CINET[1] GDS-calculator
Graph Dynamical Systems Visualization

Group CINETgds
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Recap: What is GDS?

- GDS: Graph Dynamic Systems.
- Five elements:
  - Graph.
  - Vertices, which represent states.
  - Edges, which indicate interacting vertices.
  - Vertex functions, which quantify vertex state changes.
  - Update scheme: synchronous, sequential, block, etc.

Motivation

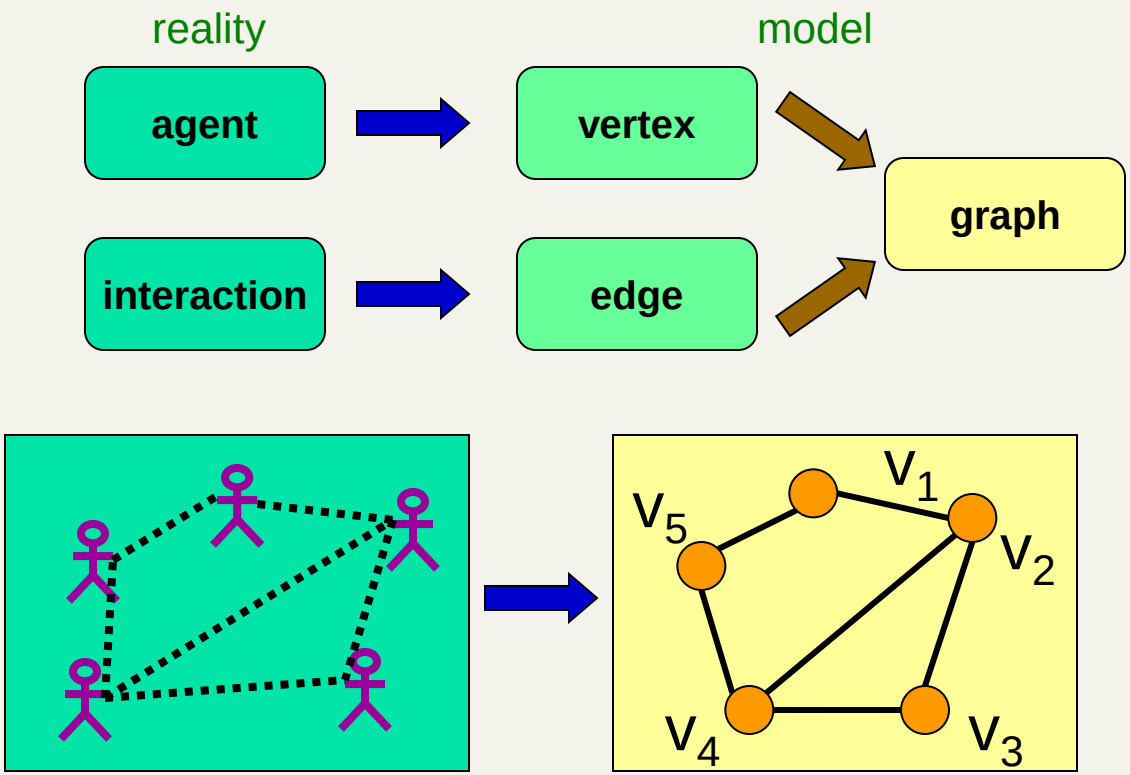
- System behaviors are of practical interest.
  - Examples
    - How epidemics spread.
    - How information spreads on Twitter.
- Understanding of system dynamics provides insights on how to control them.
  - Examples
    - How to minimize the spread of epidemics.
    - How to increase the probability that a marketing campaign goes viral.
    - How to encourage healthy youth behavior (e.g., avoid smoking, excessive drinking).

Arab Spring
Egyptian Rebellion, 2011
(Reuters)

Youth Smoking

Sociology and computer science community call these diffusing entities **contagions**.

GDS mapping: Reality to model



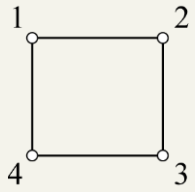
We are recasting the real problem in terms of a GDS

Have the model, then what?

- We are interested in the long term dynamical properties of the GDS system.
- Phase space reflects the long term dynamics.
  - Vertex state: For vertex i, we sign a state x_i from the state space, such as {0, 1}.
  - System state: states for all vertices, we write$x = \{x_1, x_2, \dots, x_n\}$.
  - Phase space describes the system state transitions.

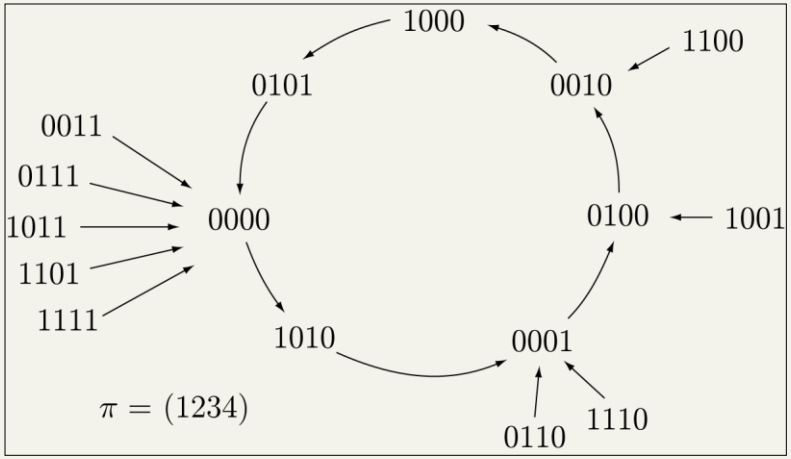
Phase space example

- **Inputs**
  - **Graph:** Circle$_4$

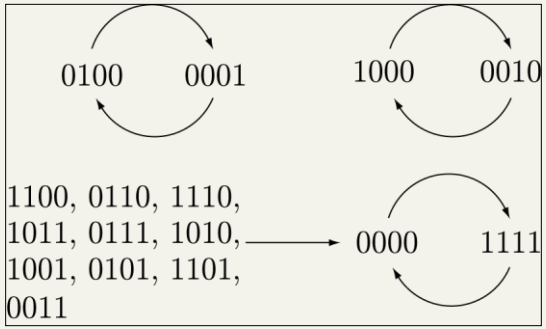


  - **Vertex state = {0,1}**
  - **Vertex functions:** nor$_3$
  - **Update scheme:**
    - Sequential with order (1,2,3,4)
    - Synchronous

Phase space: sequential update



Phase space: synchronous update

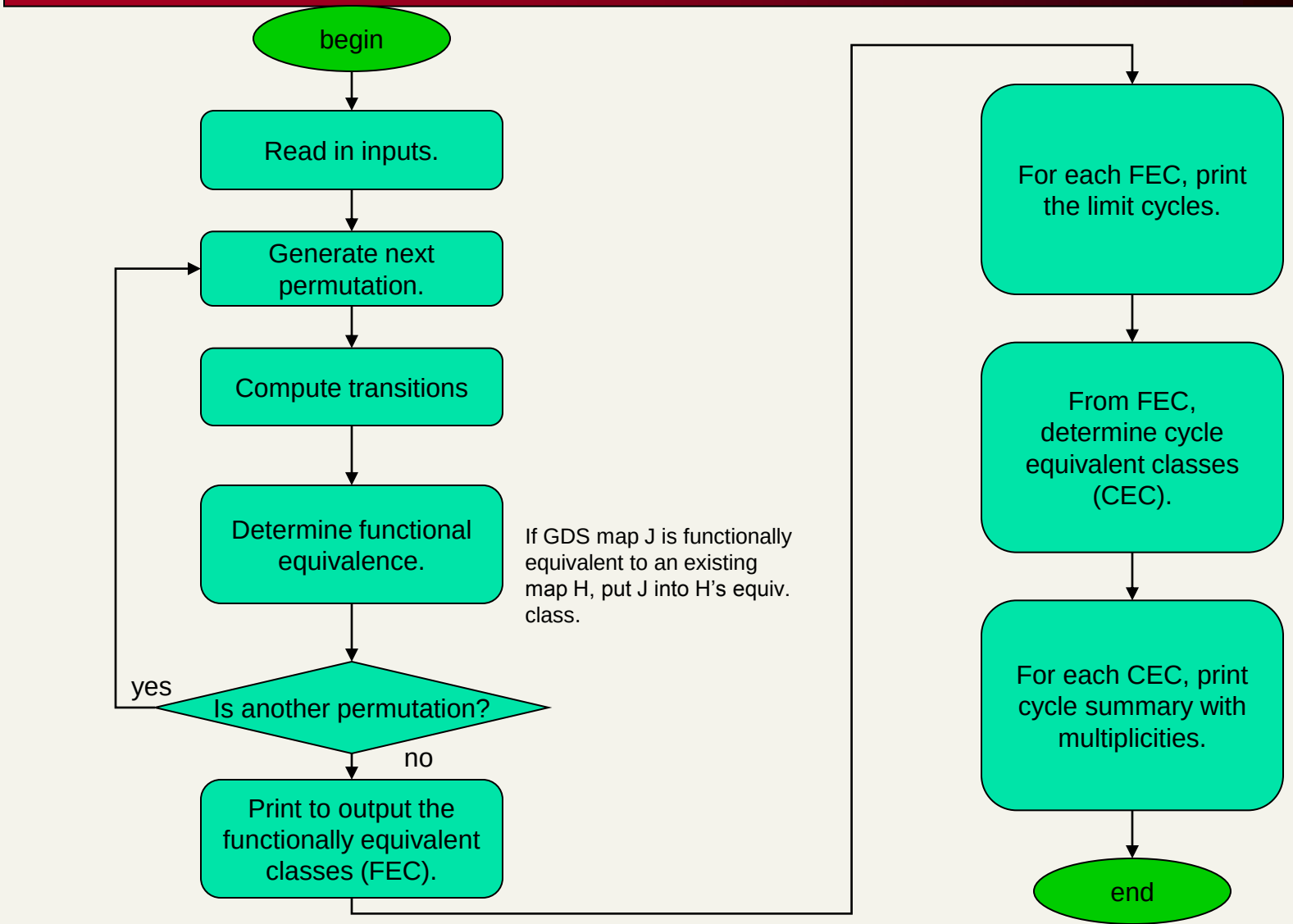


Character of phase space

- Functional equivalence (FE)
  - What GDS maps produce the same transitions for all system states?
- Dynamic equivalence (DE)
  - What GDS maps produce isomorphic sets of state transitions?
- Cycle equivalence (CE)
  - What GDS maps produce the same limit cycles?

$$FE \Rightarrow DE \Rightarrow CE$$

Phase Space Analysis



Task - Overview

- GDS calculator visualization system has three main tasks:
  - Visualizing bar charts.
  - Visualizing phase space transition graphs.
  - Exporting to graphs and charts to files.

Task – Visualizing bar chars

- Bar Charts we have implemented:
  - the number of cycles for each cycle equivalent set.
  - the number of permutations for each permutation equivalent set.
  - the number of cycles for each permutation.
  - the maximum cycle length for each permutation.
  - the number of permutations for a specific cycle length.

Task – Visualizing graphs

- Graph we have implemented:
  - functional state transitions.
  - cycle state transitions.
- Exporting to graphs and charts to files
  - Export bar charts: png, pdf.
  - Export graphs: png, ge.

Design – MVC Architecture

- View: visualization part for GDS-VIS System
  - visualizing bar charts.
  - visualizing state transition graphs.
- Controller: manipulating data in the Model
  - parsing configuration file to generate data.
  - managing data.
    - summarizing data to generate bar charts.
    - collecting data to generate graphs.
  - exporting graph to files.

Design - Model

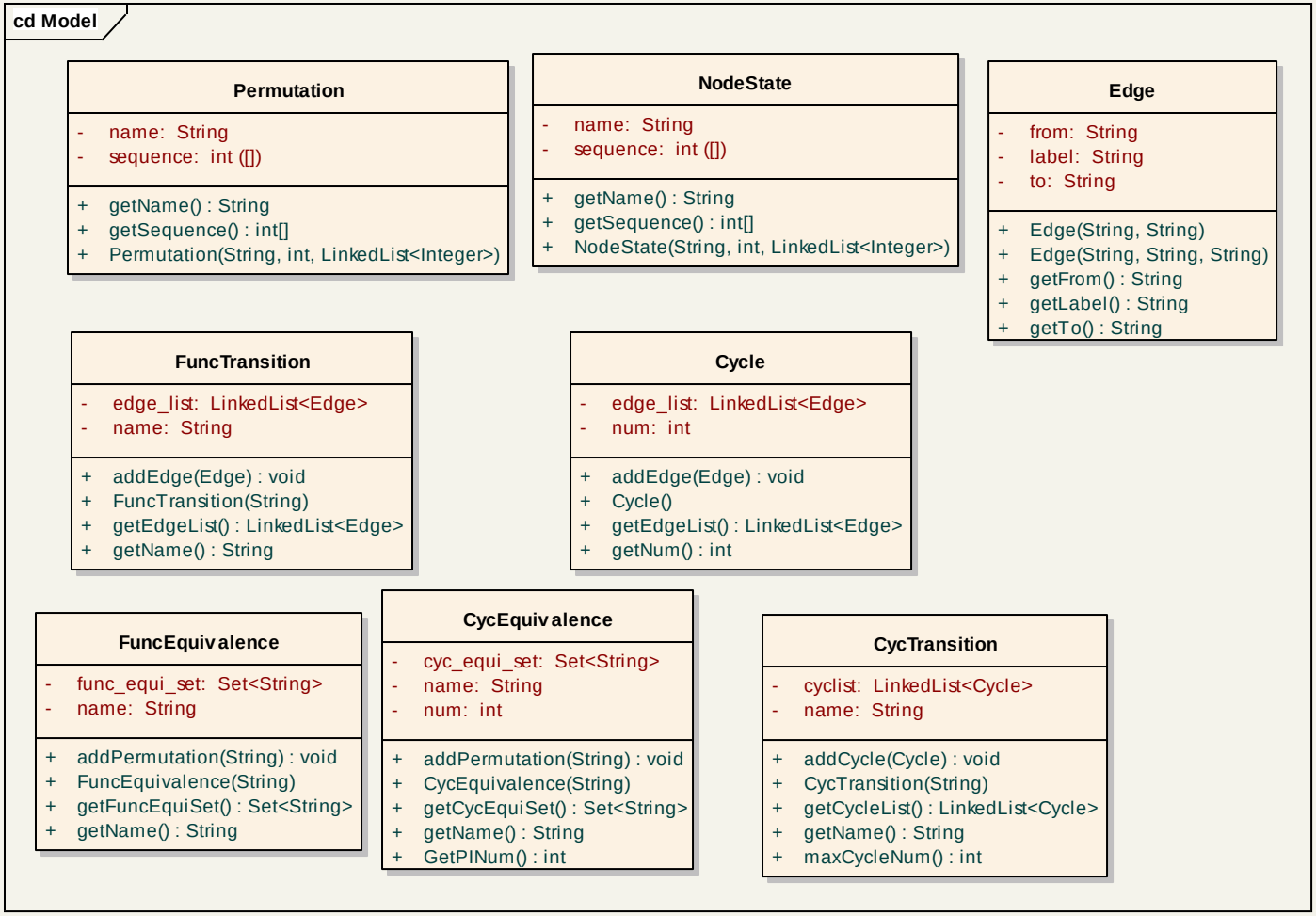
- Model: data used in GDS-VIS system
  - Permutation
  - Node state
  - Functional transition
  - Cycle transition
  - Functional equivalence
  - Cycle equivalence

Implementation - Environment

- Implementation environment:
  - Java version: JDK 1.7
  - IDE: Eclipse Juno
- Tools:
  - jdom: parsing XML files
  - jfreechart: visualizing bar charts
  - gephi-toolkit: visualizing state transformation grph
  - itext: exporting to pdf files

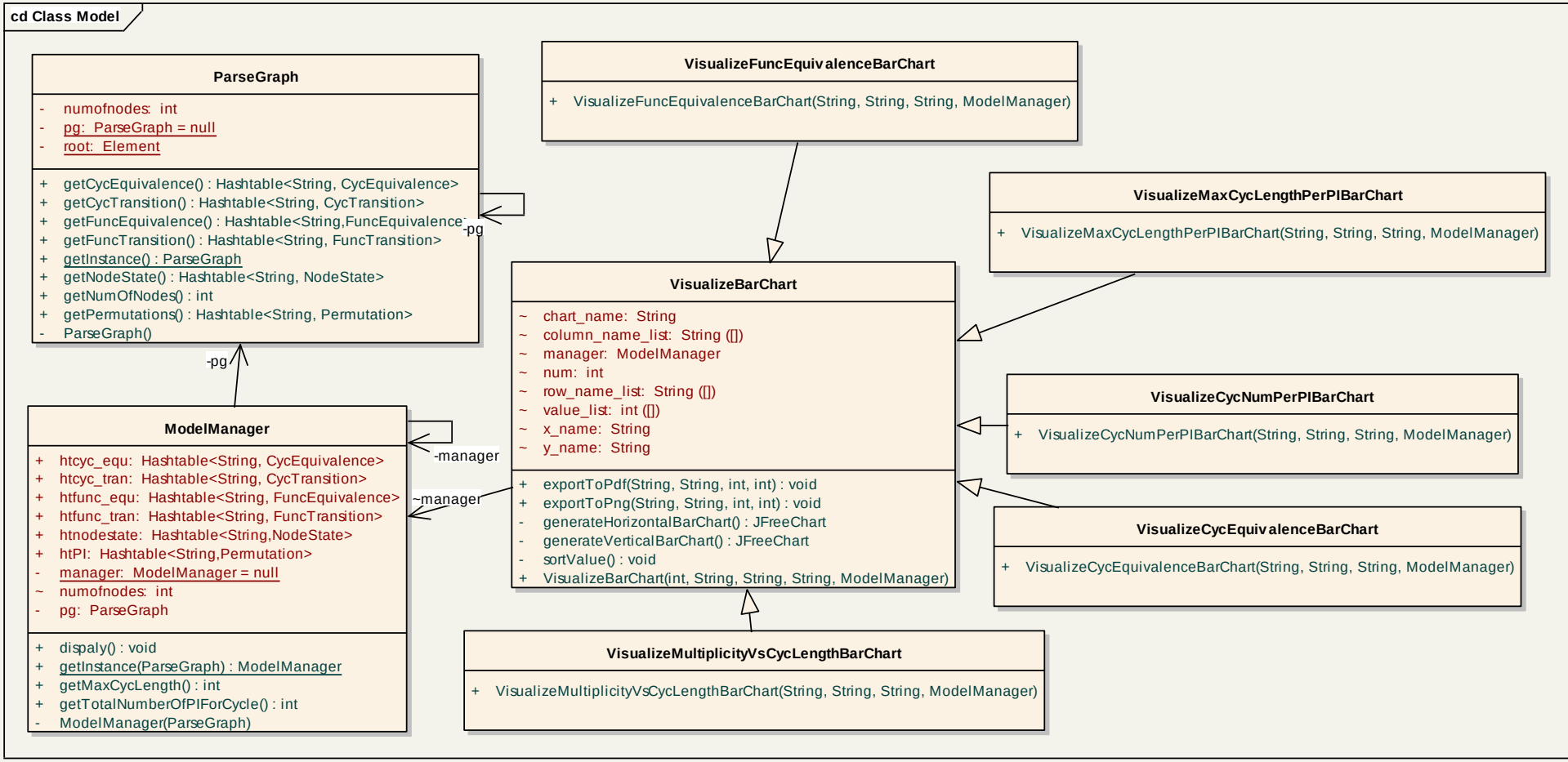
Implementation – Class diagram

- Model



Implementation – Class diagram

- Controller and View

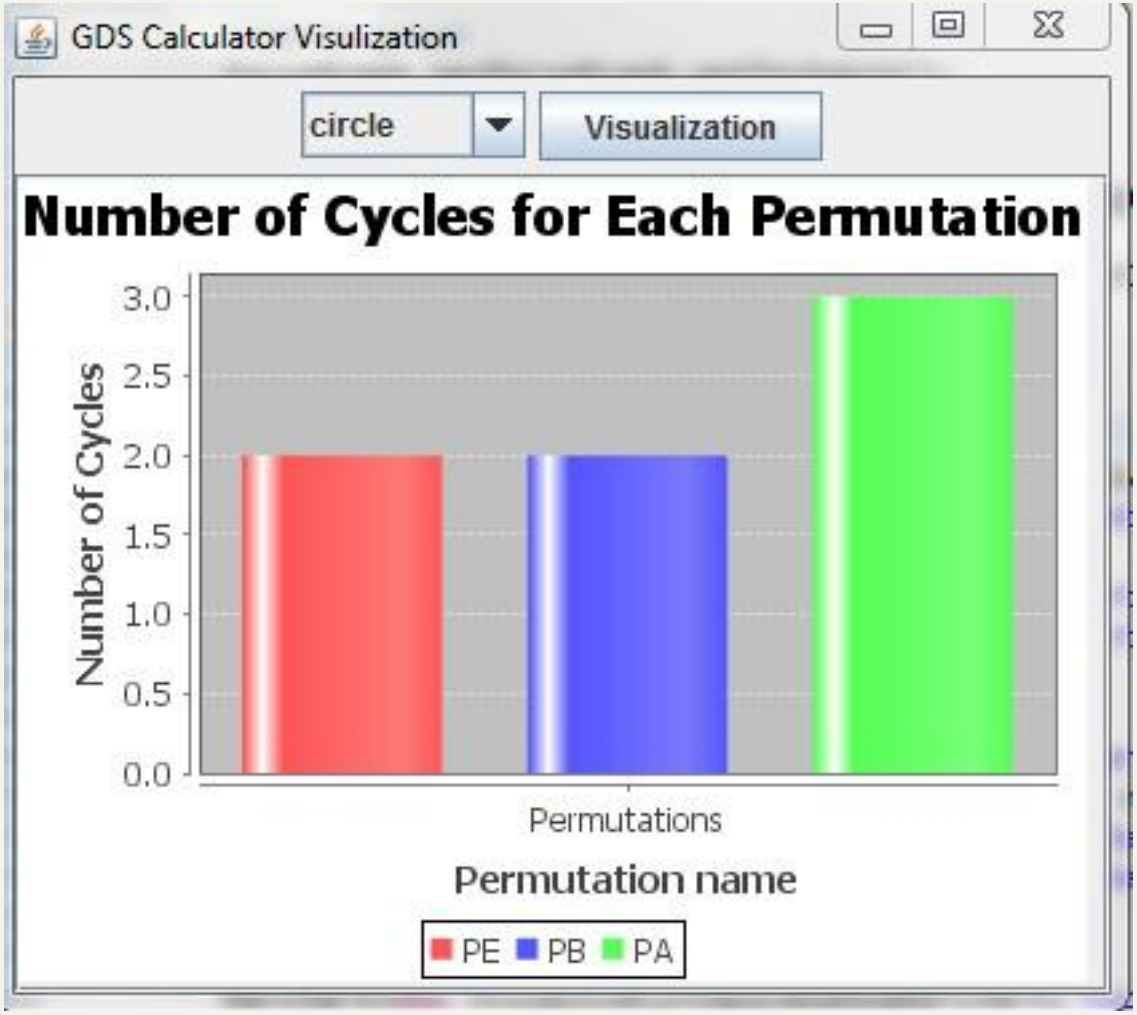


Implementation – Configuration file

```
<?xml version="1.0"?>
<GDS>
<graph>
    <numnodes>4</numnodes>
</graph>

<permutations>
    <permutation name="PA">
        <nodeid>0</nodeid>
        <nodeid>1</nodeid>
        <nodeid>2</nodeid>
        <nodeid>3</nodeid>
    </permutation>
</permutations>

<nodestates>
    <nodestate name="SA">
        <nodeid>0</nodeid>
        <nodeid>0</nodeid>
        <nodeid>0</nodeid>
        <nodeid>0</nodeid>
    </nodestate>
</nodestates>

<functional_equivalence>
    <class name="PB" >
        <member name="PB" />
        <member name="PD" />
        <member name="PJ" />
    </class>
</functional_equivalence>
```

```
<cycle_equivalence>
    <class name="PE" >
        <member name="PB" />
        <member name="PE" />
    </class>
</cycle_equivalence>

<cycle_transitions>
    <transition permutation="PA">
        <cycle>
            <edge>
                <from>SA</from>
                <to>SB</to>
                <label></label>
            </edge>
            <edge>
                <from>SB</from>
                <to>SA</to>
                <label></label>
            </edge>
        </cycle>
        <cycle>
            <edge>
                <from>SA</from>
                <to>SA</to>
                <label></label>
            </edge>
        </cycle>
    </transition>
</cycle_transitions>

</GDS>
```

Implementation - GUI



Future work

- Improving GUI implementation.
- Visualizing more statistical charts.
- Integrating with the CINET project.

Thanks