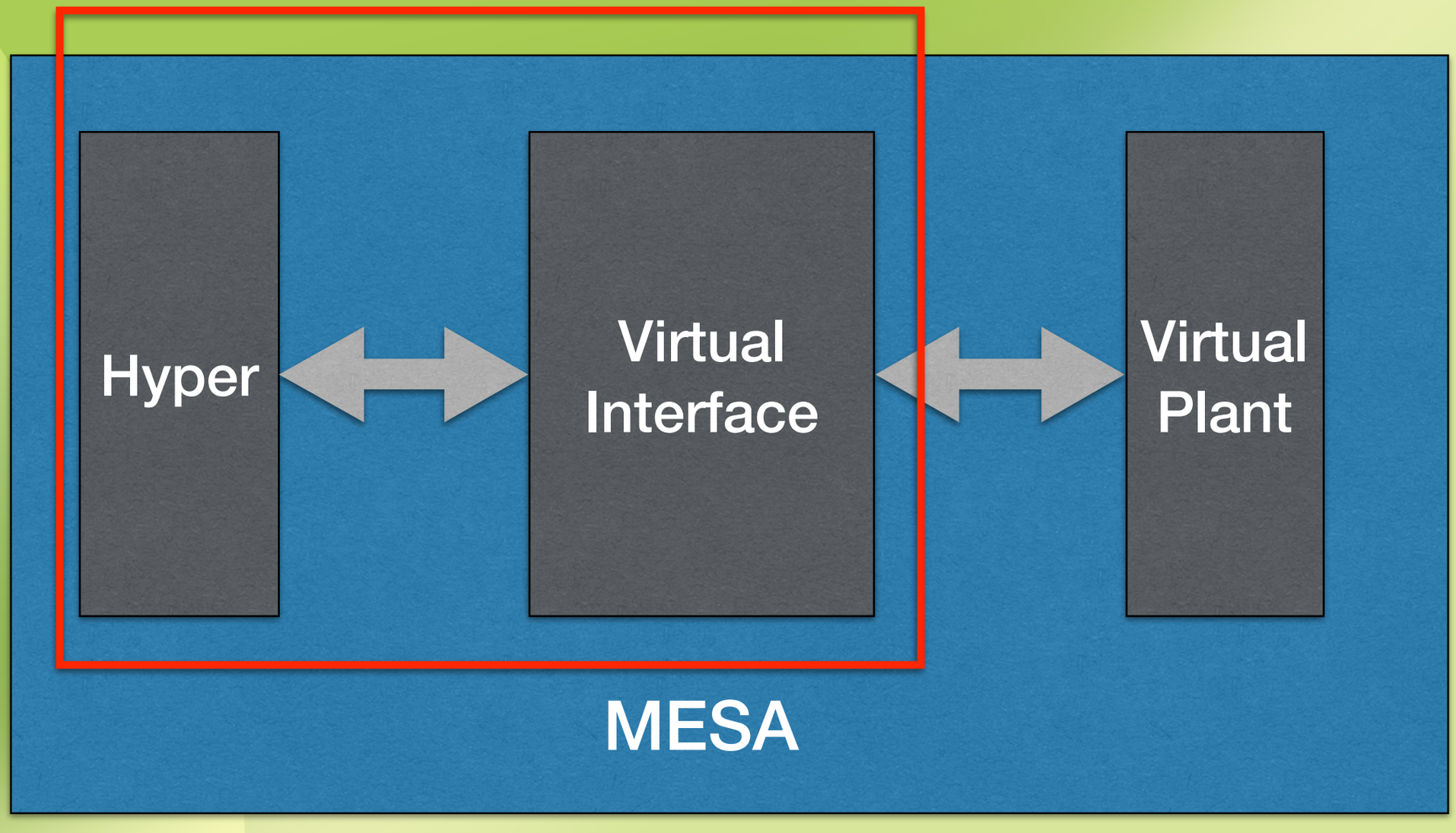


Goals

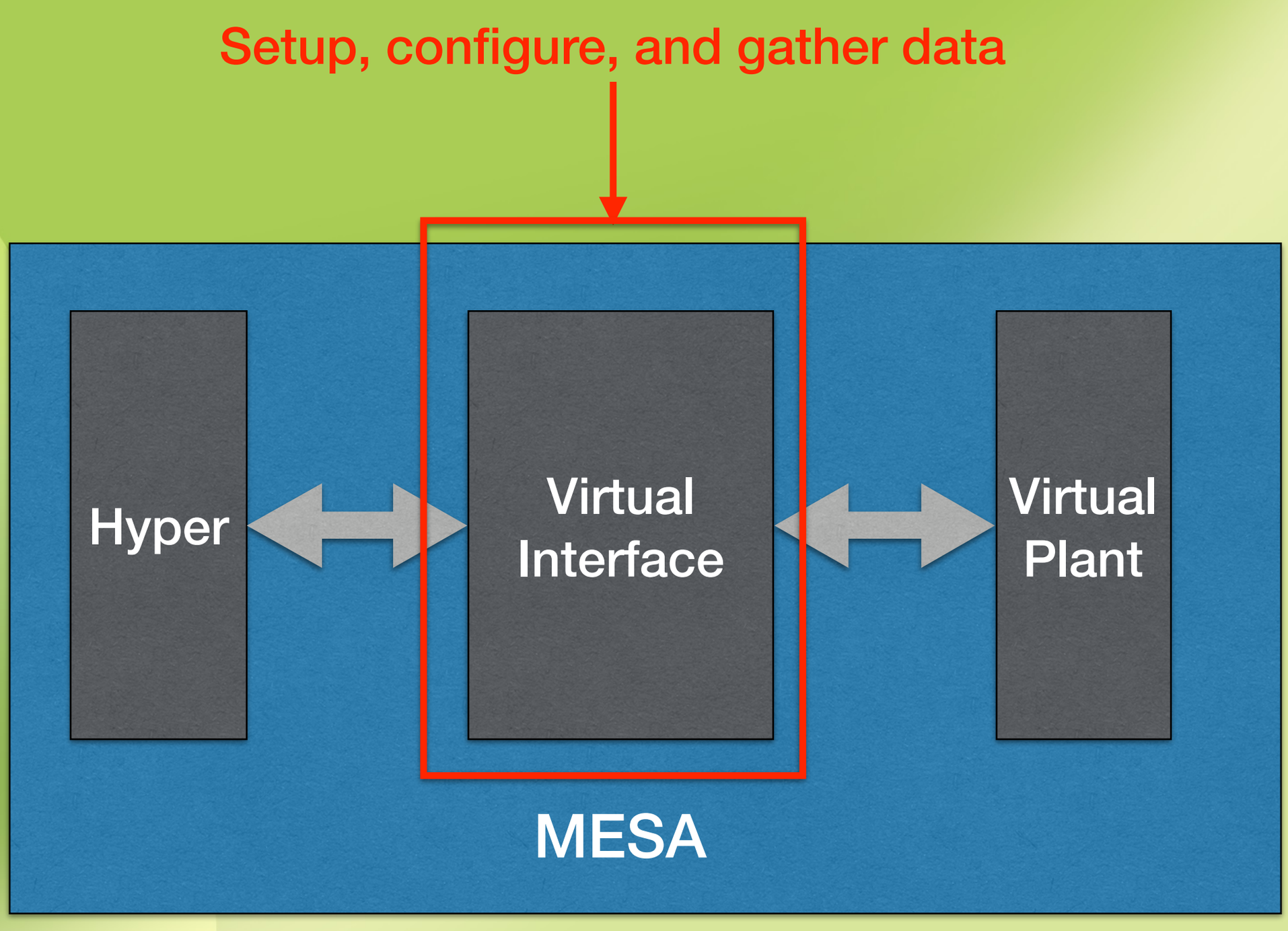
1. Test advanced control algorithms
2. Develop stigmergic and other distributed controls algorithms
3. Develop tools for human-computer interaction with complex engineered systems

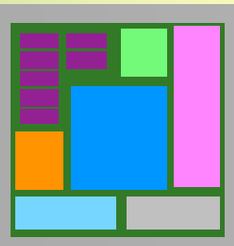


Goals



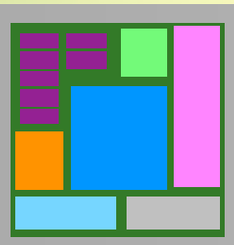
Currently available for testing


Setup, configure, and gather data
Hyper
Virtual
Interface
Virtual
Plant
MESA



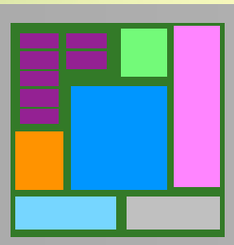
Overview

1. Test advanced control algorithms
2. Develop stigmergic and other distributed controls algorithms
3. Develop tools for human-computer interaction with complex engineered systems

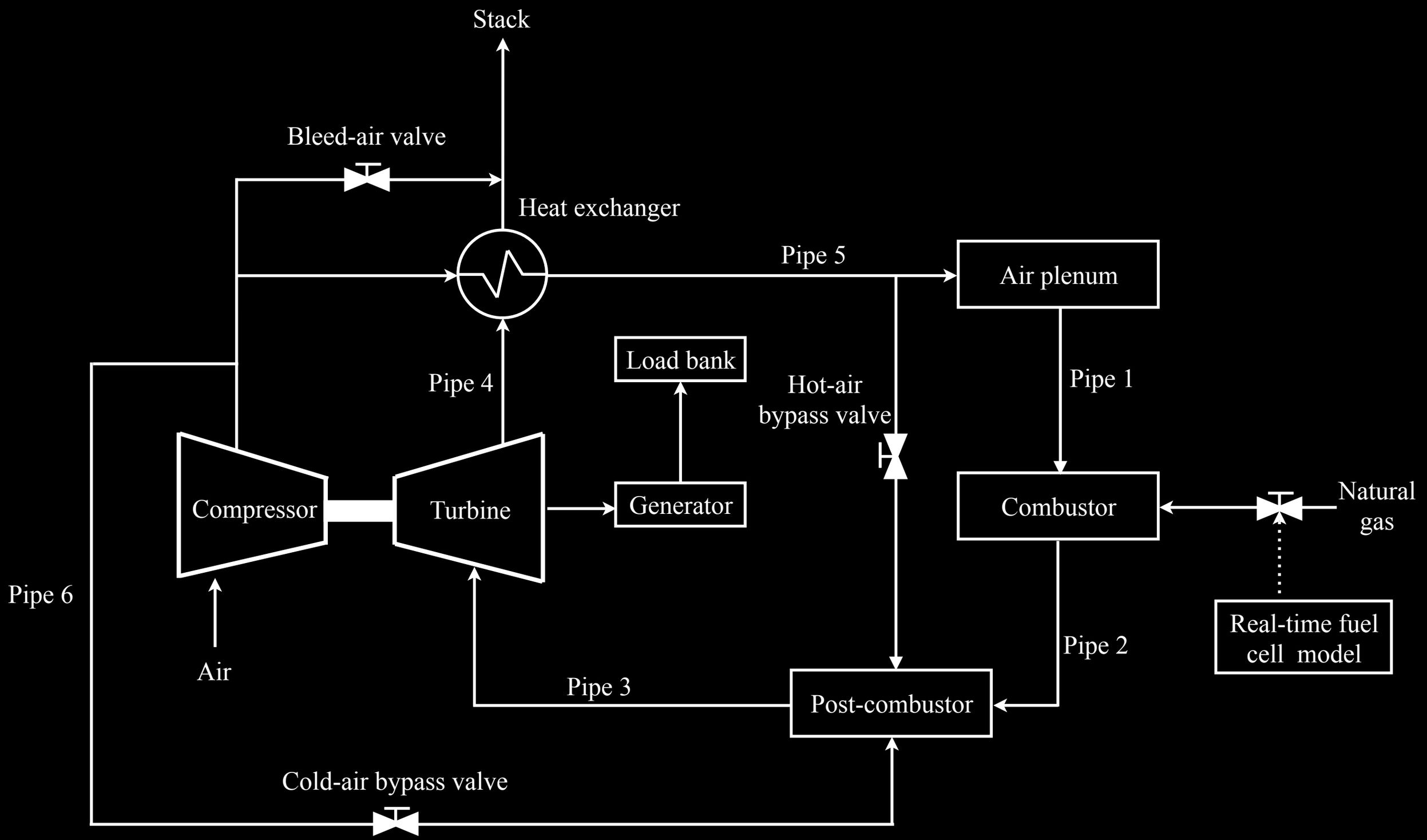


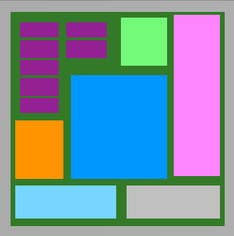
Goals

1. How to identify agent groupings
2. How to understand the information flow and the impact of changing information flow
3. Develop and test specific stigmergic controls algorithms



Distributed controls algorithms





Hyper component subsystems

1 air plenum model

2 combustor model

3 post-combustor model

4 gas turbine model

5 empirical back-pressure database

6 compressor model

7 heat exchanger model

8 generator model

9 stack model

10 bleed air valve model

11 cold air bypass valve

12 hot air bypass valve

13 ambient conditions model

14 fuel cell model

15 pipe 1 model

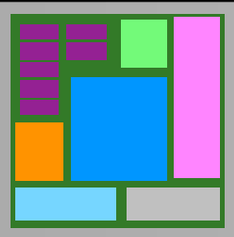
16 pipe 2 model

17 pipe 3 model

18 pipe 4 model

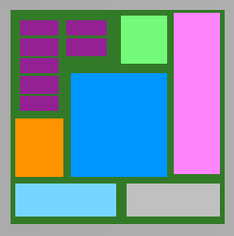
19 pipe 5 model

20 pipe 6 model

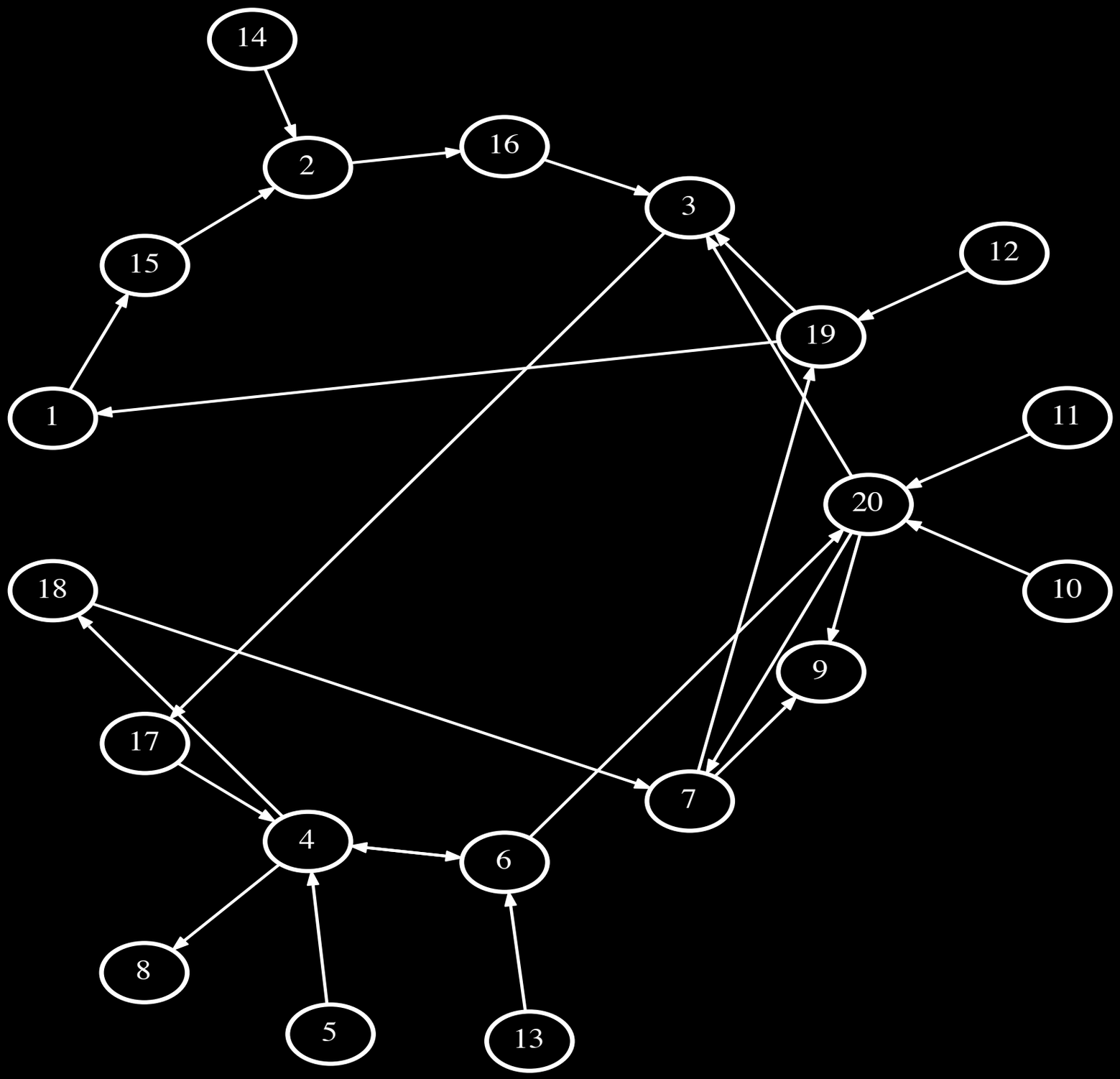


Models representing Hyper operation

- mass flow, temperature, and pressure data
- one-way coupling between adjacent components in direction of airflow
- empirical database for turbine back pressure
- two-way coupling between gas turbine model and compressor model

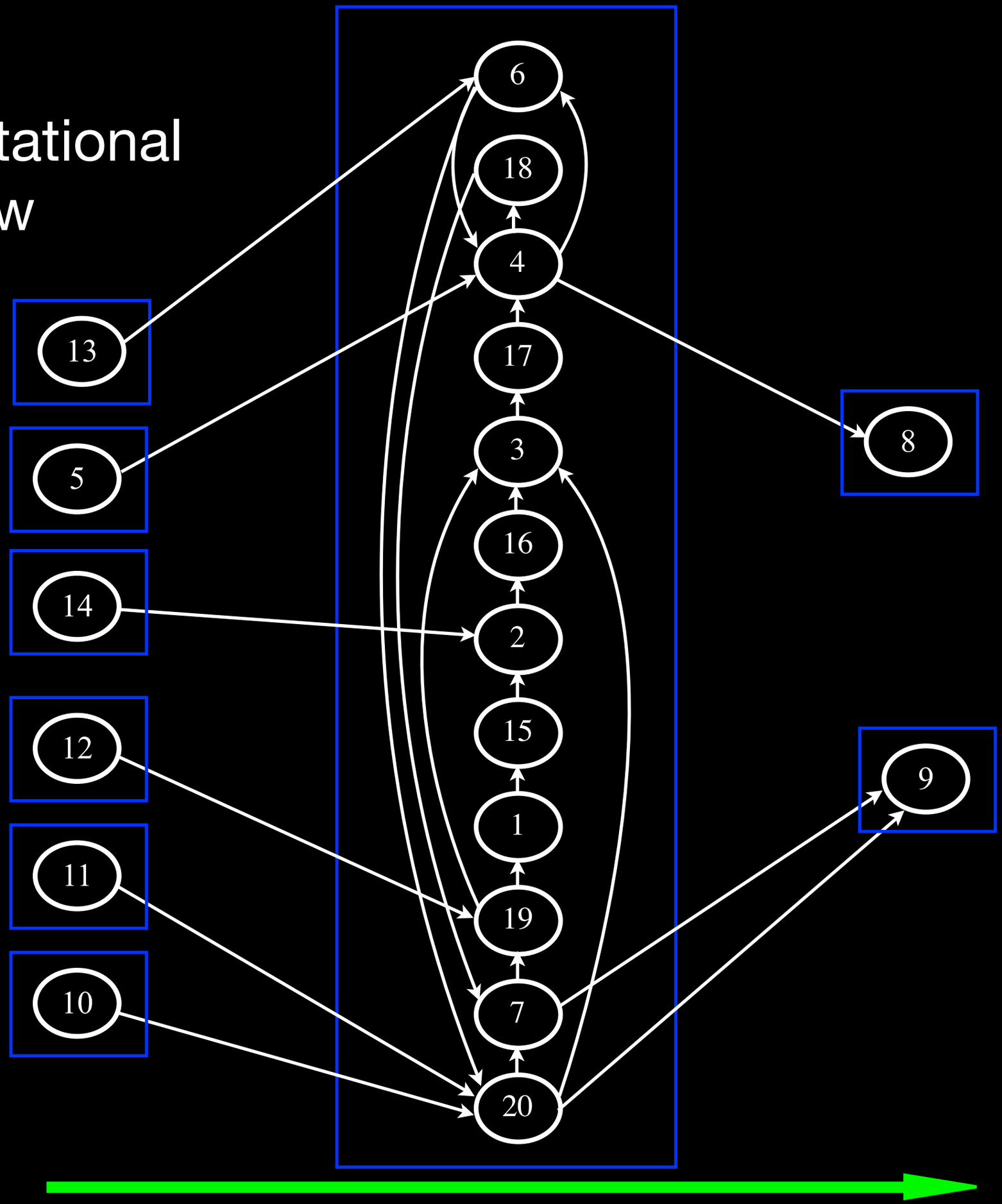


Local data exchanges

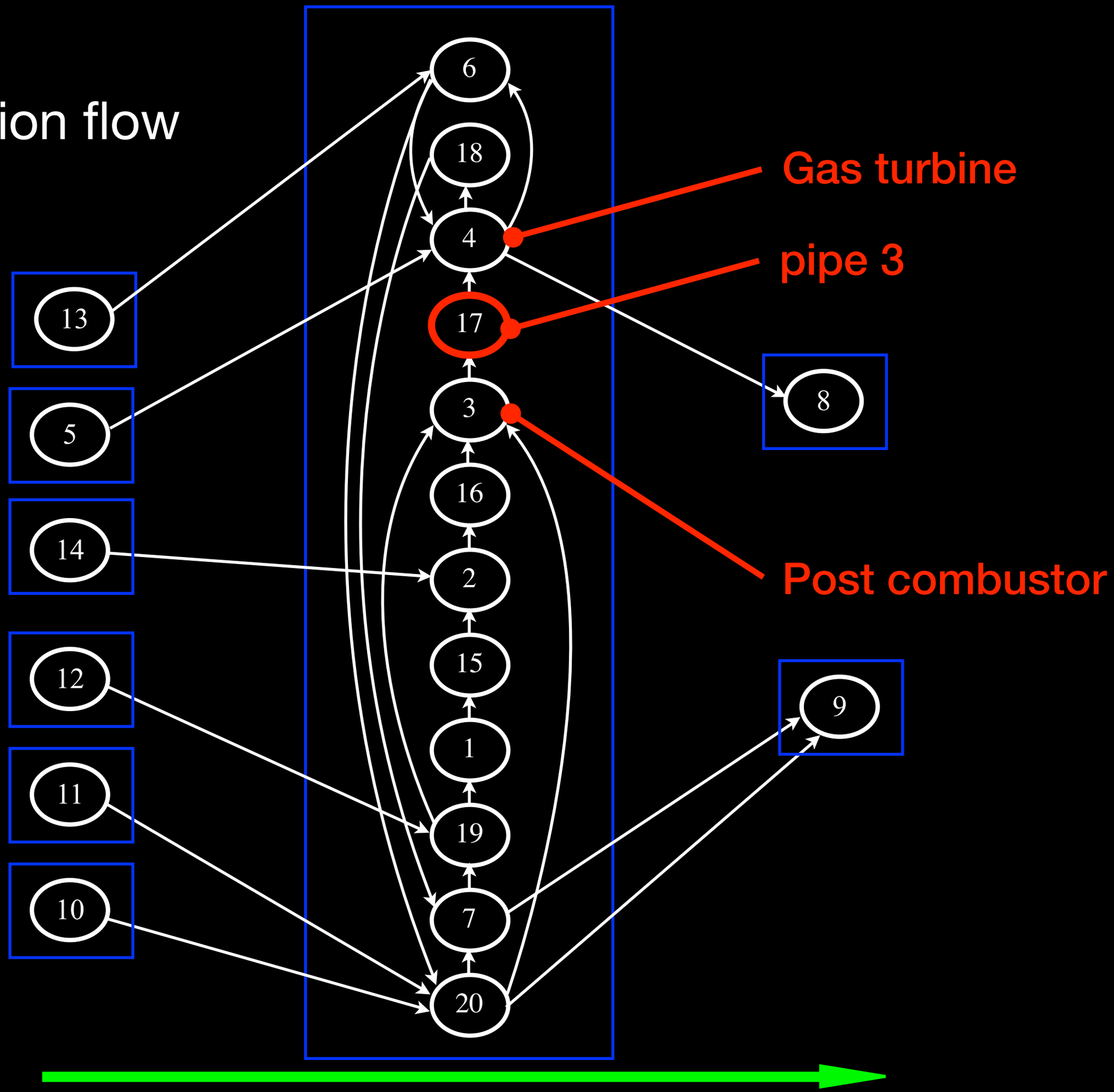


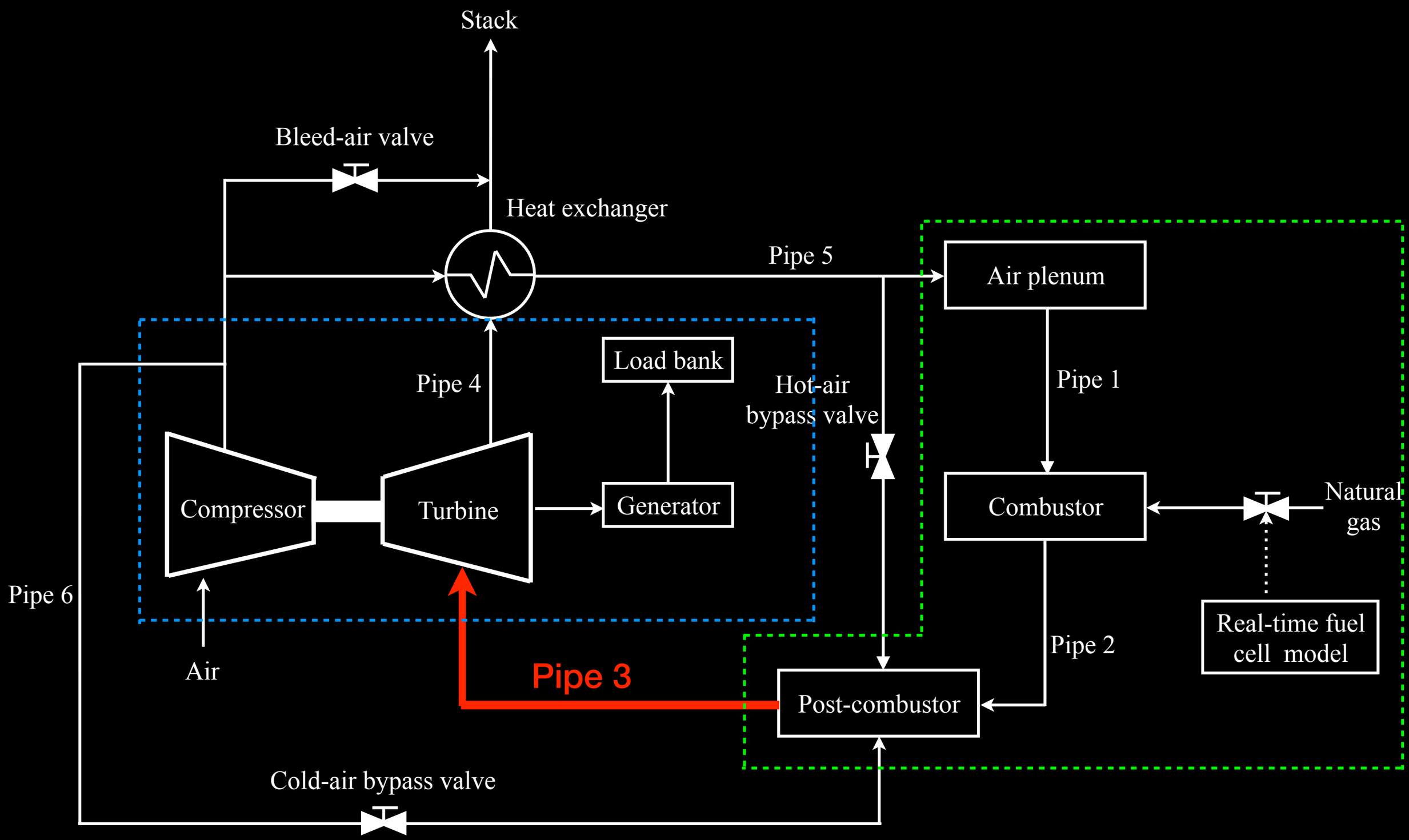
Directed graph of the system of models

Computational workflow



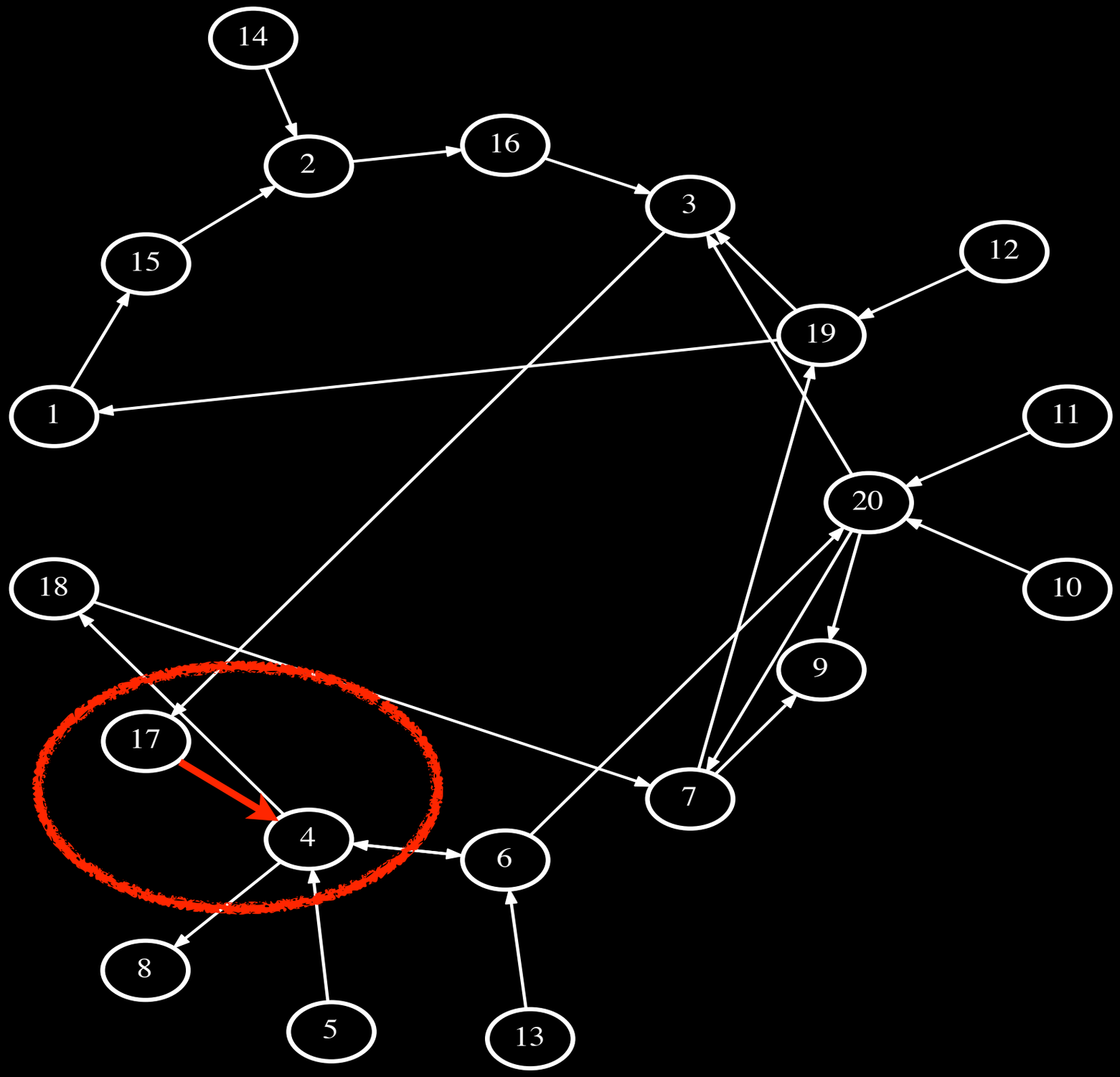
Information flow





Hyper facility major components

Directed graph of system

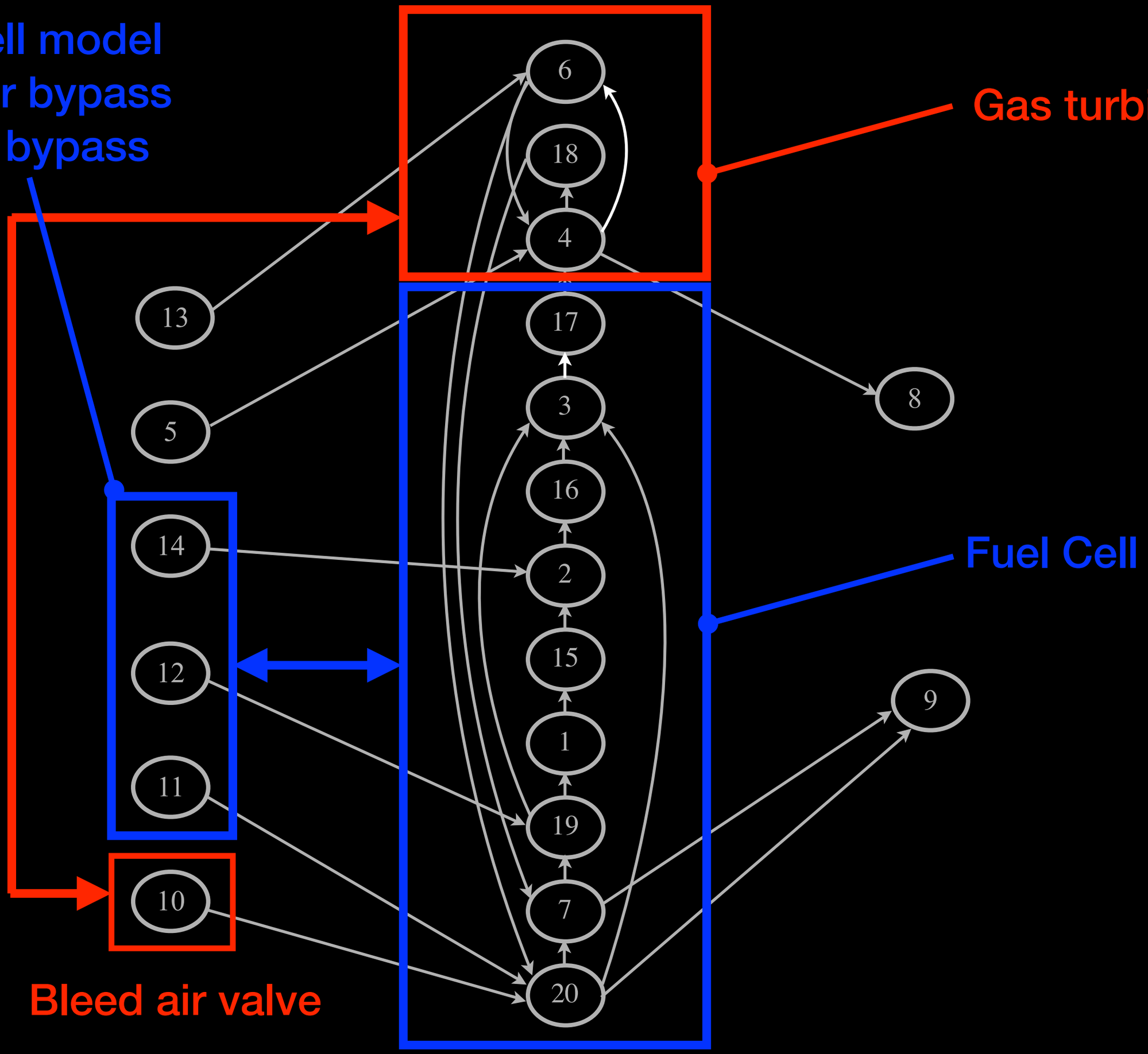


Fuel cell model
Cold air bypass
Hot air bypass

Gas turbine

Fuel Cell

Bleed air valve



<u>National Energy Technology Laboratory</u>

Paolo Pezzini

David Tucker

<u>University of Genova</u>

Alberto Traverso

<u>West Virginia University</u>

Larry Banta

<u>Ames Laboratory</u>

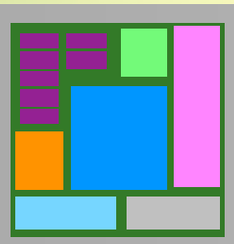
Daniel Bell

Kris Bryden

Peter Finzell

Doug McCorkle

Zach Reinhart



Collaborators

Mark Bryden

515-294-3891

kmbryden@iastate.edu