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CORE – COmmon Reference Environment

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Outline

- Introduction
- CORE Design
- CORE Architectural Components
- Illustration of CORE Platform
- Case studies
- CORE Follow-up

Introduction

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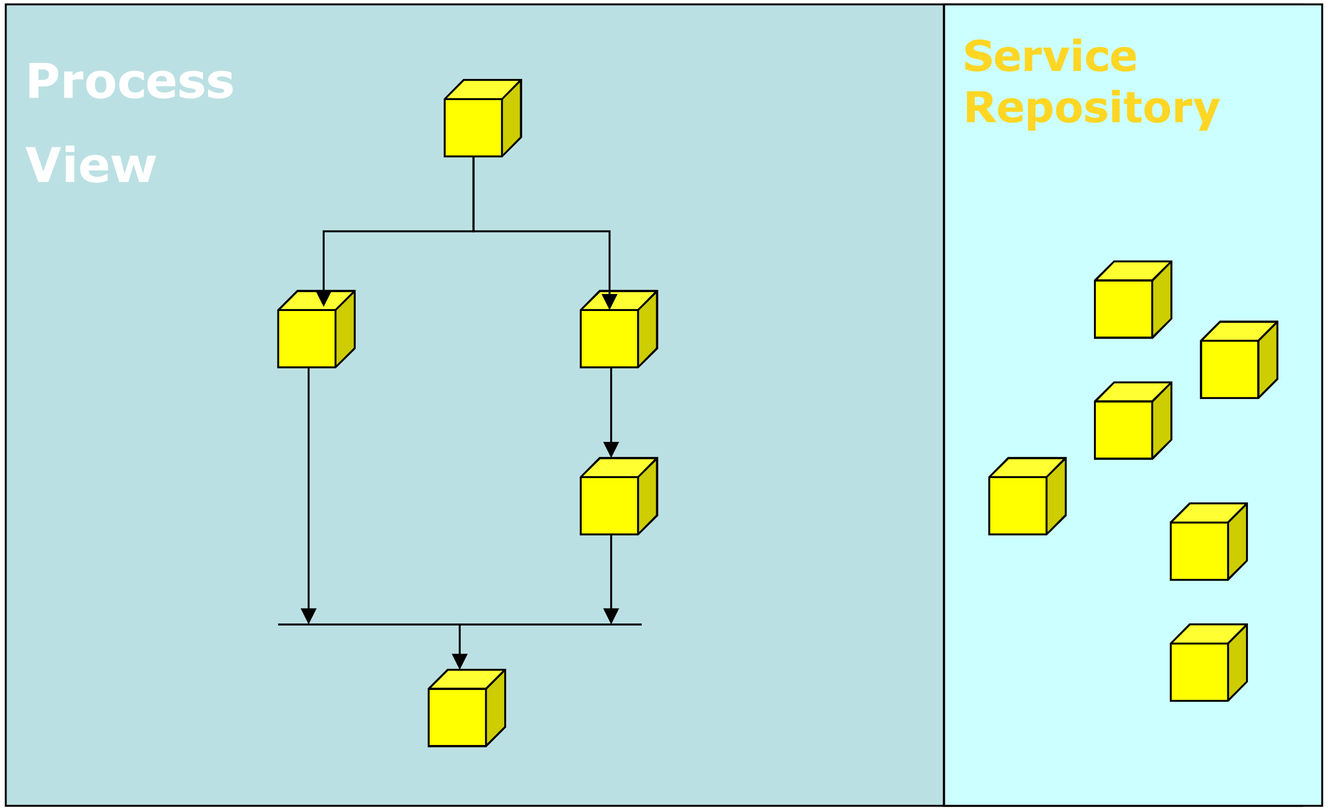
CORE Generalities

- Principal Outcome: Environment for the definition and execution of standard statistical processes
  - **Definition of a process in terms of available services**
  - **Execution of the composed workflow**

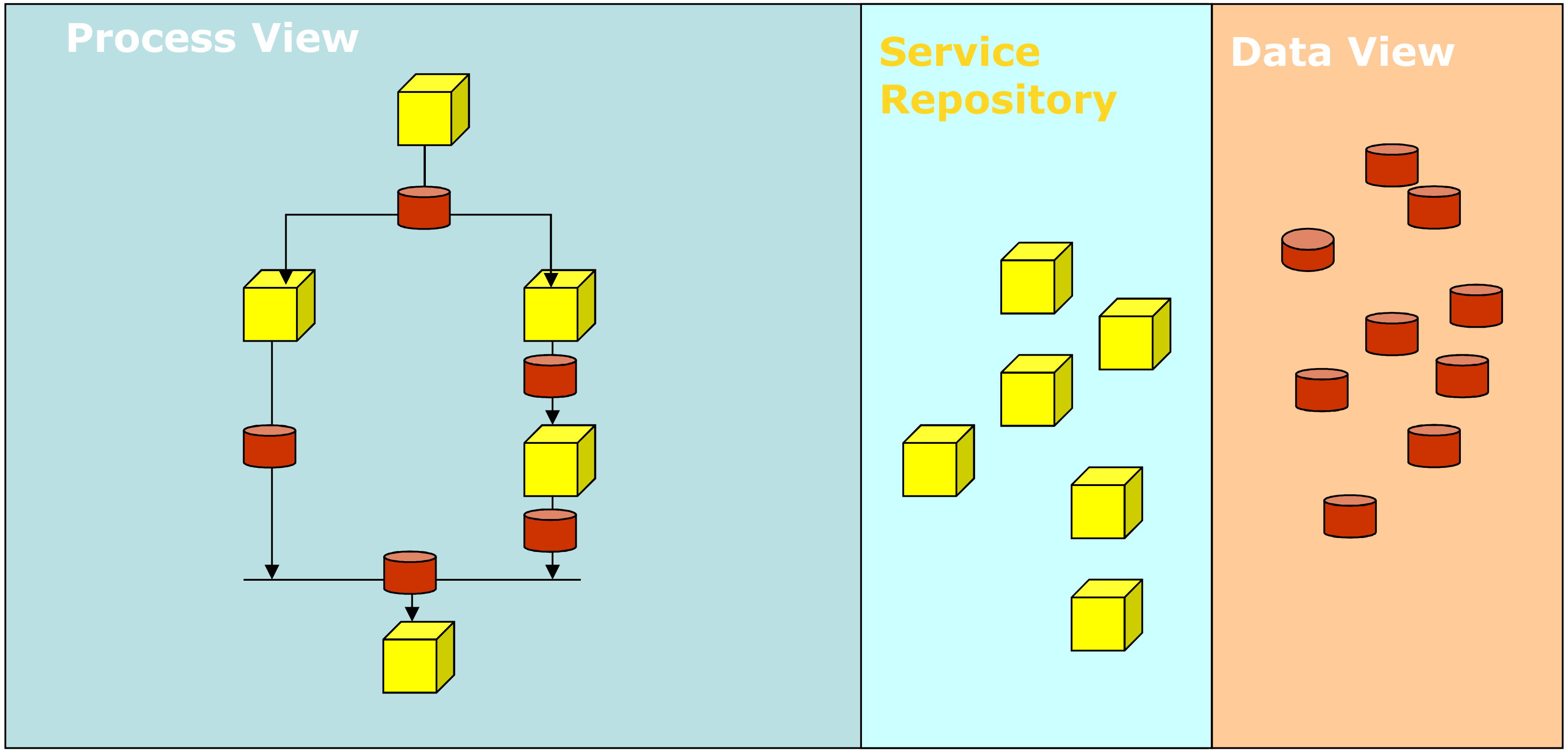
CORE Generalities

"Plug and play" approach to process execution

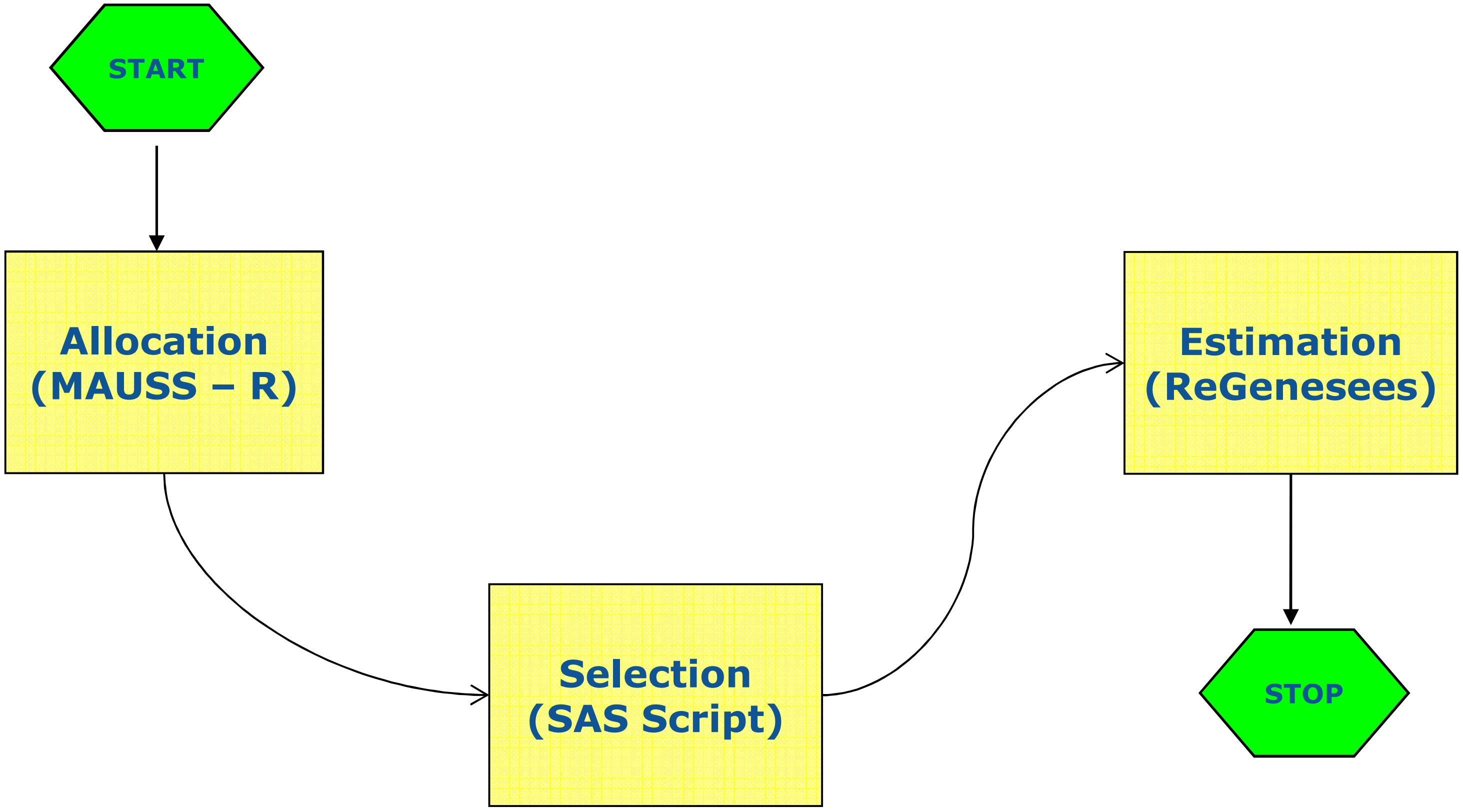


CORE Generalities

“Plug and play” approach to process execution



Why CORE?


START
Allocation
(MAUSS – R)
Selection
(SAS Script)
Estimation
(ReGenesees)
STOP

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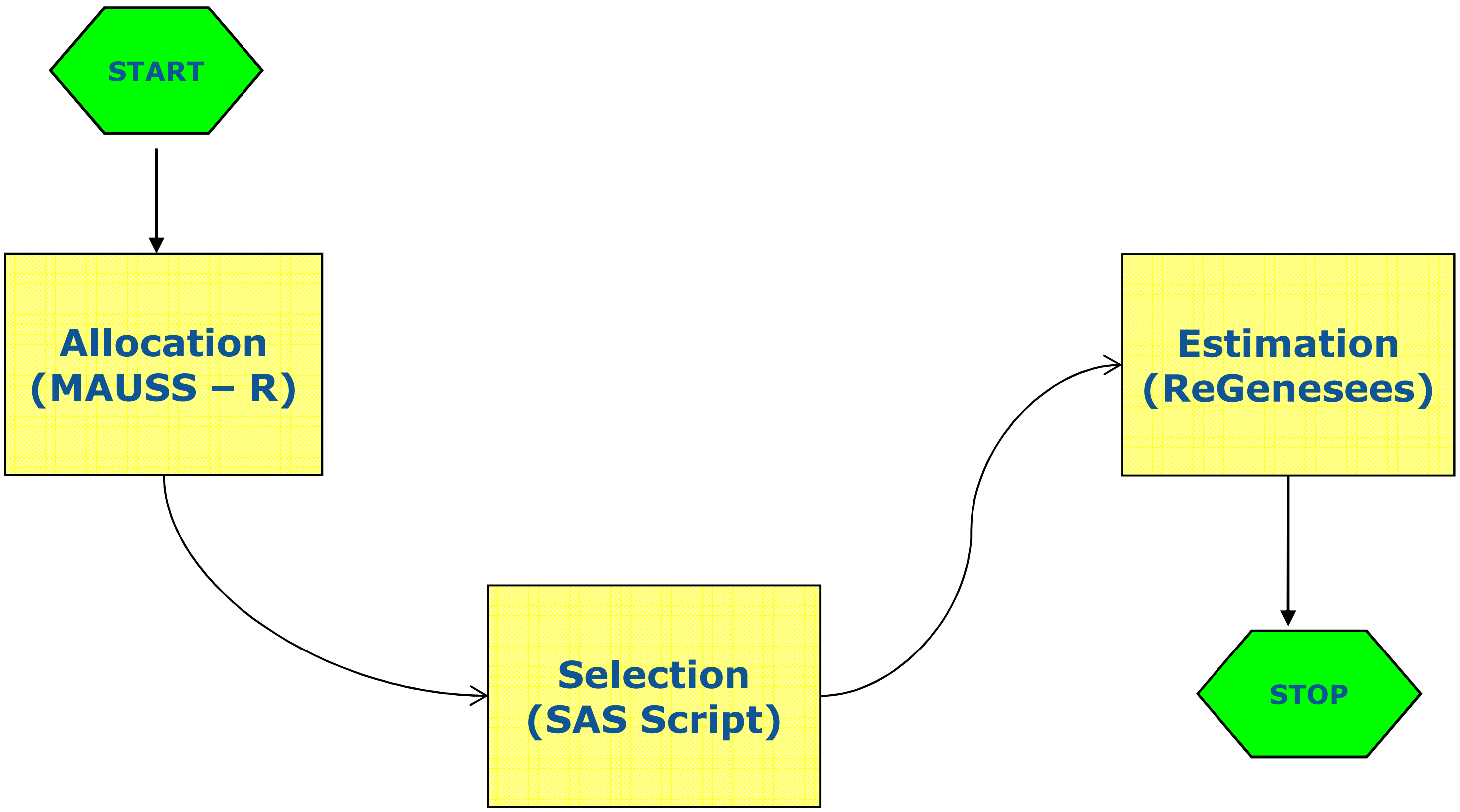
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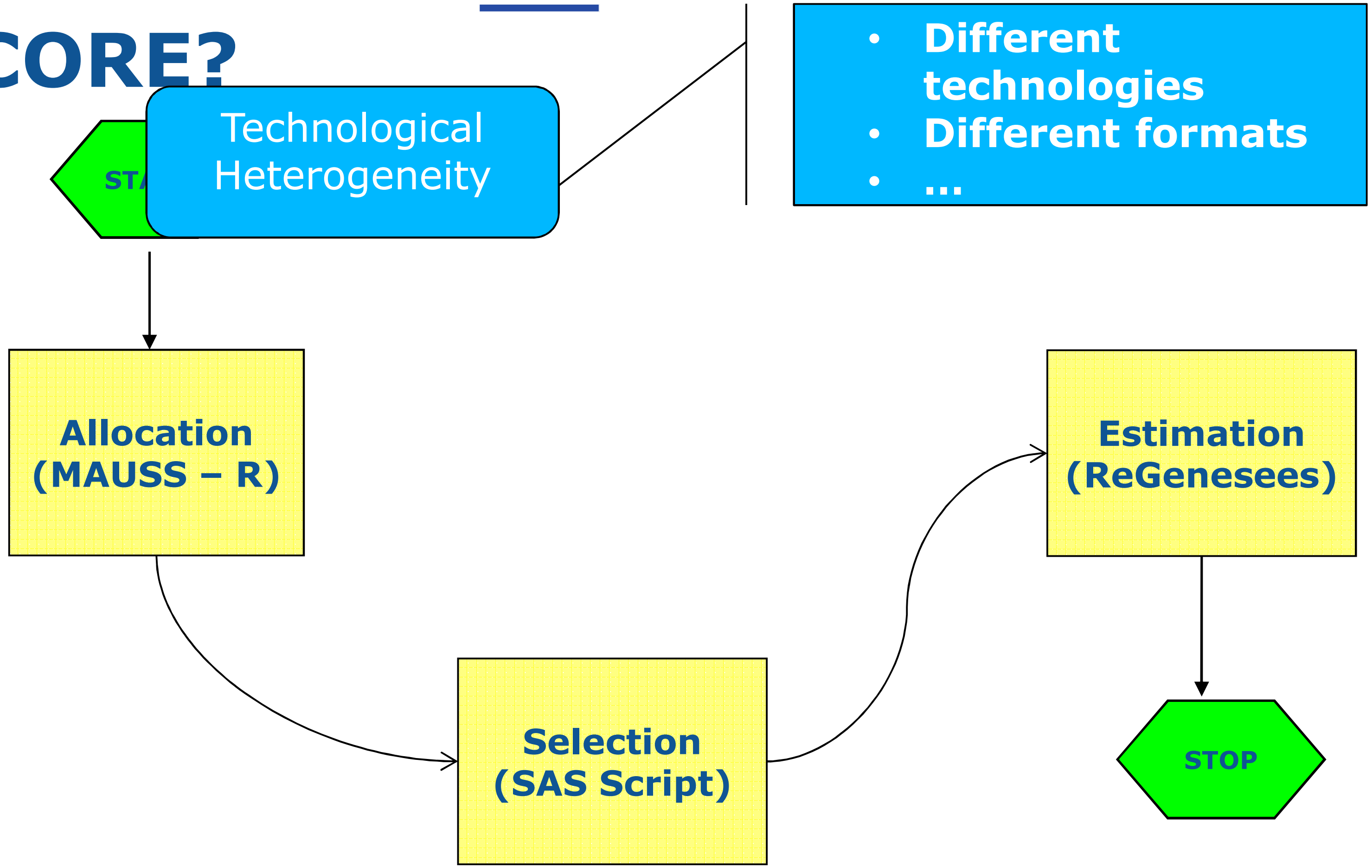
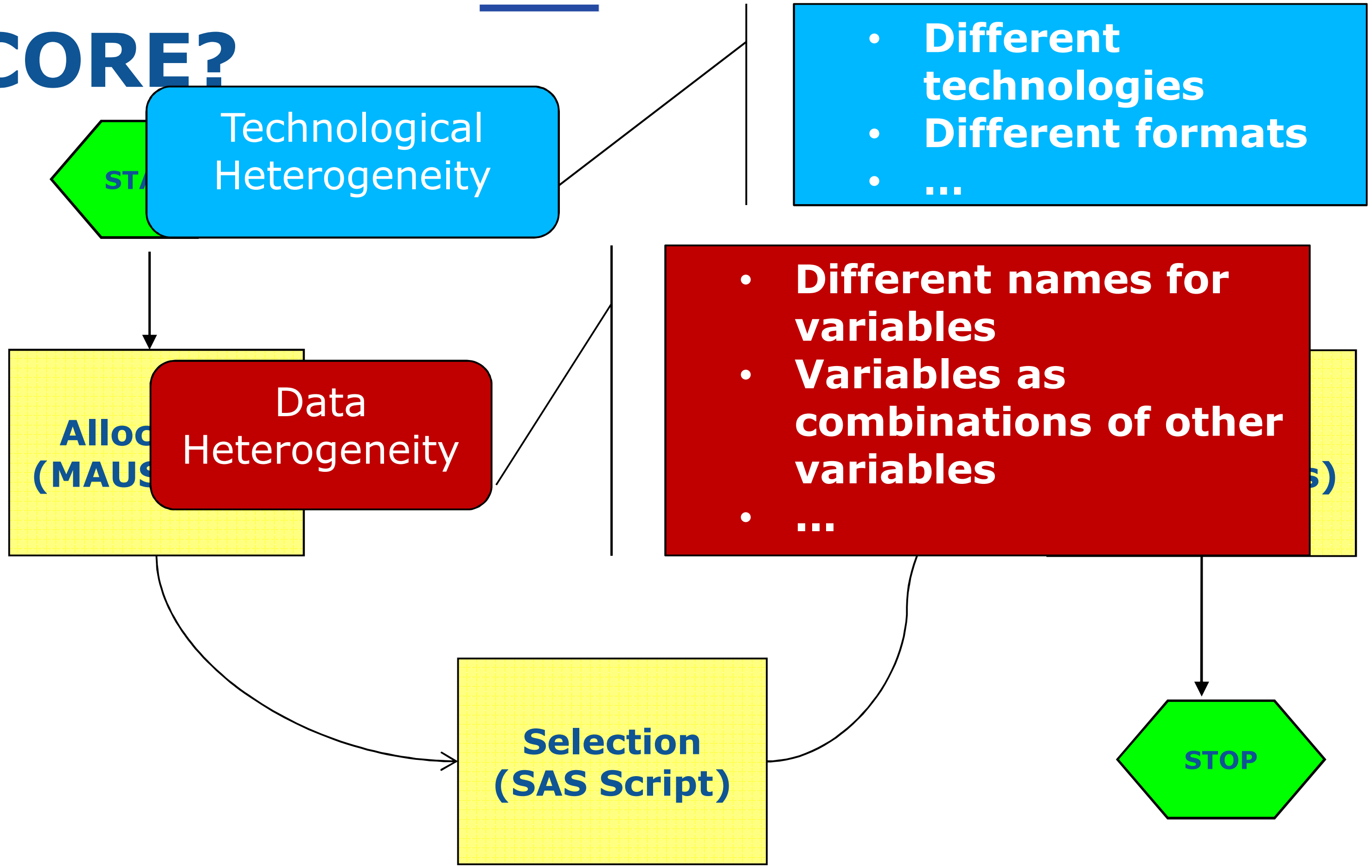

Technological Heterogeneity
• Different technologies
• Different formats
• ...
Allocation (MAUSS – R)
Selection (SAS Script)
Estimation (ReGenesees)
STOP

Why CORE?


Technological
Heterogeneity
• Different technologies
• Different formats
• ...
Data
Heterogeneity
• Different names for variables
• Variables as combinations of other variables
• ...
Selection
(SAS Script)
STOP

Why CORE?

- Technological heterogeneity can be solved by solutions available on the market

CORE permits to solve both technological and data heterogeneity in a single environment

CORE Vision

1. **Abstract services**: *well-defined*, *technology-independent* functionalities implemented by different IT tools;
2. **Statistical process**: workflow defined in terms of available services;
3. **Data model**: *standardization* of the semantics/format of services data, i.e. definition of the domain entities involved as input/output between services.

CORE Vision

1. Abstract services: well-defined, technology-independent functionalities implemented by IT tools

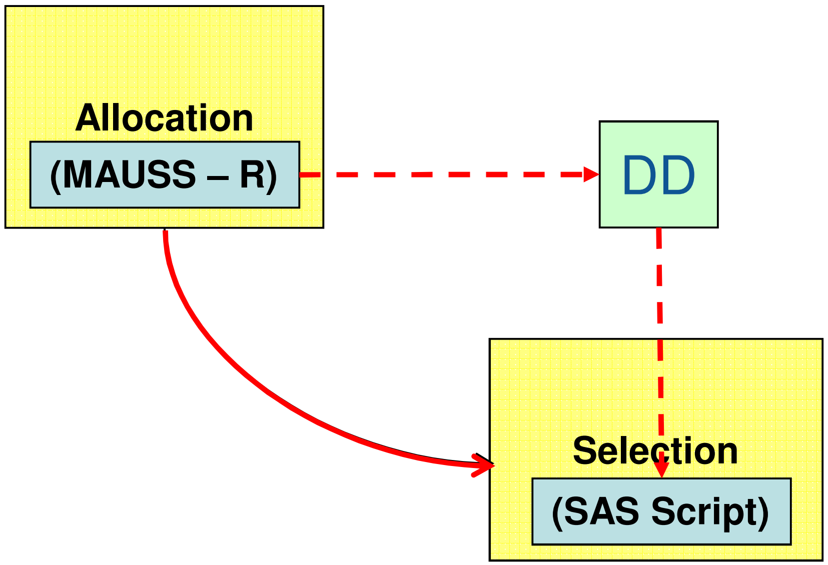
Allocation
(MAUSS – R)

Estimation
(ReGenesees)

Selection
(SAS Script)

CORE Vision

3. Data model: *standardization* of the semantics/format of services data



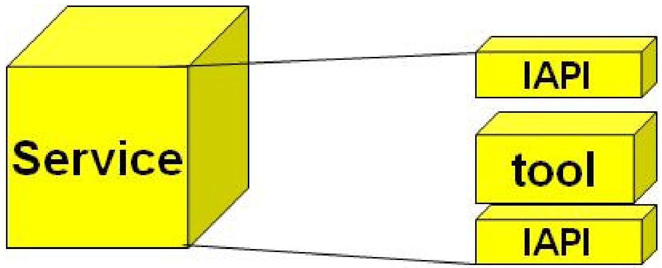
3.1 Domain descriptor (DD)

```
<schema name="DEMO_DD">
   <entity name="SamplePlan">
       <property name="VAR"/>
       <property name="SIZE"/>
  . . .
</entity>
</schema>
```

3.2 Mapping to/from DD

CORE Design Tasks - 1

- Design of services
- Definition of integration APIs (IAPIs)
- Data conversion from/to CORA model to/from tool specific format
- Graphical front ends for designing schemas and mappings



CORE Design Tasks - 2

- Design of processes
- How to define and execute processes within CORE
  - **Modelling language**
  - **Execution**
  - **Visual interfaces design**
- Design of a service repository

CORE Design Tasks - 3

- Design of exchanged data
- Definition of data models and formats (plain XML/XSD, SDMX…) to be used for data exchanges
- Definition of metadata necessary for process execution
- SDMX Relationships

CORE Design

CORE Design: Services

- Abstract services: specify a well-defined functionality in a technology-independent way
- An abstract service can be implemented by one or more concrete services, i.e. IT tools
- Examples: sample allocation, record linkage, estimates and errors computation, etc.

CORE Design: Services

- GSBPM classification
  - **Documentation purpose**
  - **Provided that a CORE service can be linked to IT tools, GSBPM tagging enables the performance of a search e.g. retrieving**

"all the IT tools implementing the 5.4 Impute subprocess of GSBPM proposal"

CORE Design: Services

- Service inputs and outputs
  - **Specified by logical names**
  - **Characterized with respect to their "role" in data exchange**

    Non-CORE: if they are not provided by/to other services of the process, but are only "local" to a specific service

    CORE: they are passed by/to other services and hence they do need to undergo CORE transformations

CORE Design: Data and Metadata

- They are specified as service inputs and outputs
  - **Logical names link them to previously specified services**
  - **Non-CORE data only need the file system path where they can be retrieved**

CORE Design: CORE Data

- The specification of CORE data is provided by 3 elements:
  - **Domain descriptor**
  - **CORE data model**
  - **Mapping model**

Domain Descriptor: Model

- Entity
  - **Like “entities” in Entity Relationships**
- Entity properties
  - **Like “attributes” in Entity Relationships**
- Very simple (meta-)model

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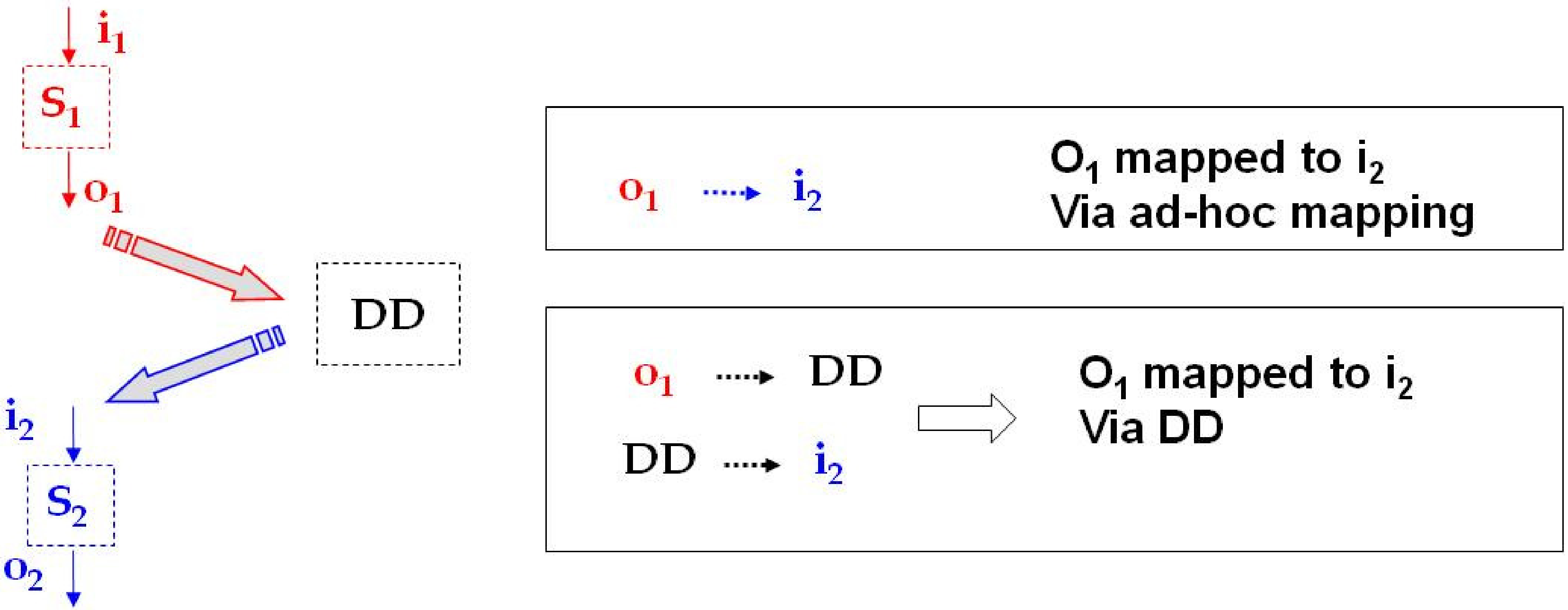
Domain Descriptor: Example

```
<schema name="DEMO_Domain_Descriptor">
<entity name="SamplePlan">
    <property name="STRATIFICATION_VAR"/>
    <property name="STRATUM_SAMPLE_SIZE"/>
    <property name="STRATUM_POPULATION_SIZE"/>
</entity>
<entity name="Enterprise">
    <property name="IDENTIFIER"/>
    <property name="STRATIFICATION_VAR"/>
    <property name="WEIGHT"/>
    <property name="SAMPLING_FRACTION"/>
    <property name="ENTERPRISE_FLAG"/>
    <property name="EMPLOYEES_NUM"/>
    <property name="VALUE_ADDED"/>
    <property name="AREA"/>
</entity>
</schema>
```

Domain Descriptor Role

- Role of the Domain Descriptor (DD): from service-to-service data mapping to service-to-global data mapping



CORE Data Model: Role

- Specified once and valid for all processes
- Extensible, i.e. core tag, data set kind, column kind can be modified
- Adds more semantics to data
  - **Example of usage: mapping to other models**

CORE Data Model

- Rectangular data set
- CORE tag:
  - Data set level (mandatory)
  - Column level (optional)
  - Rows level (optional)
- Data set kind
- Column kind

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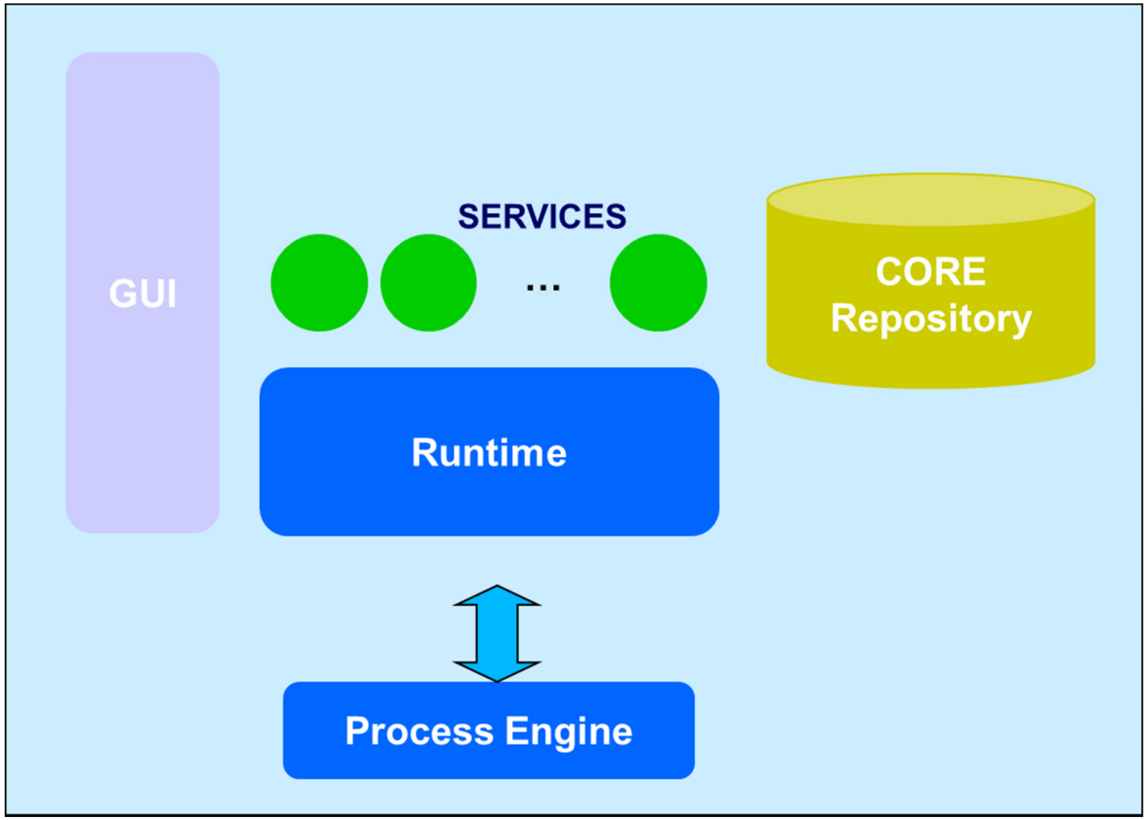
CORE Data Model Role

- Specified once and valid for all processes
- Extensible, i.e. core tag, data set kind, column kind can be modified
- Adds more semantics to data
  - **Example of usage: mapping to other models**

Mapping Model

- Rectangular data assumption
- Mapping is intended to be specified with respect to Domain Descriptor
  - Columns are to be mapped to properties of an entity
- It contains the specification of how CORE data model concepts are associated to data

CORE Logical Architecture

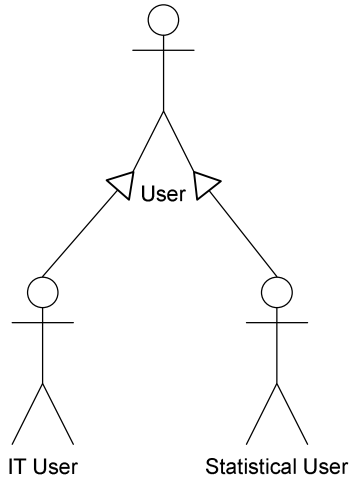


CORE GUIs

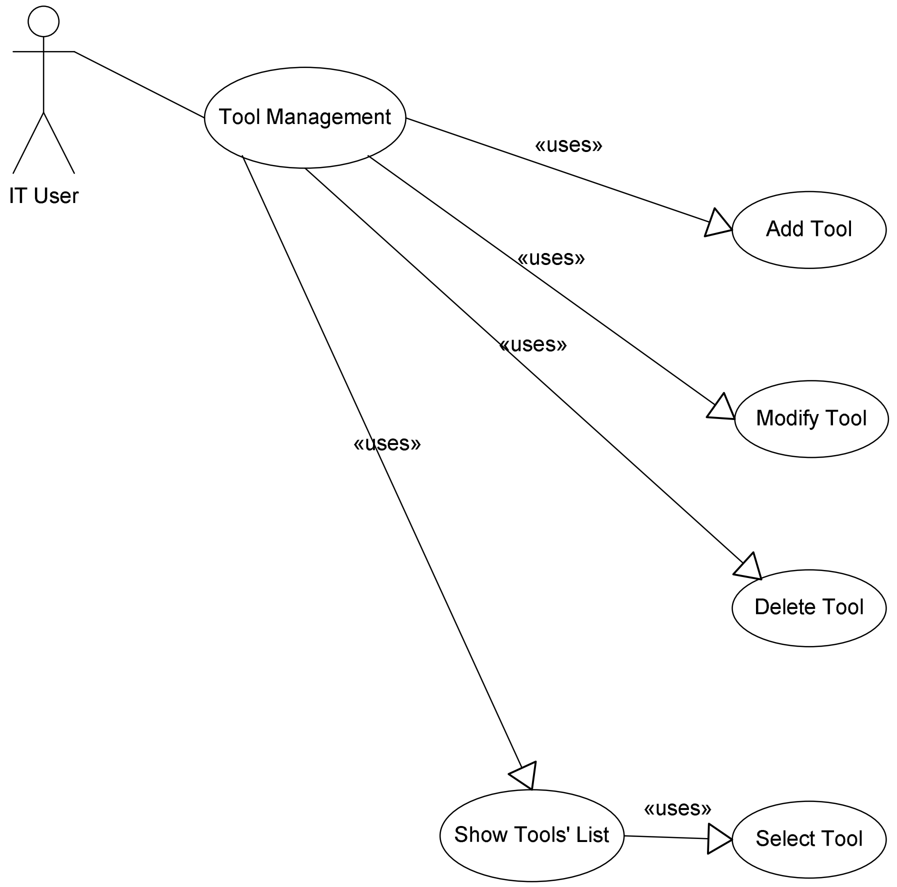
- Process design
  - **Service data flow**
- Service design
  - **Set of interfaces for the definition of services and related data flow**
- Data design
  - **Set of interfaces for the specification of domain descriptors and mapping files**

Use Case Specification

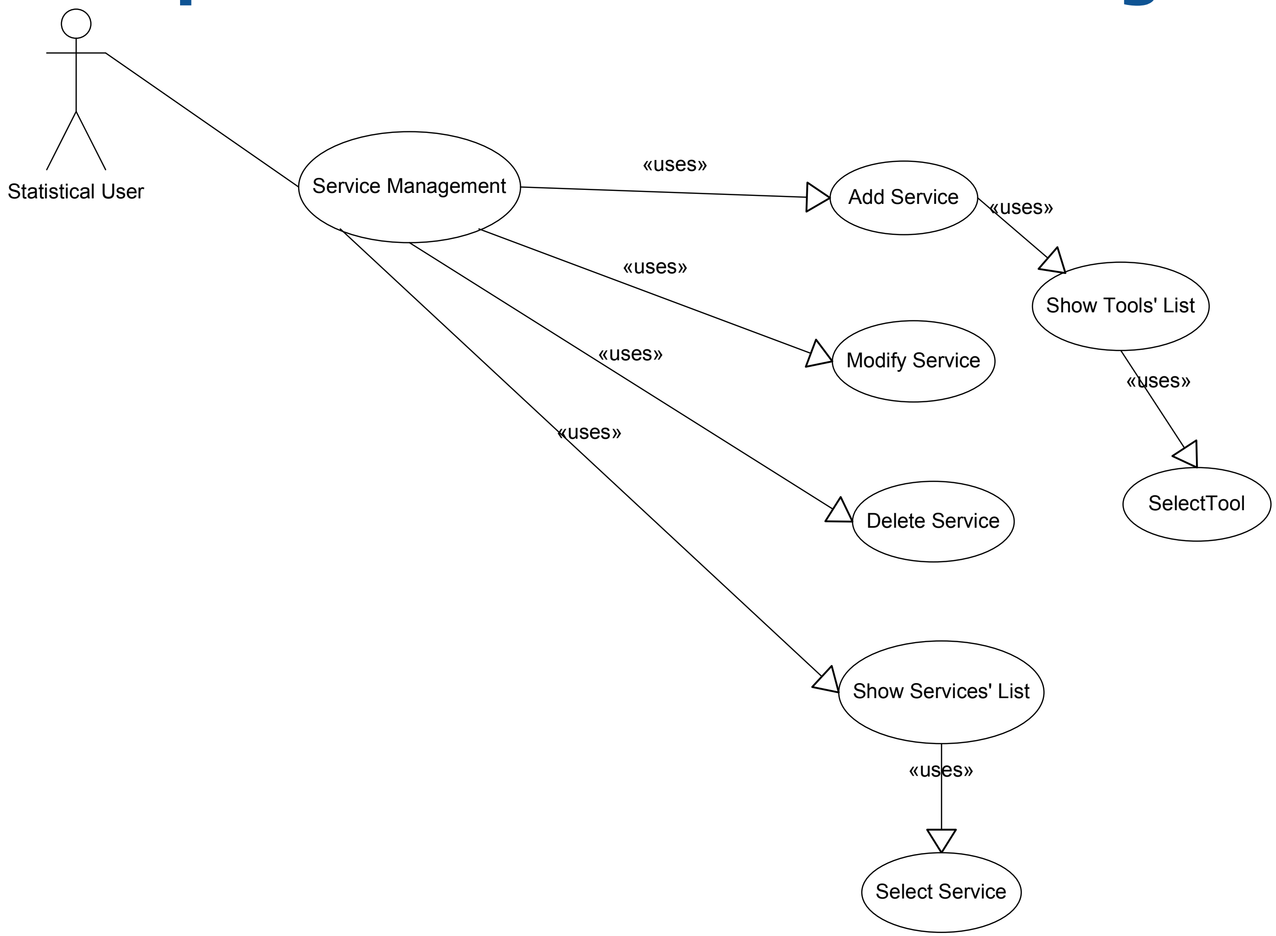
- CORE (Principal) Users



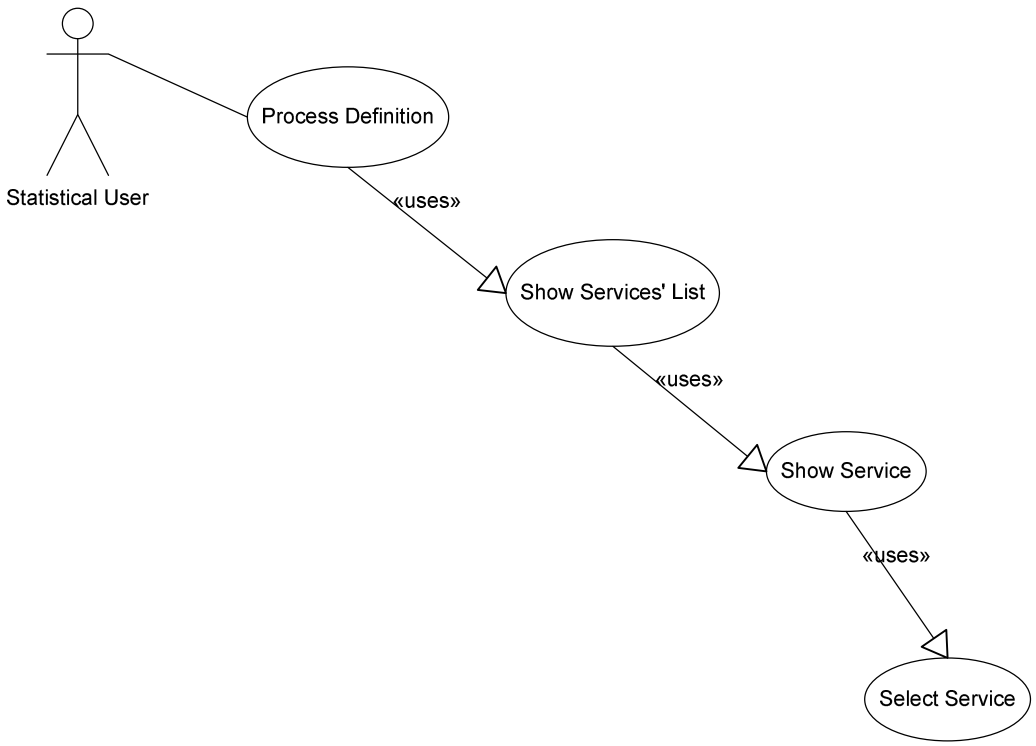
Use Case Specification: Tool Management



Use Case Specification: Service Management

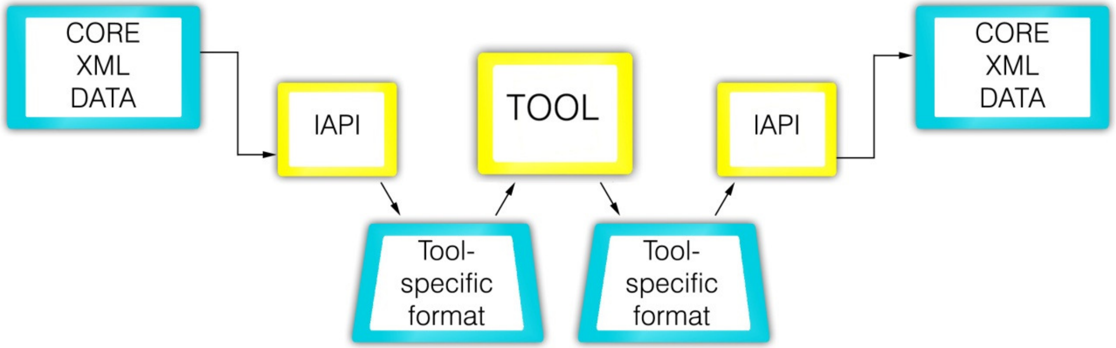


Use Case Specification: Process



Integration APIs

- Purpose: wrapping a tool by a CORE service
  - Translates inputs and outputs of the tool in a completely transparent and automatic way



Repository

- Processes and their instances
- Services with their GSBPM and CORE classifications
- Tools and their runtime features
- Data with their logical classification within CORE processes

Process Engine

- Official statistics processes can be viewed from two perspectives:
  - Functional: they are data-oriented, reflecting a common feature of scientific workflows
  - Organizational: they are workflow-oriented, have the complexity of real production lines, with the need for harmonizing the work of different actors

Process Engine

- Hence our process engine has two layers …

WF ENGINE

Complex control flows
- ✓ Syncronizing constructs, cycles, conditions, etc.
- ✓ E.g.: Interactive multi-user editing imputation

DATA FLOW CONTROL SYSTEM

Simple control flows
- ✓ Sequence of tasks is composed by connecting the output of one task to the input of another
- ✓ Data intensive operations

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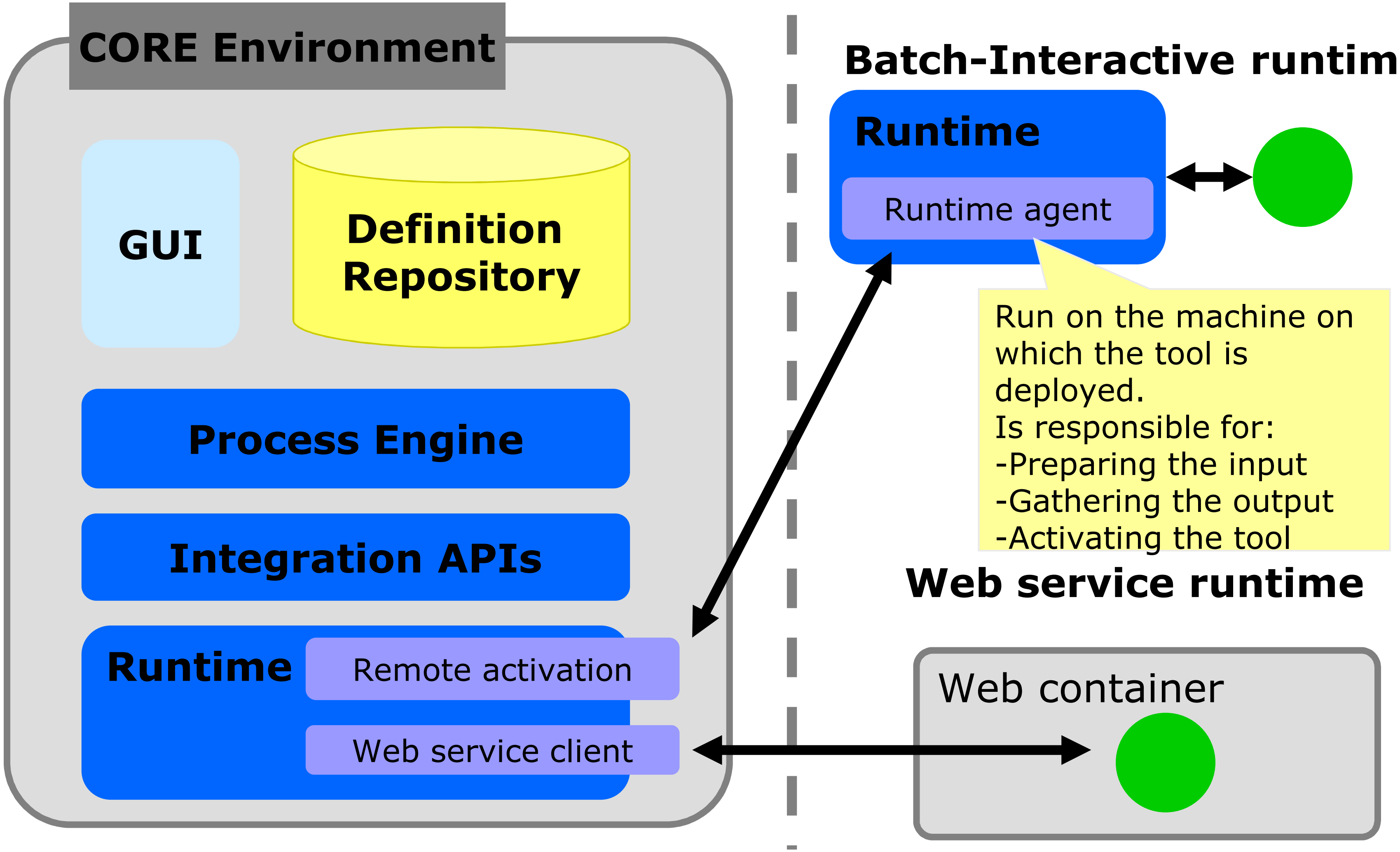
Architecture Deployment

- Web-based architectured centered on a centralized component
  - **CORE Environment**
- Different CORE deployments can co-exist
  - **Intra- or Inter- organization**
- Services can be remotely executed
  - **Support is needed in the form of a distibuted component for tool execution and data transfer**

Types of service runtime

- Batch
  - **Tool executed by a command line call**
  - **Can be automated**
- Interactive
  - **User interact with the tool through a tool-provided GUI**
  - **Cannot be automated**
- Web service
  - **No tool – procedure distributed on a web service actived by a programming language call**
  - **Can be automated**

CORE Technical Architecture



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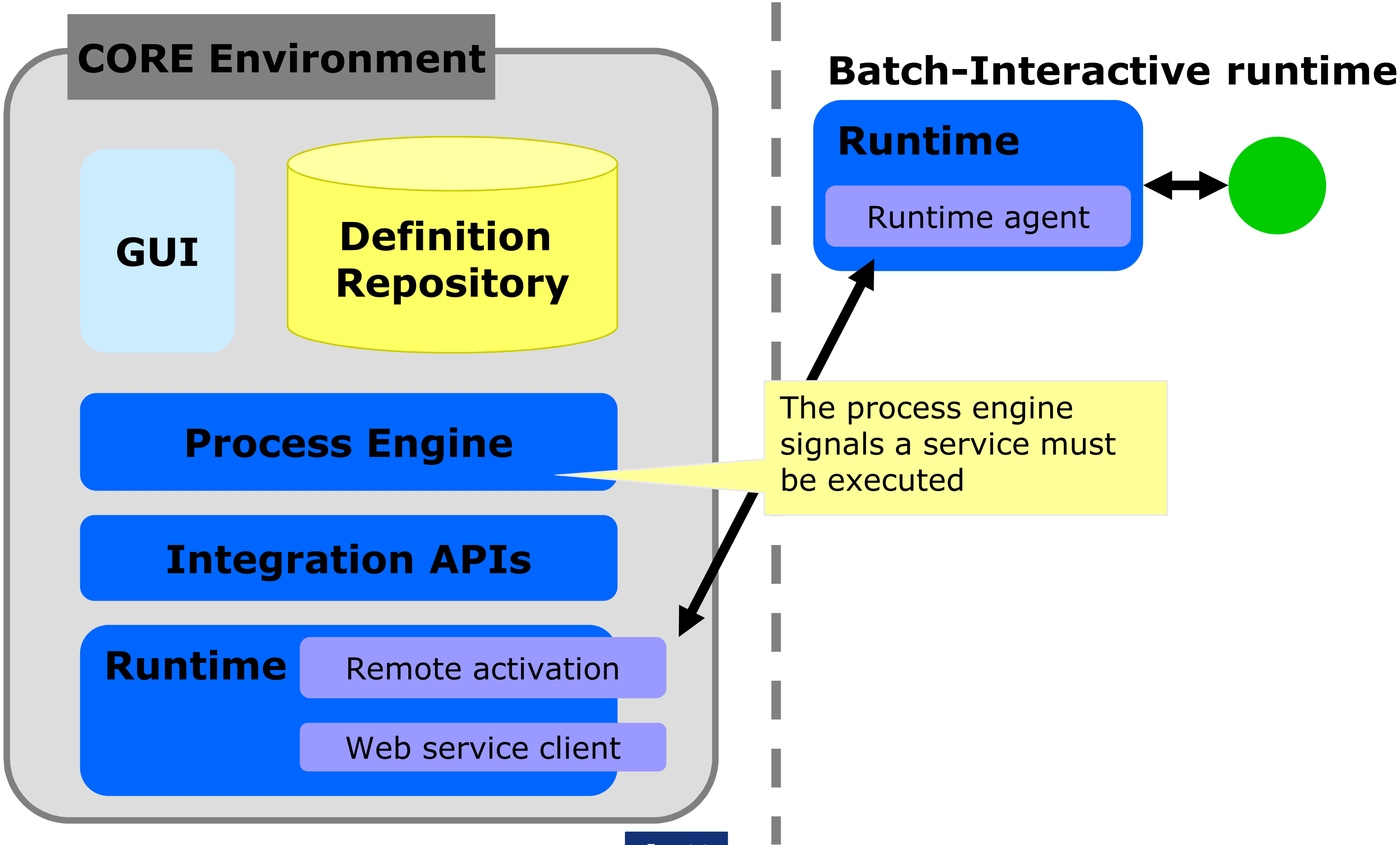

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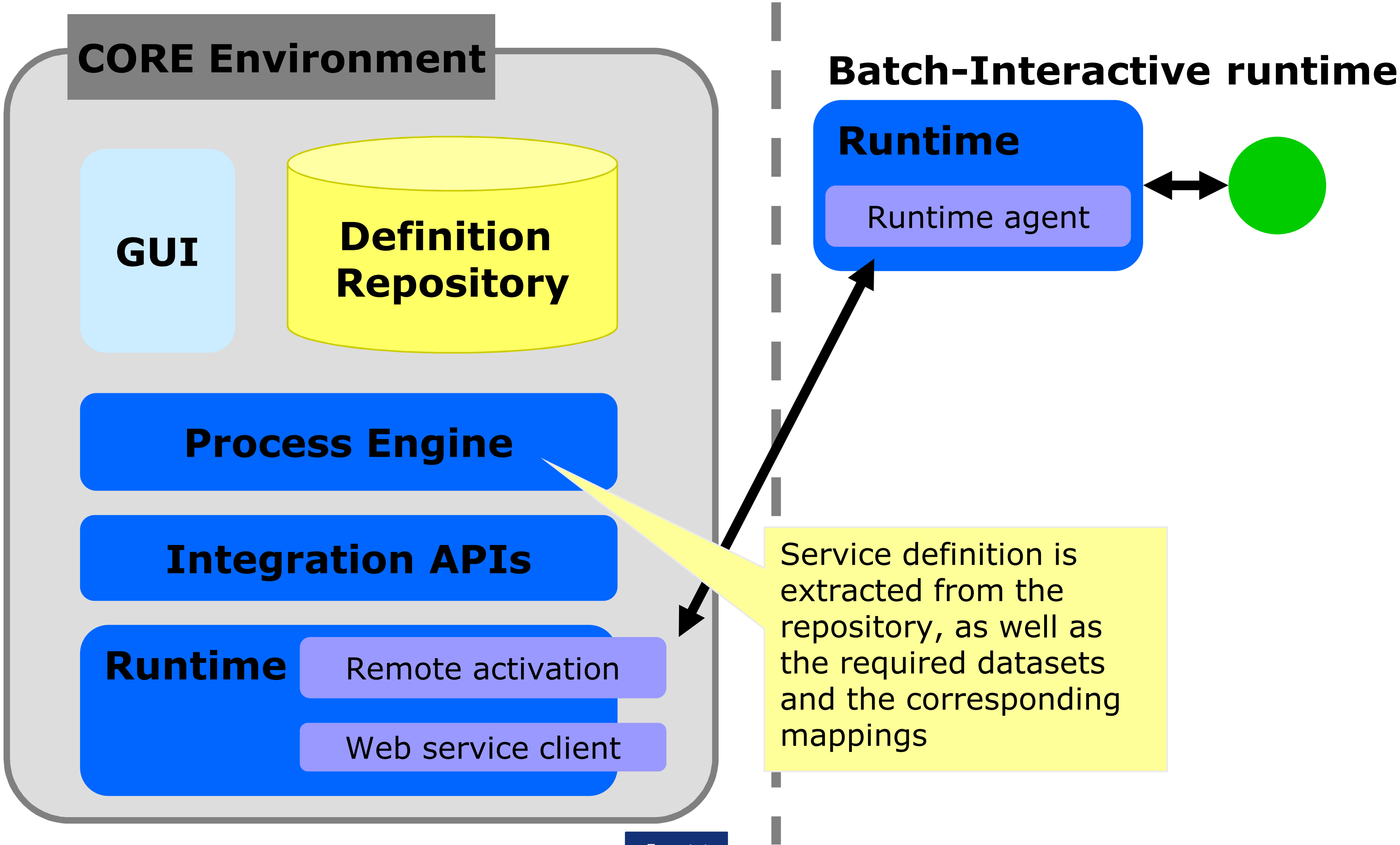

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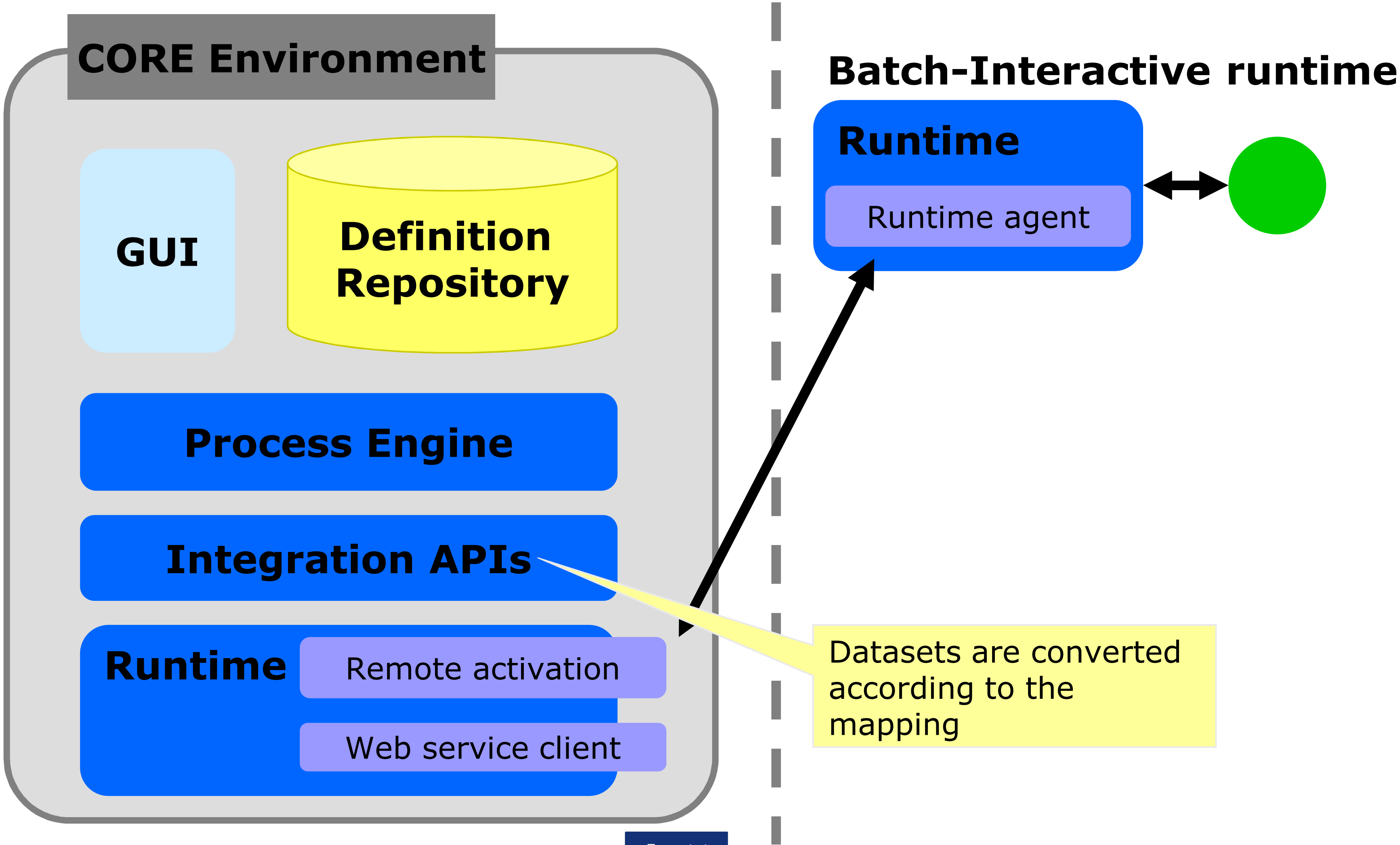

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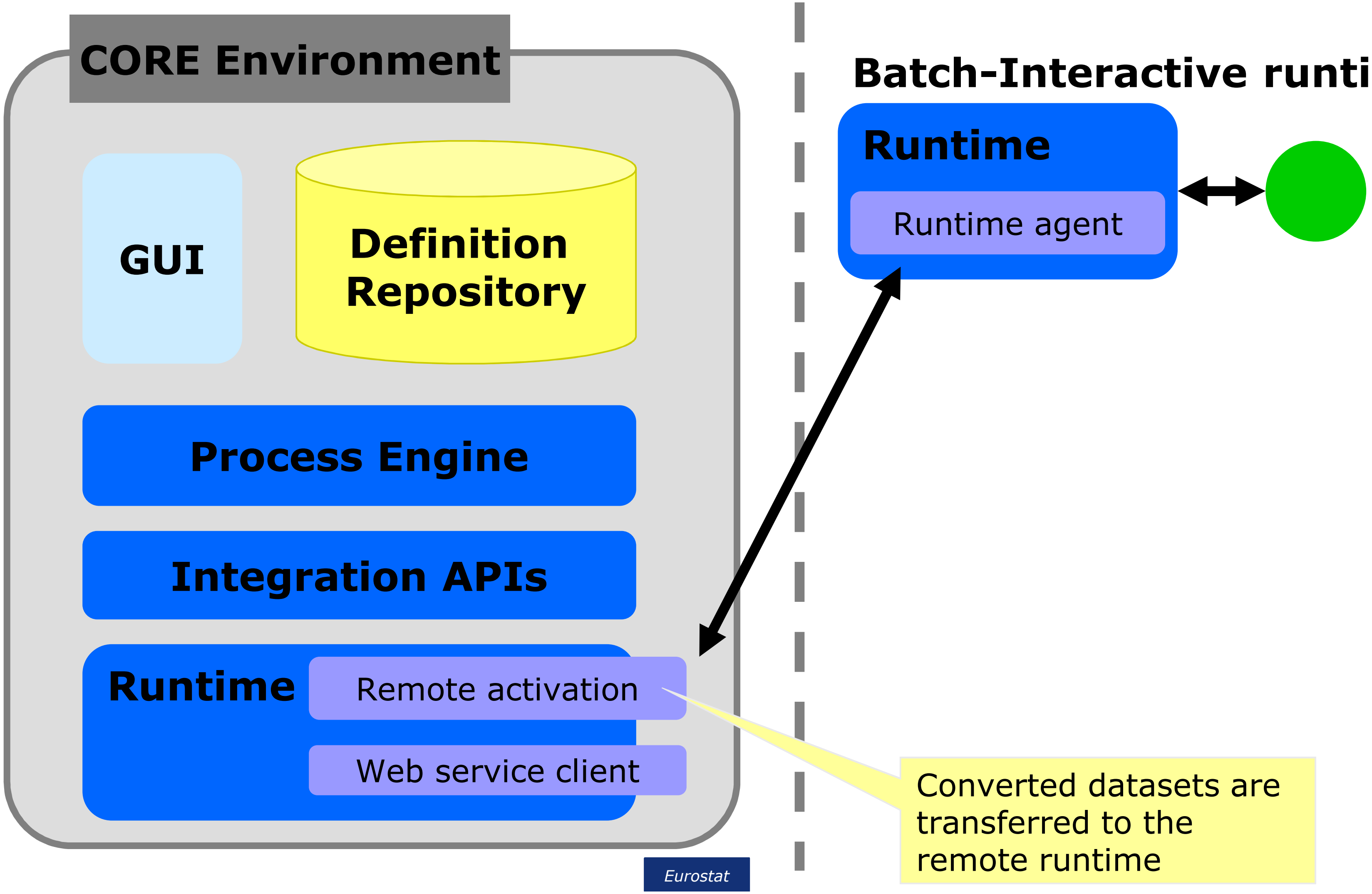

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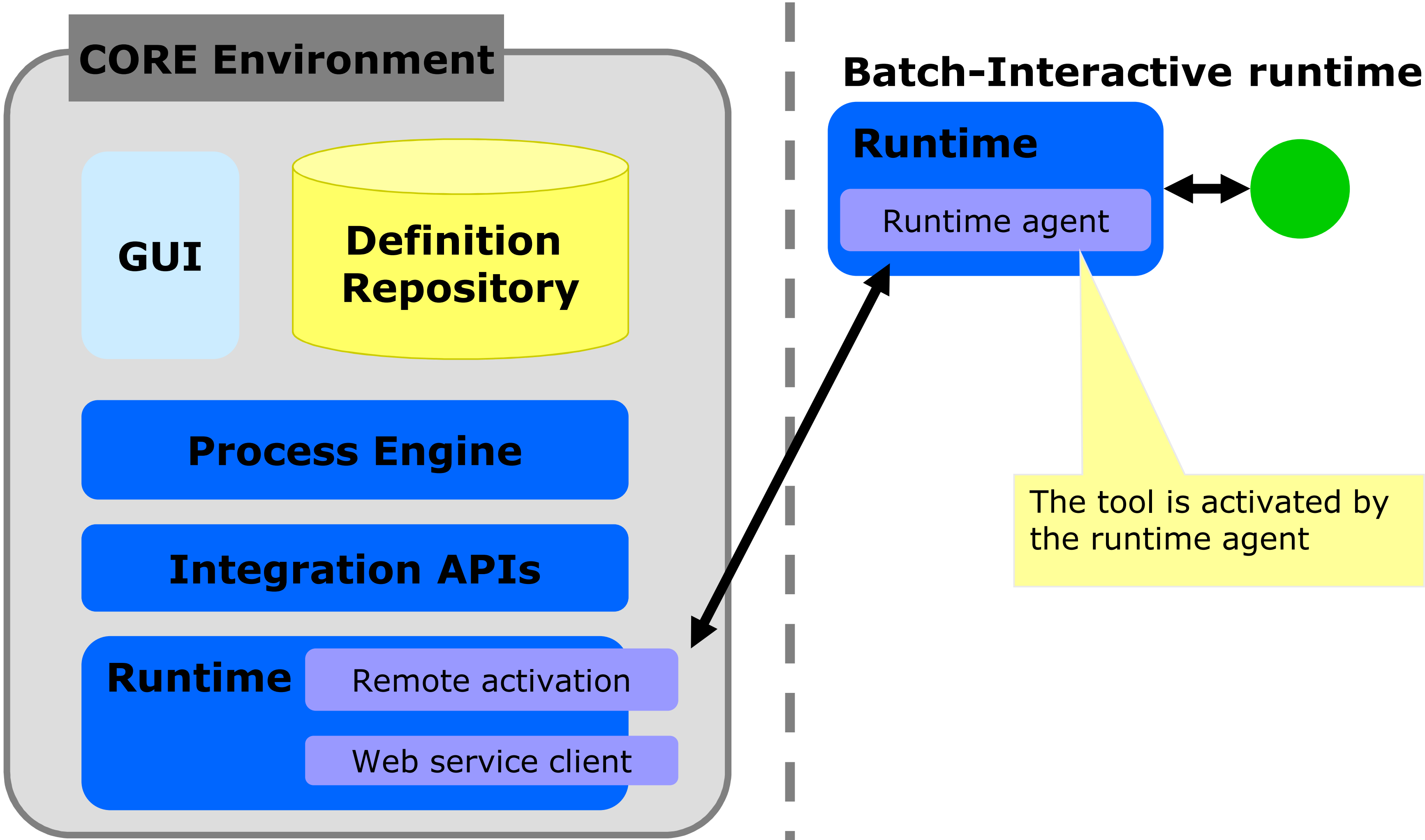

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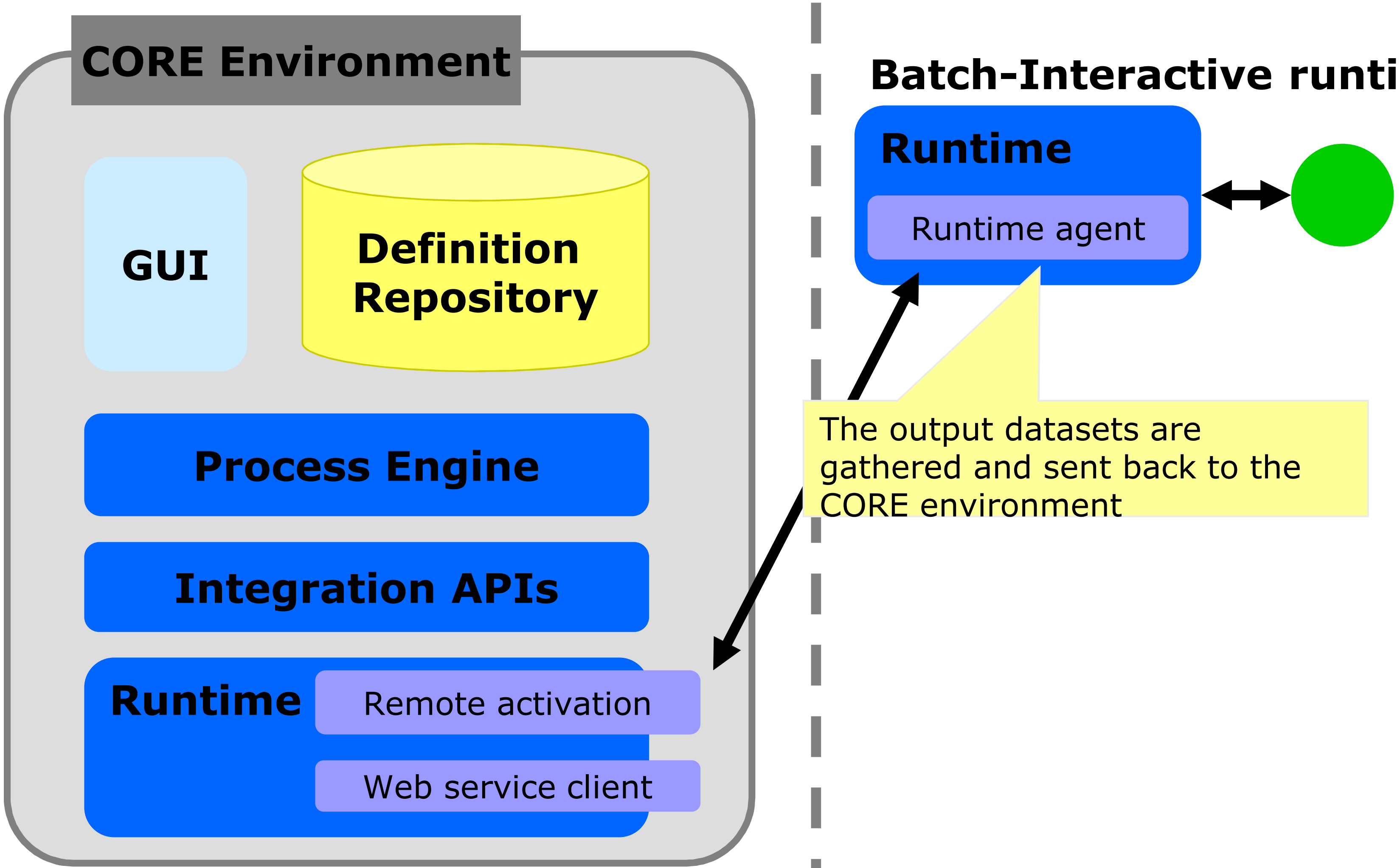

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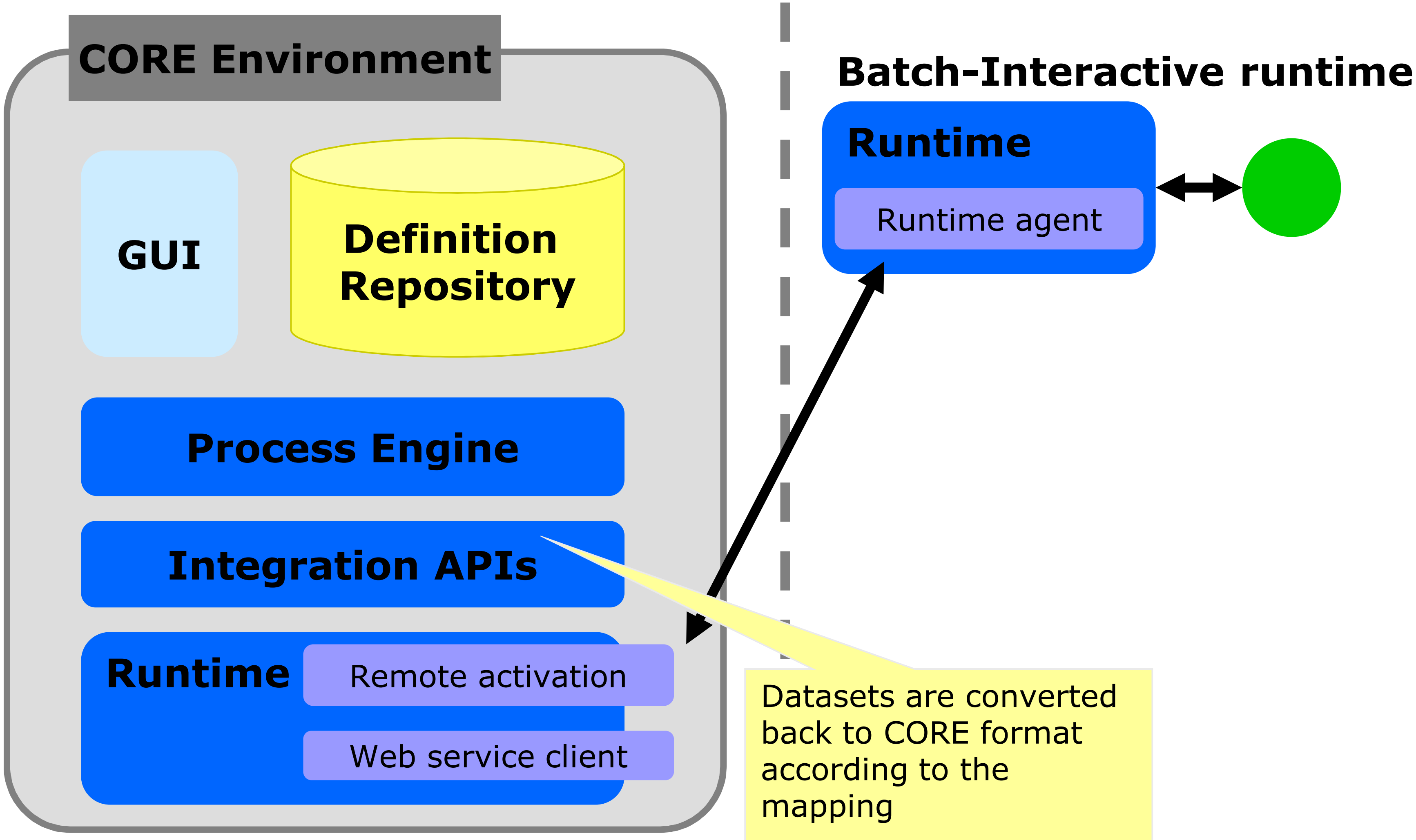

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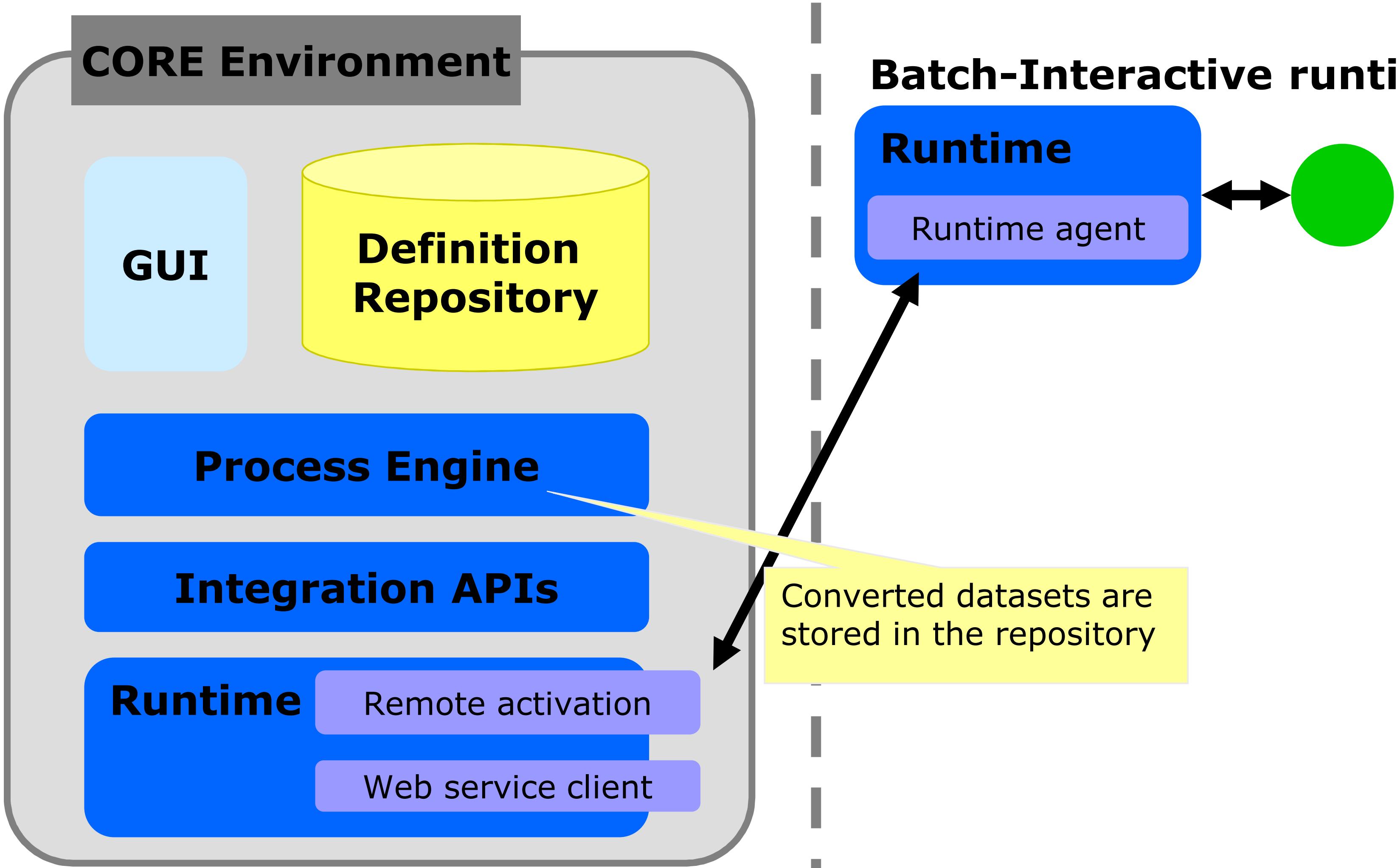

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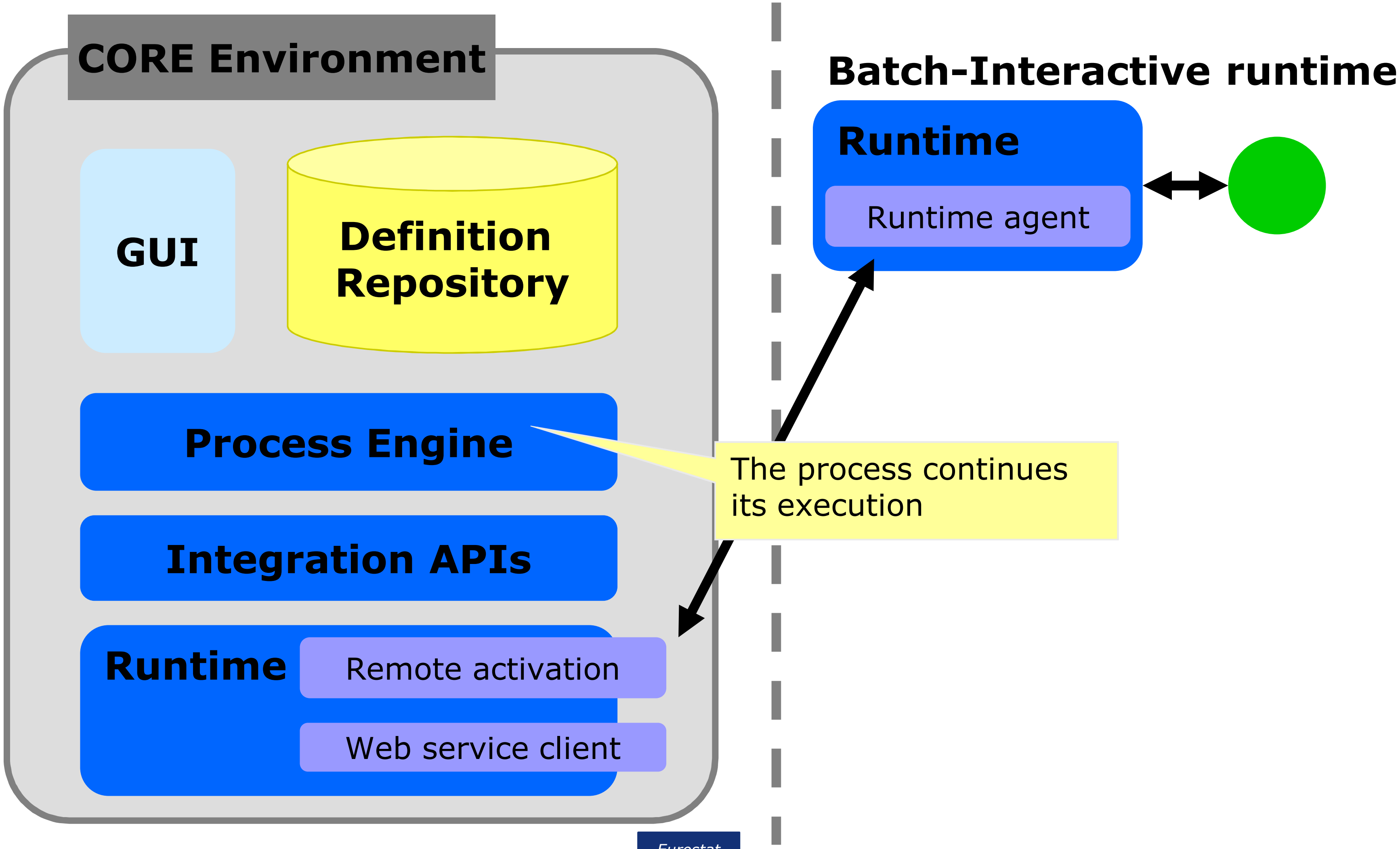

Scenario 1

- Remote execution command line/GUI
  - **Physical layers: CORE env, Service**
  - **AGENT**

Scenario 2

- Remote execution web service
  - **Physical layers: CORE env, Service**

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CORE Scenario

Why a Process Scenario?

- Helps to clarify ideas and to asses their feasibility
- Forces to make newly proposed solutions concrete
- Can/will be used as empirical test-bed during the whole implementation cycle of the CORE environment

How did we build the Scenario?

- Rationale for our Scenario:
  - **Naturality: involves typical processing steps performed by NSIs for sample surveys**
  - **Minimality: very easy workflow (no conditionals, nor cycles), can be run without a Workflow Engine**
  - **Appropriateness: incorporates as much heterogeneity as possible: heterogeneity is precisely what CORE must be able to get rid of**

Spreading Heterogeneity over the Scenario

- The Scenario incorporates both:
  - **Data Heterogeneity**

    Via data exchanged by CORE services belonging to the scenario process
  - **Technological Heterogeneity**

    Via IT tools implementing scenario sub-processes

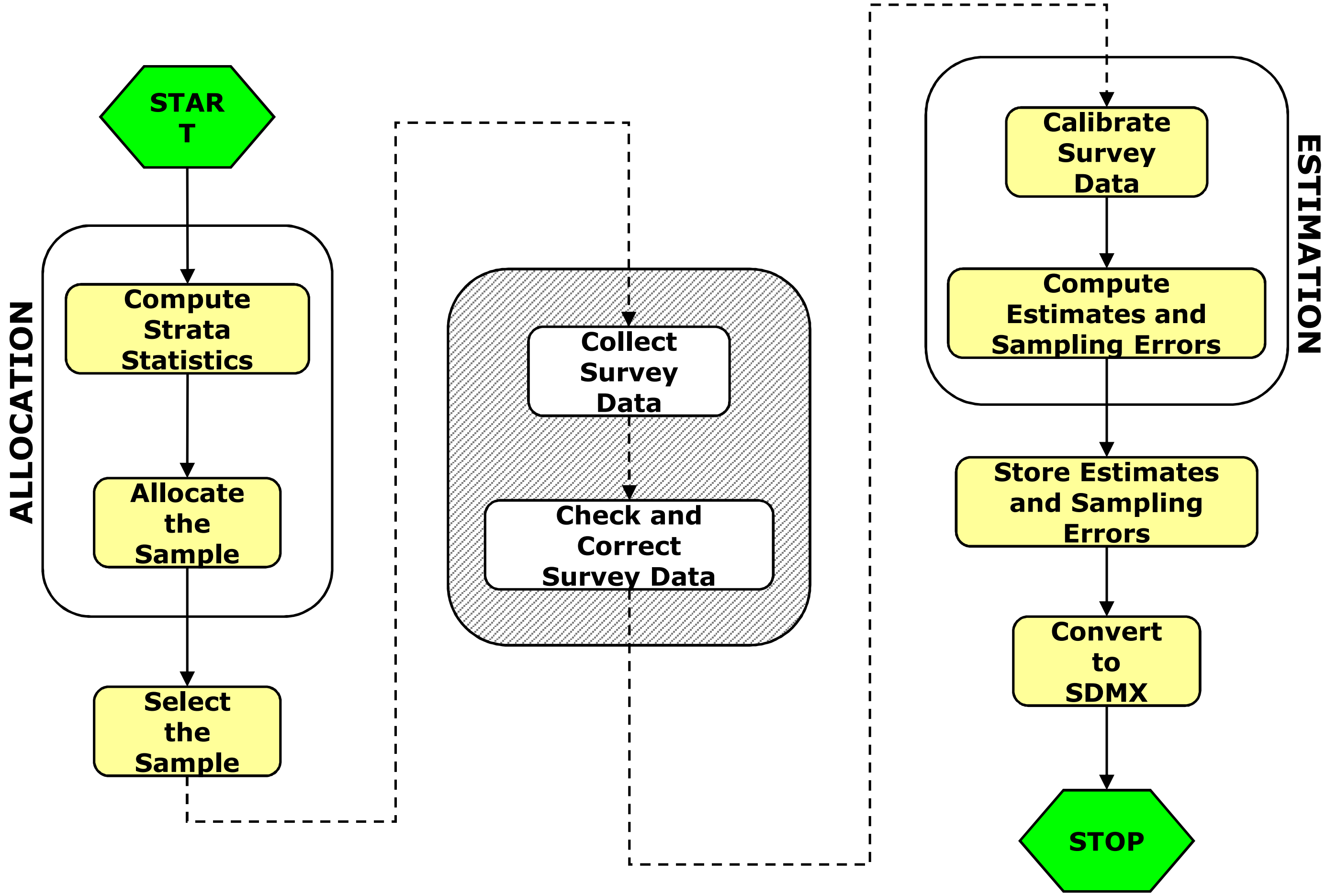
Data Heterogeneity

- The Scenario entails different levels of data heterogeneity:
  - **Format Heterogeneity: CSV files, relational DB tables, SDMX XML files involved**
  - **Statistical Heterogeneity: both Micro and Aggregated Data involved**
  - **"Model" Heterogeneity: some data refer to ordinary real-world concepts (e.g. enterprise, individual, …), some other to concepts arising from the statistical domain (e.g. stratum, variance, sampling weight, …)**

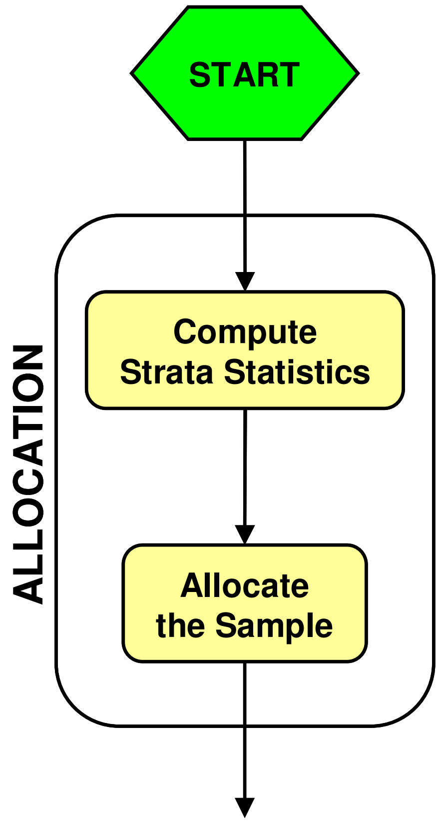
Technological Heterogeneity

- The Scenario requires to wrap inside CORE-compliant services very different IT tools:
  - **simple SQL statements executed on a relational DB**
  - **batch jobs based on SAS or R scripts**
  - **full-fledged R-based systems requiring a human-computer interaction through a GUI layer**

The Scenario at a glance

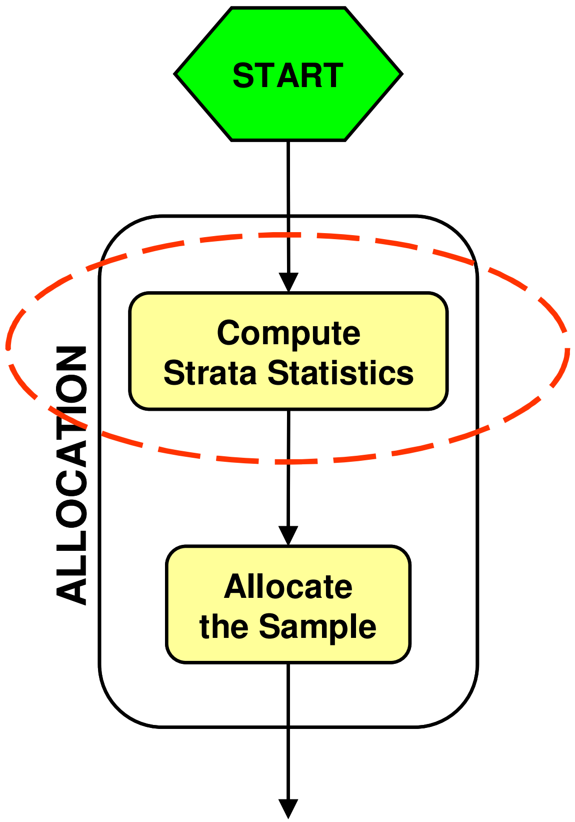


Sample Allocation Subprocess



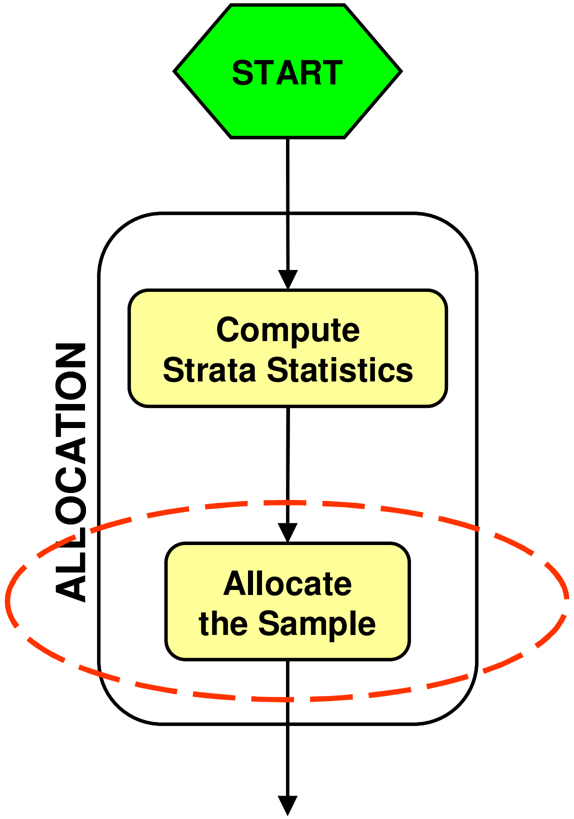
- Overall Goal: determine the minimum number of units to be sampled inside each stratum, when lower bounds are imposed on the expected level of precision of the estimates the survey has to deliver
- Two statistical services are needed:
  - **Compute Strata Statistics**
  - **Allocate the Sample**

Compute Strata Statistics Service



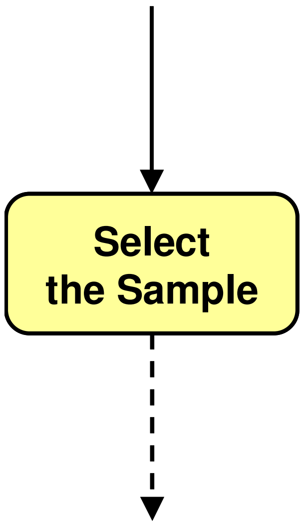
- Goal: compute, for each stratum, the population mean and standard deviation of a set of auxiliary variables
- IT tool: a simple SQL aggregated query with a group-by clause
  - **NSIs usually maintain their sampling frame(s) as Relational DB tables**
- Integration API: must support Relational/CORE transformations
- CORA tag: “Statistics”

Allocate the Sample Service



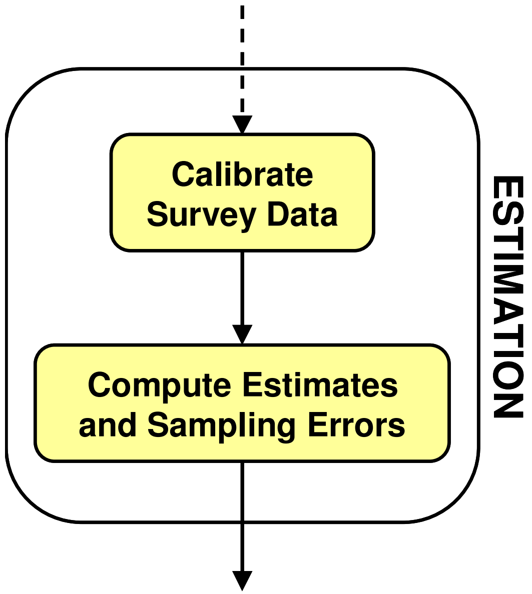
- Goal: solve a constrained optimization problem to find and return the optimal sample allocation across strata
- IT tool: Istat MAUSS-R system
  - **implemented in R and Java, can be run either in batch mode or interactively via a GUI**
- Integration API: must support CSV/CORE transformations
  - **MAUSS handles I/O via CSV files**
- CORA tag: "Statistics"

Sample Selection Subprocess



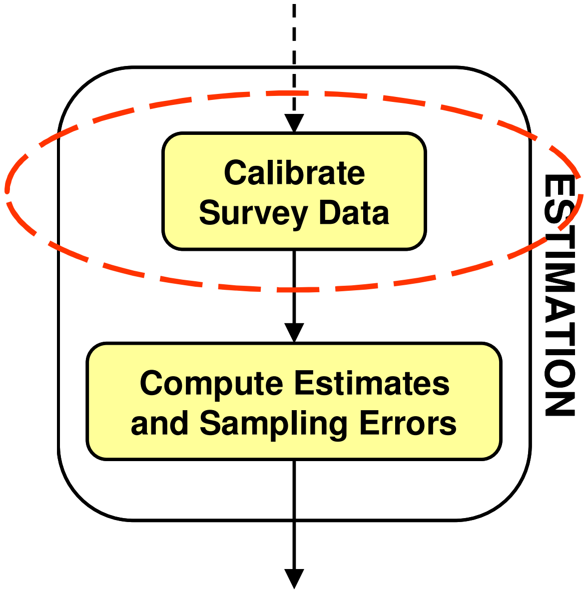
- Goal: draw a stratified random sample of units from the sampling frame, according to the previously computed optimal allocation
- IT tool: a simple SAS script to be executed in batch mode
- Integration API: CSV/CORE transformation
  - **SAS datasets have proprietary, closed format ➡ we'll not support direct SAS/CORE conversions**
- CORA tag: "Population"
  - **output stores the identifiers of the units to be later surveyed + basic information needed to contact them**

Estimation Subprocess



- Overall Goal: compute the estimates the survey must deliver, and asses their precision as well
- Two statistical services are needed:
  - **Calibrate Survey Data**
  - **Compute Estimates and Sampling Errors**

Calibrate Survey Data Service



- Goal: provide a new set of weights (the "calibrated weights") to be used for estimation purposes
- IT tool: Istat ReGenesees system
  - **implemented in R, can be run either in batch mode or interactively via a GUI**
- Integration API: can use both CSV/CORE and Relational/CORE transformations
- CORA tag: "Variable"

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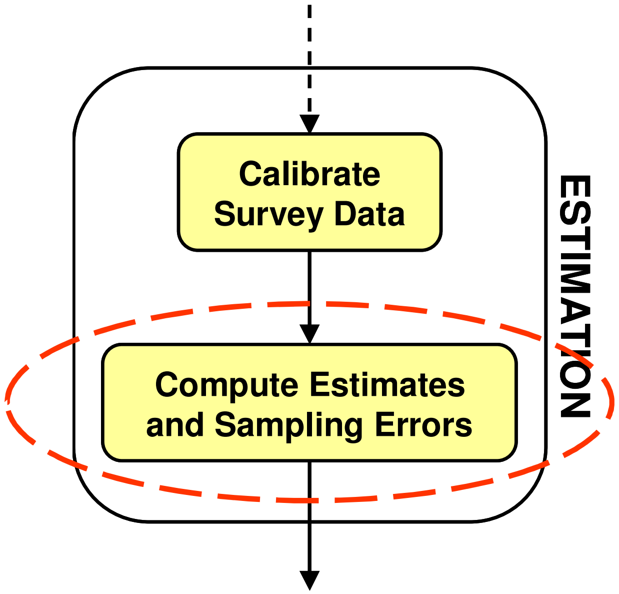
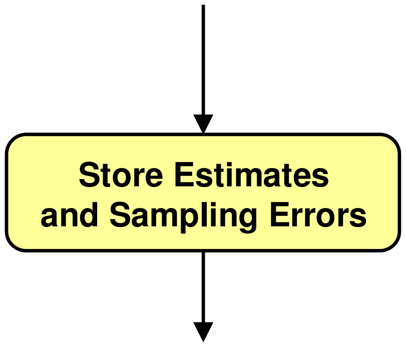
Estimates and Errors Service



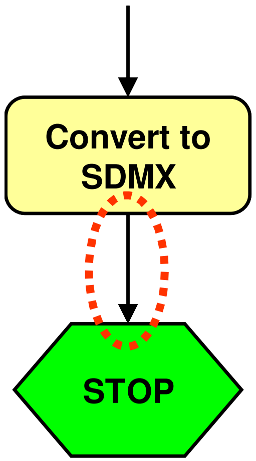
- Goal: use the calibrated weights to compute the estimates the survey has to provide (typically for different subpopulations of interest) along with the corresponding confidence intervals
- IT tool: Istat ReGenesees system
- Integration API: can use both CSV/CORE and Relational/CORE transformations
- CORA tag: “Statistic”

Store Estimates Subprocess



- Goal: persistently store the previously computed survey estimates in a relational DB
  - **e.g. in order to subsequently feed a data warehouse for online publication**
- IT tool: a set of SQL statements
- Integration API: Relational/CORE transformation again
- CORA tag: "Statistics"

Convert to SDMX Service



- Goal: retrieve the aggregated data from the relational DB and directly convert them in SDMX XML format
  - **e.g. to later send them to Eurostat**
- IT tool: ???
- Integration API: must support SDMX/CORE transformations
- CORA tag: “Statistics”

Scenario Open Issues

- Besides I/O data, CORE must be able to handle “service behaviour parameters”. How?
  - **e.g. to analyze a complex survey, ReGenesees needs a lot of sampling design metadata, namely information about strata, stages, clusters identifiers, sampling weights, calibration models, and so on**
- Enabling the CORE environment to support interactive services execution is still a challanging problem
  - **we plan to exploit MAUSS-R and/or ReGenesees to test the technical feasibility of any forthcoming solution**
- How to implement a SDMX/CORE converter?

Demo Scenario

- Involves 3 typical processing steps performed by NSIs for sample surveys:
  - **Sample Allocation**
  - **Sample Selection**
  - **Estimation**
- It has been used as empirical test-bed during the whole implementation cycle of the CORE environment

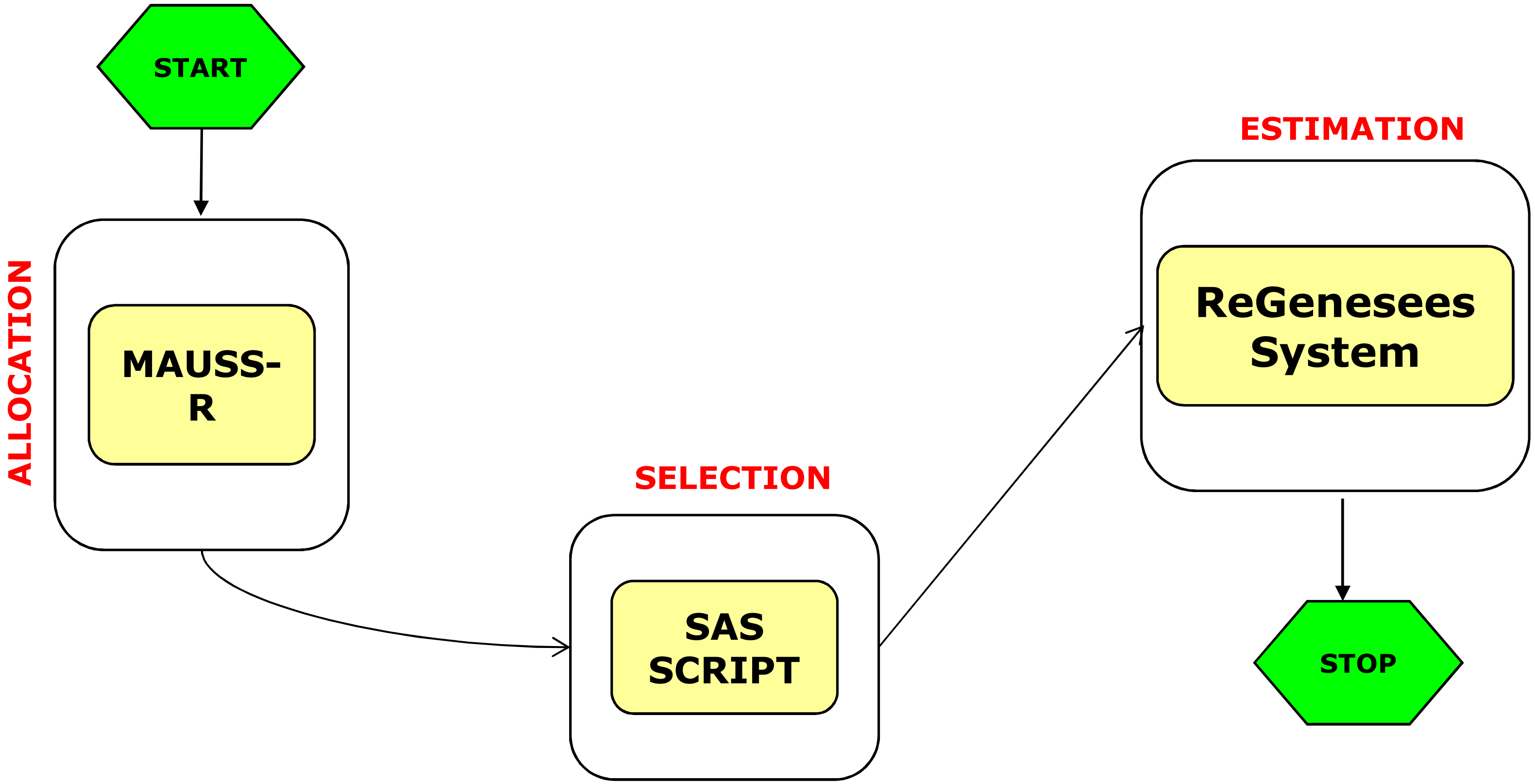
Rationale for the Scenario

- Minimality: very easy workflow (no conditionals, nor cycles), can be run without a Workflow Engine
- Appropriateness: addresses heterogeneity issues
  - **heterogeneity is precisely what CORE must be able to get rid of**

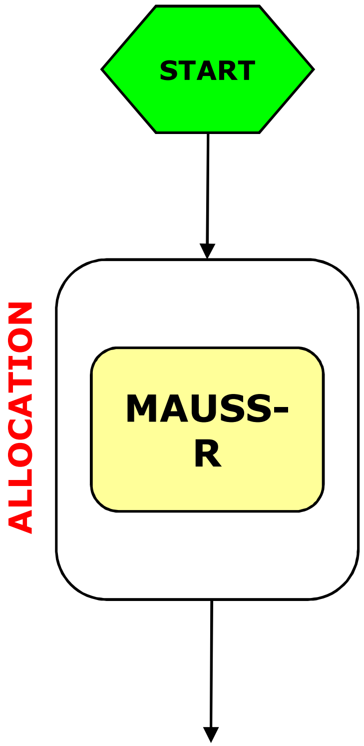
Spreading Heterogeneity over the Scenario

- The Scenario incorporates both:
  - **Data Heterogeneity: Via data exchanged by CORE services belonging to the scenario process**
  - **Technological Heterogeneity: Via IT tools implementing scenario services**
    - A batch job based on a SAS script
    - Two full-fledged R-based systems

The Scenario at a glance



Sample Allocation Service



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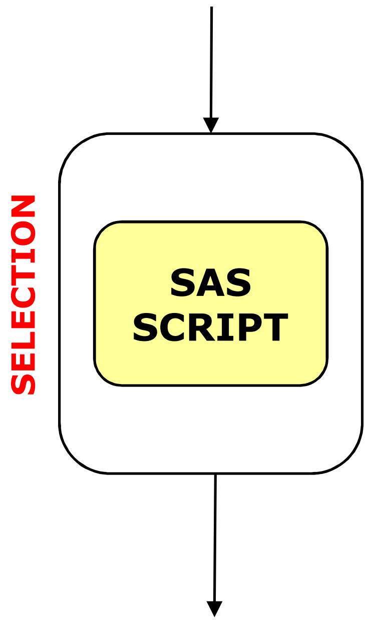
Sample Selection Service



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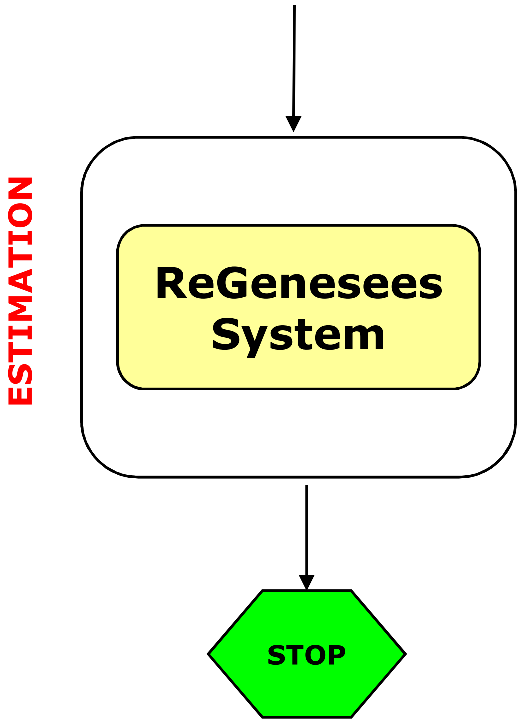
Estimates and Errors Service



- Goal: compute the estimates the survey has to provide (typically for different subpopulations of interest) along with the corresponding confidence intervals
- IT tool: Istat ReGenesees System
  - **R-based**
- CORA tag: “Statistics”