Flowbster: Dynamic creation of data pipelines in clouds

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Motivations for Flowbster

- Processing big data typically means to execute a set of tasks on a large data set
- These tasks are typically executed in a certain order
- Such an ordering of tasks can be represented as a Dataflow graph
- Such dataflow graphs can be executed by dataflow workflow systems
- The goal is to execute such dataflow workflow systems in clouds using as many cloud resources as needed (on-demand resource usage)
- The name of this new workflow system is **Flowbster**

Flowbster contra job-oriented workflow systems

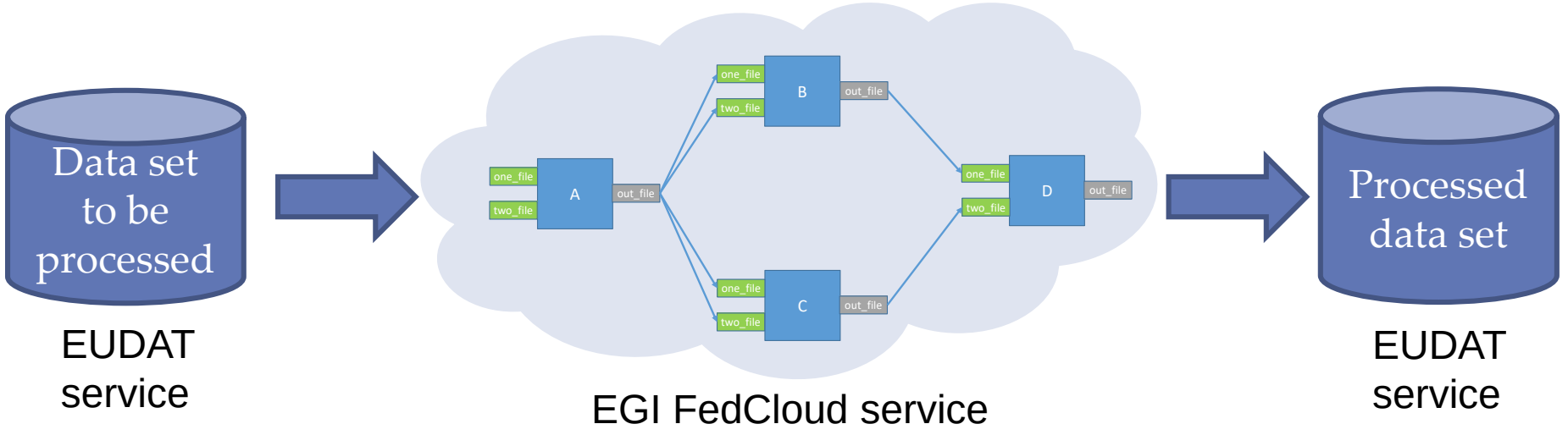
- Job-oriented workflow systems work based on service orchestration
- Nodes of a workflow represent jobs to be executed in the infrastructure
- There is a workflow enactor (orchestrator) that recognizes that a certain node/job can be executed and submits this job together with the required data
- The result data is typically transferred back to the enactor (or its storage)
- This execution mechanism is not optimal, requires to much data transfer

Flowbster contra job-oriented workflow systems

- In Flowbster there is no enactor, it works based on **service coreography**
- Nodes of the workflow directly communicate the data among them
- Data is passed through the workflow as a **data stream**
- A node is activated and executes the assigned task when all the input data arrived
- There is no useless data transfer
- Nodes of Flowbster workflows are deployed in the cloud as VMs and they exist until all the input data sets are processed
- As a result a Flowbster workflow works as a temporary **virtual infrastructure deployed in the cloud**
- Input data sets flow through this virtual infrastructure and meanwhile they flow through they are processed by the nodes of the workflow

Concept of Flowbster

- The goal of Flowbster is to enable
  - The quick deployment of the workflow as a pipeline infrastructure in the cloud
  - Once the pipeline infrastructure is created in the cloud it is activated and data elements of the data set to be processed flow through the pipeline
  - As the data set flows through the pipeline its data elements are processed as defined by the Flowbster workflow



Structure of the Flowbster workflow system

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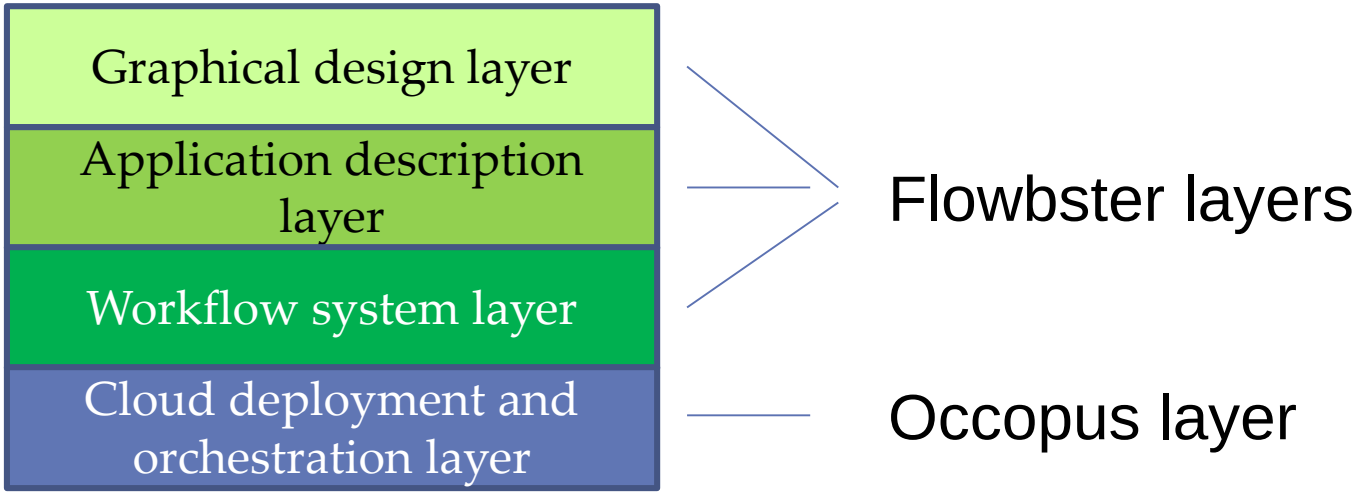
- Goal:
  - To create the Flowbster workflow in the cloud without any cloud knowledge
- Solution:
  - To provide a layered concept where users with different expertise can enter to the use of Flowbster
- 4 layers:



Occopus Layer

- Occopus is a cloud orchestrator and manager tool
- It automatically deploys virtual infrastructures (like Flowbster workflows) in the cloud based on an Occopus descriptor that consists of:
  - **Virtual infrastructure description**:
    - Specifies the **nodes** (services) to be deployed and all **cloud-independent** attributes e.g. input values for a service.
    - Specifies the **dependencies** among the nodes, to decide the order of deployment
    - Specifies **scaling** related attributes like min, max number of instances
  - **Node definition:**
    - Defines **how to construct the node** on a target cloud. This contains all **cloud dependent** settings, e.g. image id, flavour, contextualization
- See detailed tutorials at the Occopus web page:
  - http://occopus.lpds.sztaki.hu/tutorials

Flowbster Workflow System Layer

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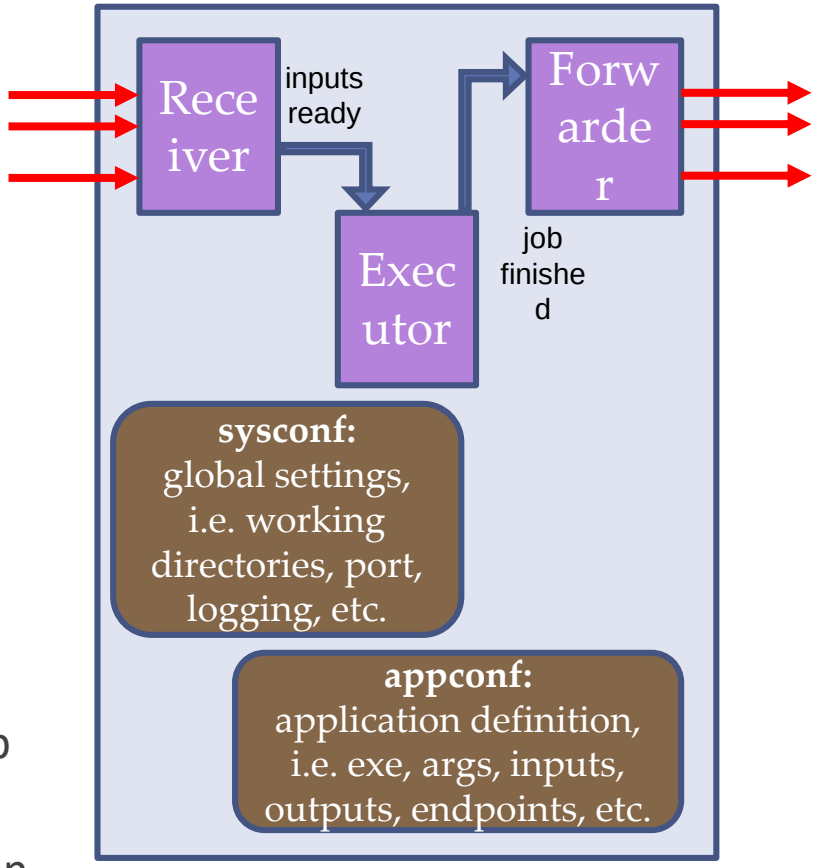
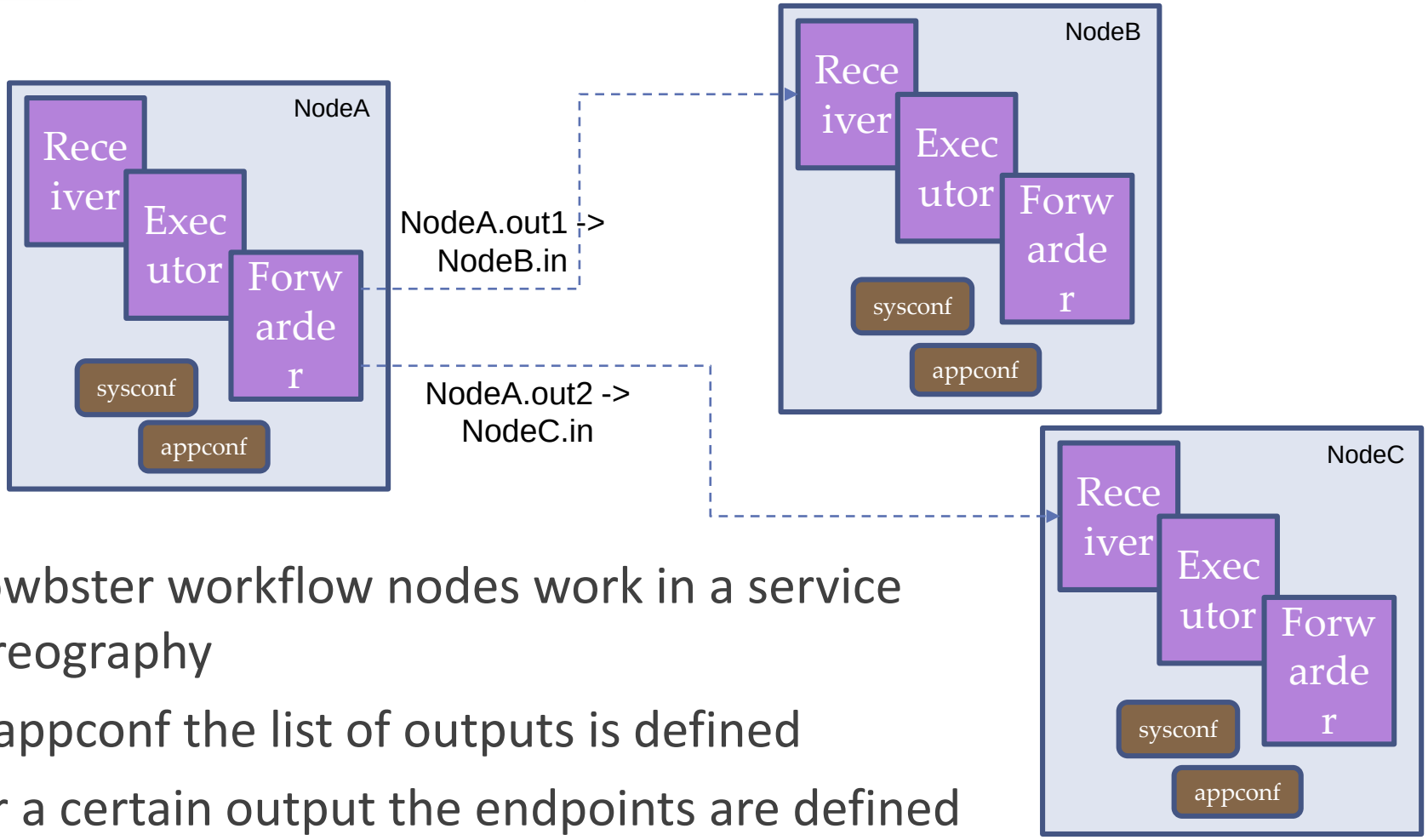
- Contains uniform Flowbster workflow nodes which have the internal structure shown in the figure
- Every node provides the following actions:
  - Receives and keeps track of the input items
  - Executes the (pre-) configured application when inputs are ready
  - Identifies and forwards results of execution towards a (pre-) configured endpoint
- Contains 3 components:
  - Receiver: service to receive inputs
  - Executor: service to execute predefined app
  - Forwarder: service to send results of the finished app to a predefined remote location



Also requires 2 config files in order to costumize the node according to the workflow definition

Connecting Flowbster nodes into a workflow



- Flowbster workflow nodes work in a service coreography
- In appconf the list of outputs is defined
- For a certain output the endpoints are defined
- An endpoint must point to a receiver node

Flowbster Graphical Design Layer

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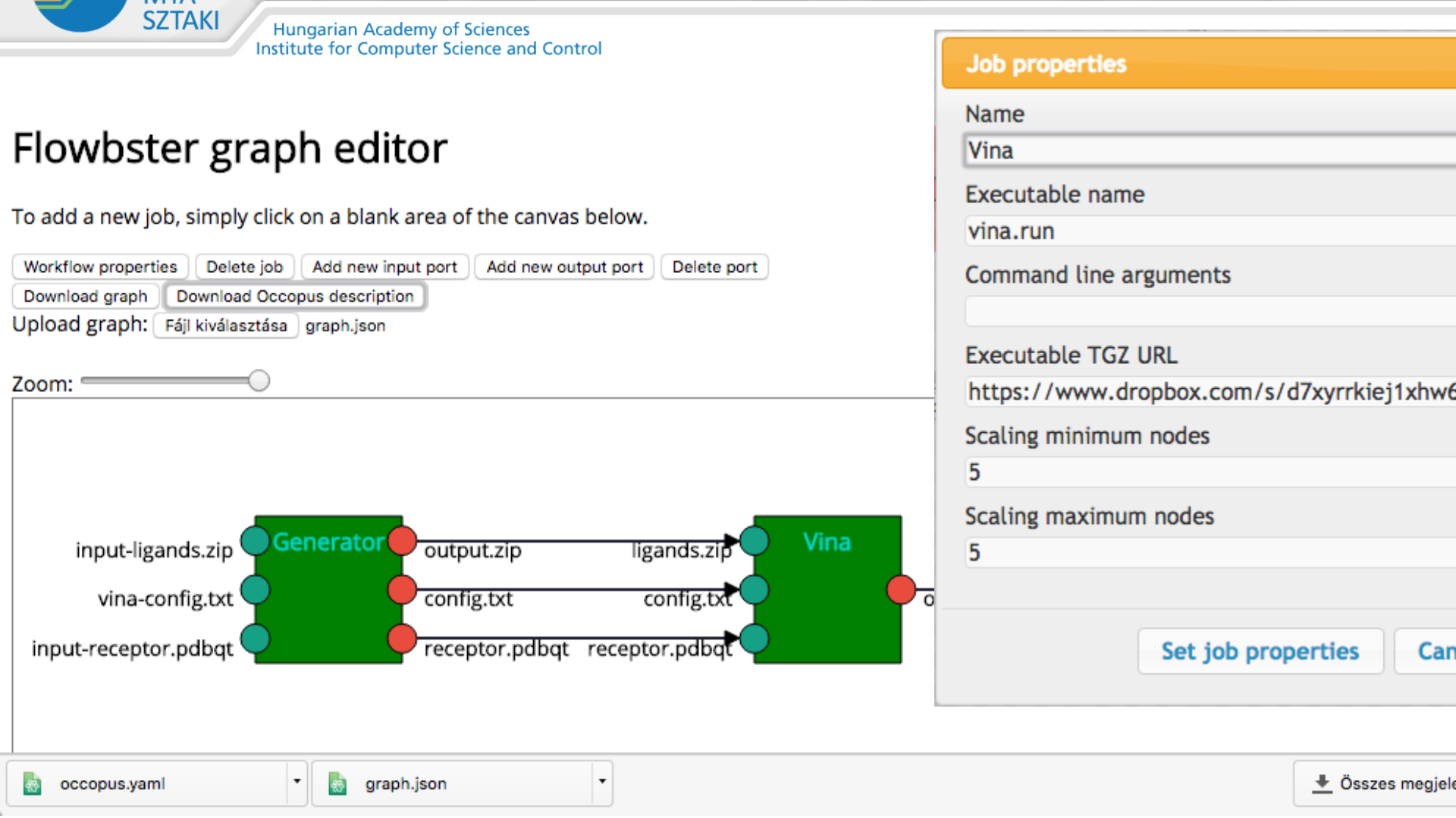

Flowbster Graphical D

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Flowbster graph editor

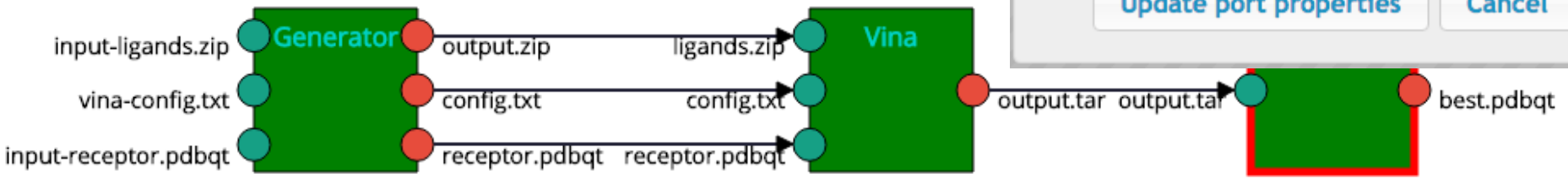
To add a new job, simply click on a blank area of the canvas below.

Workflow properties | Delete job | Add new input port | Add new output port | Delete port

Download graph | Download Occopus description

Upload graph: Fájl kiválasztása graph.json

Zoom:



occopus.yaml | graph.json | Összes megjele

Port properties

Name: output.tar

Target IP

Target port

Generator port

Filter regexp

Distribution

Update port properties | Cancel

Flowbster Application Description Layer

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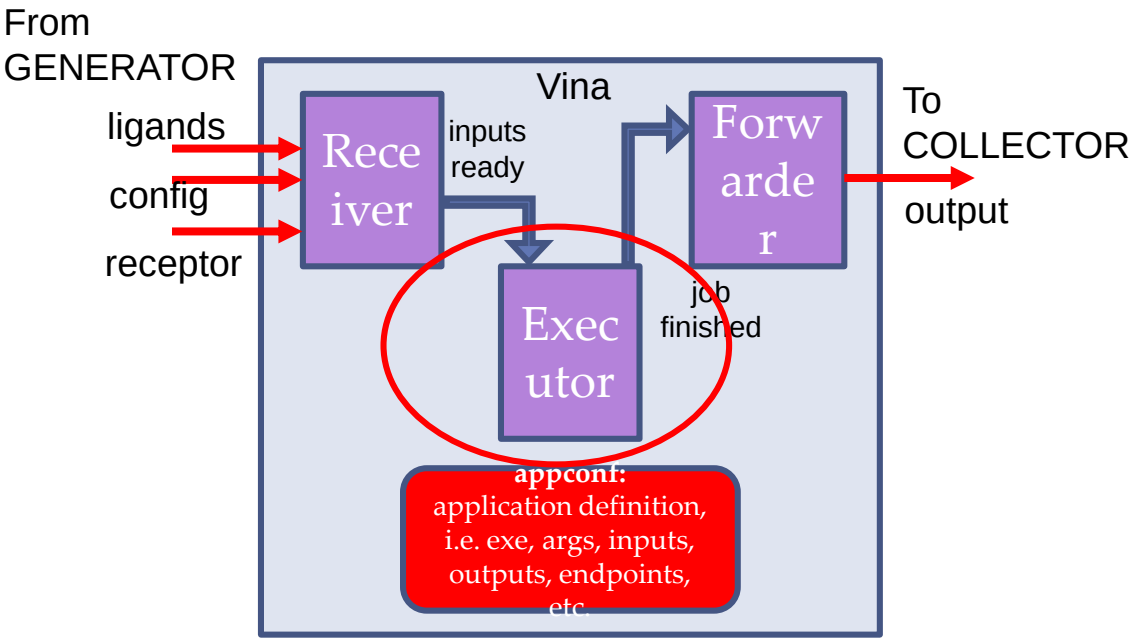
- **Automatically generated from the graphical view**
- It contains the Occopus descriptor of the Flowbster workflow
  - Virtual infrastructure descriptor representing the workflow graph
  - Customized node definitions for each node of the workflow. E.g. Vina node:




```
- &Vina
    name: Vina
    type: flowbster_node
    scaling:
        min: 5
        max: 5
    variables:
      jobflow:
        app:
          exe:
            filename: vina.run
            tgzurl: http://foo.bar/vina.tgz
          args: "
          in:
            -
              name: ligands.zip
            -
              name: config.txt
            -
              name: receptor.pdbqt
          out:
            -
              name: output.tar
              targetname: output.tar
              targetnode: COLLECTOR
```

Define parallellism

Feeding and gathering data set elements

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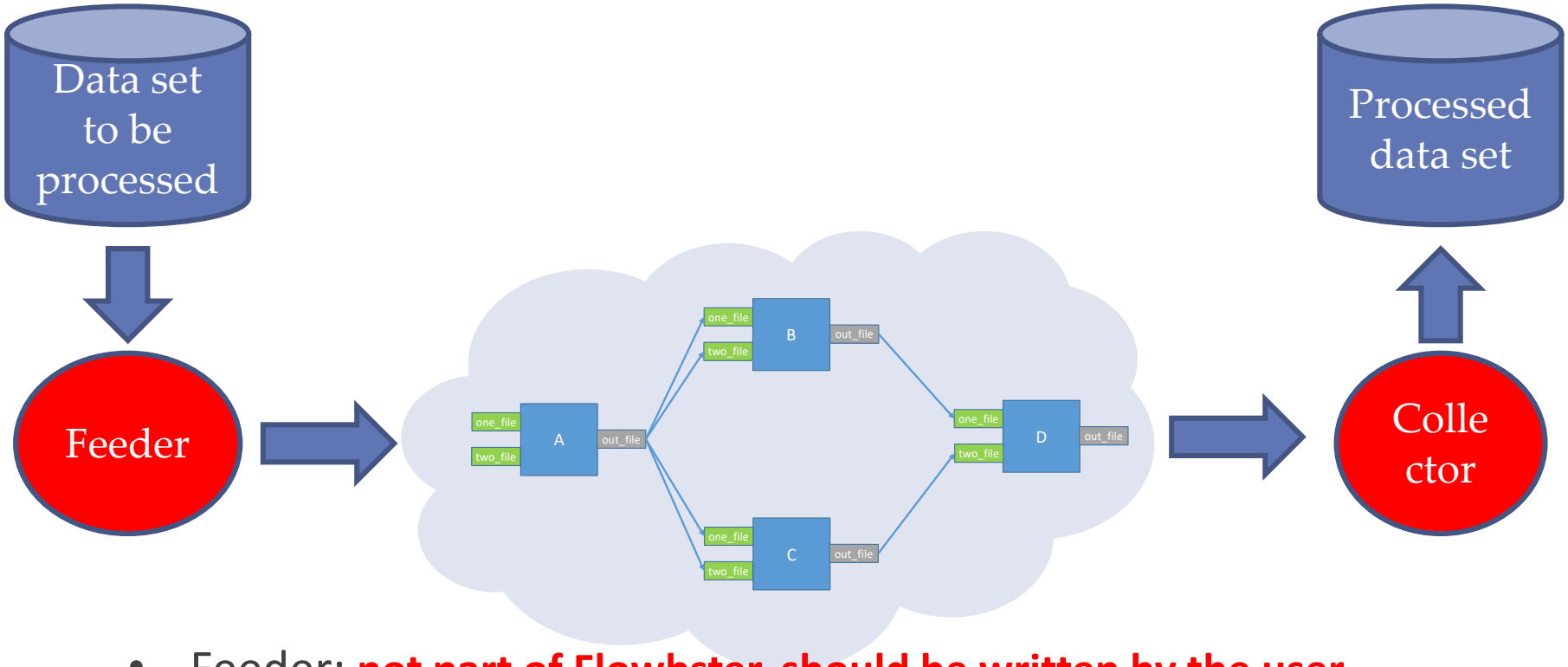
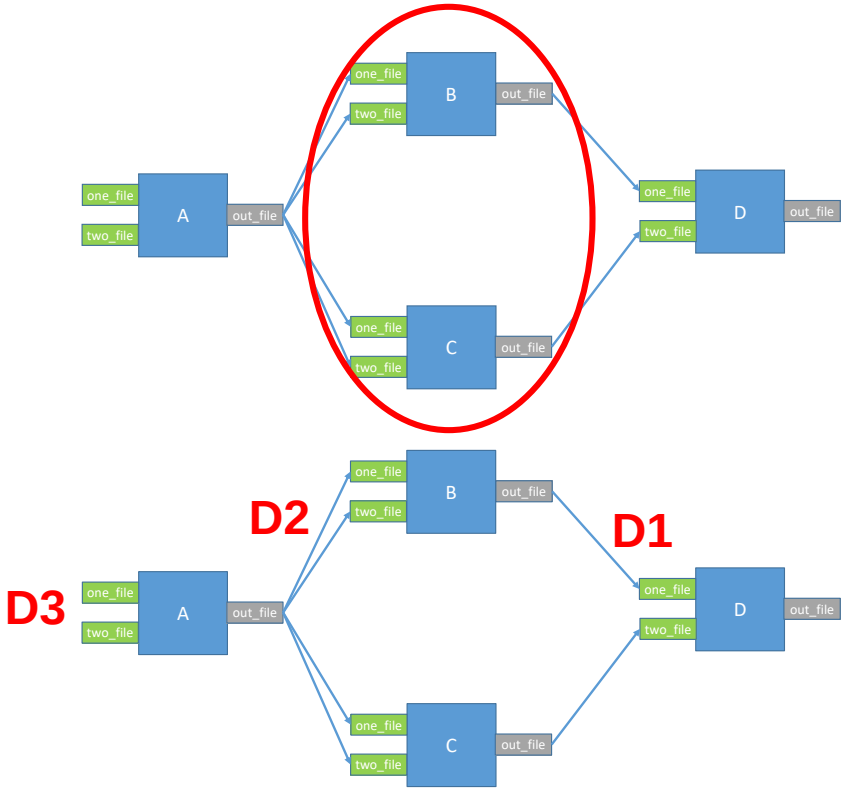


- Feeder: **not part of Flowbster, should be written by the user**
  - Command line tool
  - Feeds a given node/port of Flowbster workflow with input data items
- Collector: **not part of Flowbster, should be written by the user**
  - Web service acting as a receiver
  - Transfers the incoming data items into the target storage

Exploitable parallelisms in Flowbster

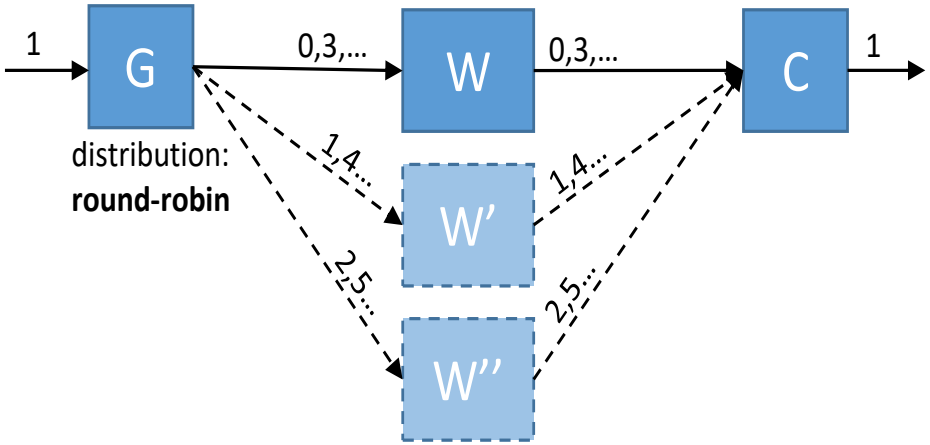
- **Parallel branch parallelism**
- **Pipeline parallelism**
- **Node scalability parallelism**



Node scalability parallelism in Flowbster

Generator-Worker-Collector parameter sweep processing pattern:

- The Generator generates N output data from 1 input data
- The Worker should be executed for every input data -> **N Worker instances can run in parallel** for processing the N data
- The Collector collects the N results coming from the N Worker instances and after processing them creates 1 output data



Heterogeneous multi-cloud setup of Flowbster in EGI FedCloud

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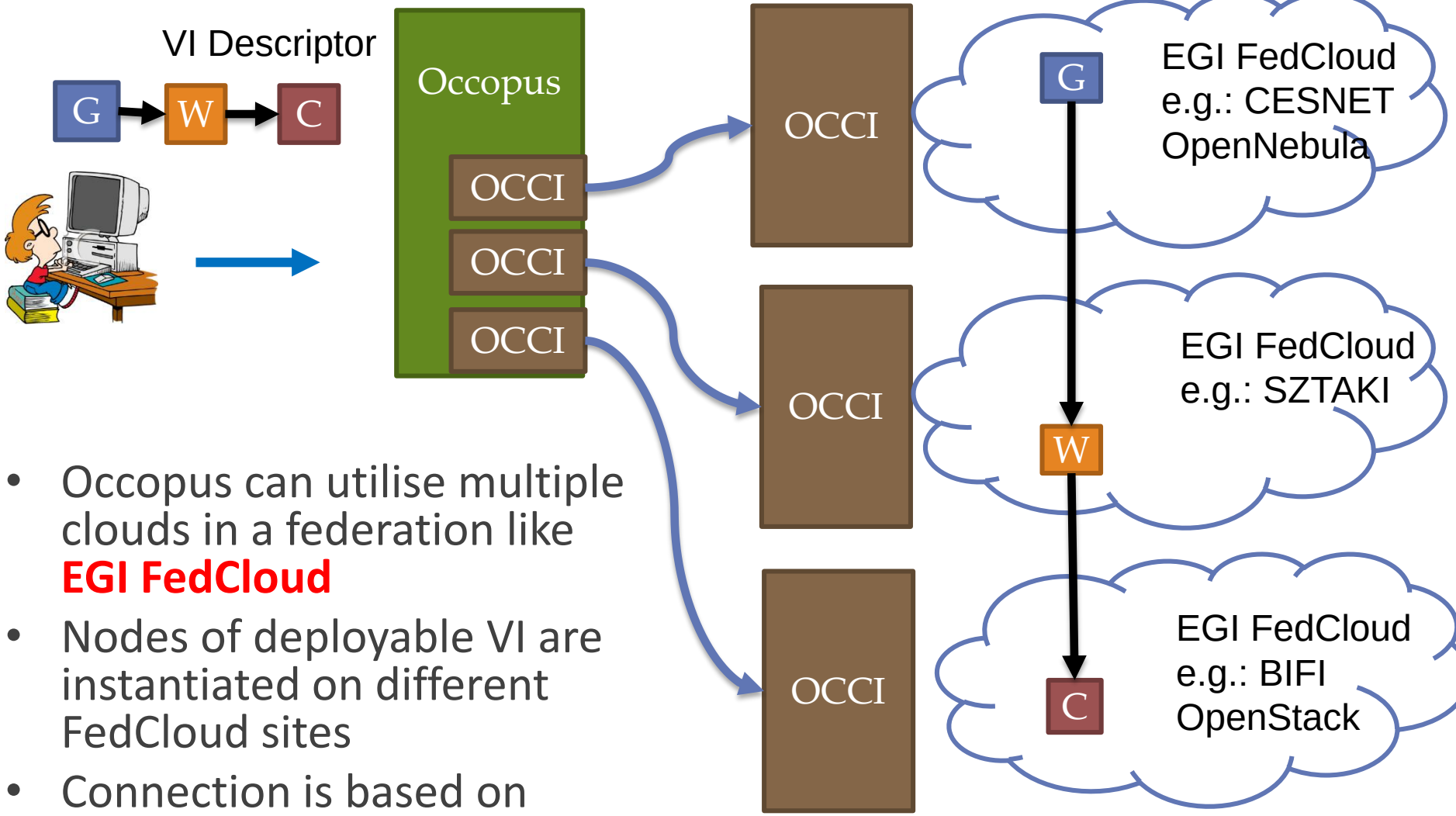

- Occopus can utilise multiple clouds in a federation like **EGI FedCloud**
- Nodes of deployable VI are instantiated on different FedCloud sites
- Connection is based on public ips

Performance measurements

- Experiment with Autodock Vina Workflow
- **Question:** What speedup can be achieved by node scalability parallelism?
- 256 docking simulation having 2, 4, 8 and 16 instances of the Vina (worker) node

Case (number of Vina node instances)	Makespan (minutes)
2	8
4	5
8	3
16	2

Current state of Occopus

- Open-source (License: Apache v2)
- 6 releases so far (latest in August 2016)
- **Now: Release v1.2 (3rd production release)**
- Python 2.7
- Base webpage: http://occopus.lpds.sztaki.hu
- Git: https://github.com/occopus
- Documentation:
  - Users' Guide
  - Developers' Guide
  - Tutorials (e.g. building docker/swarm cluster)
- Package repository: http://pip.lpds.sztaki.hu/packages

Current state of Flowbster

- Open-source (License: Apache v2)
- Running prototype
- **First release comes in October 2016**
- Available at Git: https://github.com/occopus
- Documentation under development:
  - Users' Guide
  - Developers' Guide
  - Tutorials
- Further development plans
  - Dynamic scalability for node scalability parallelism
  - Built-in error diagnostic and fault-recovery mechanism