Life-cycle of a Simulation Project

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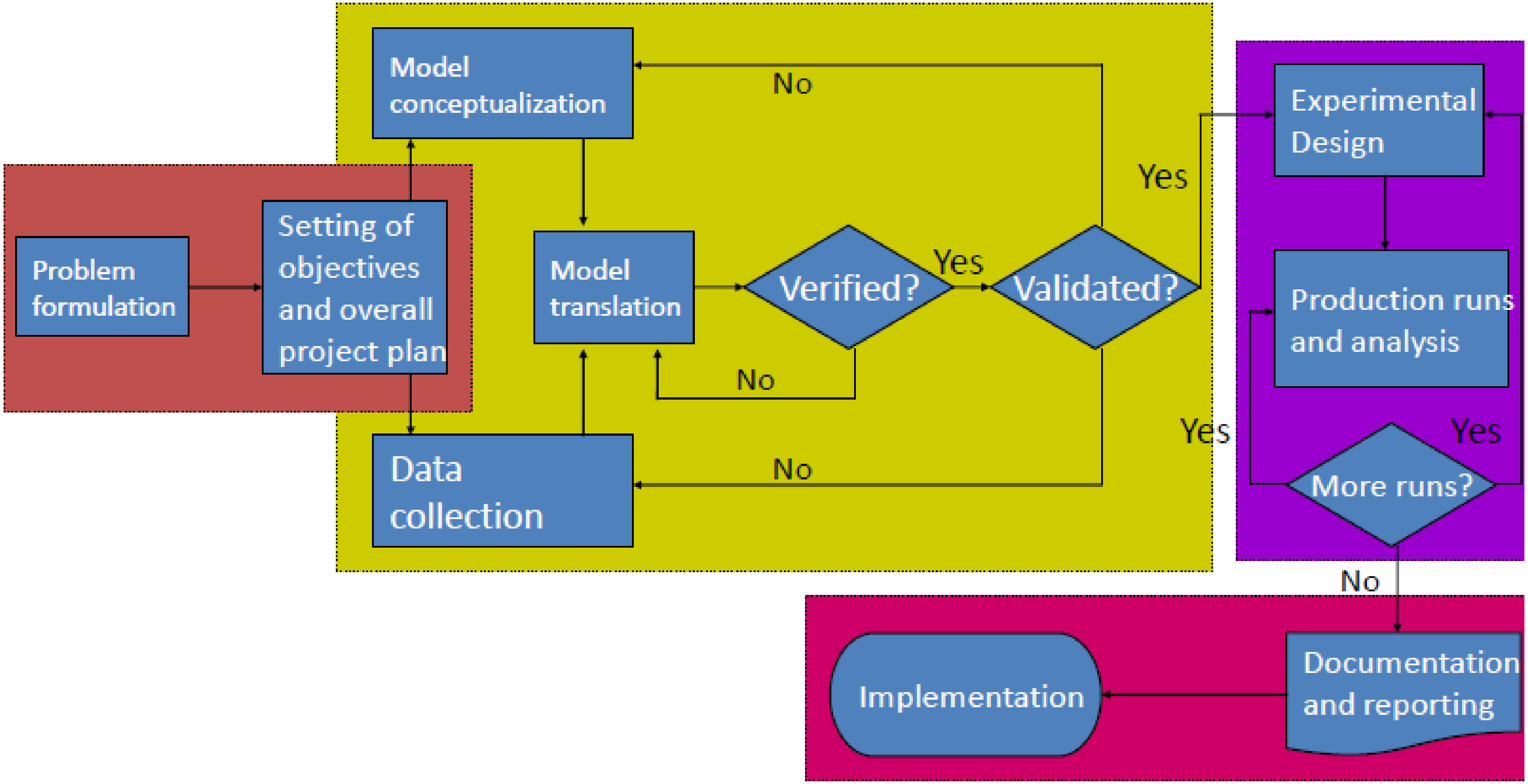
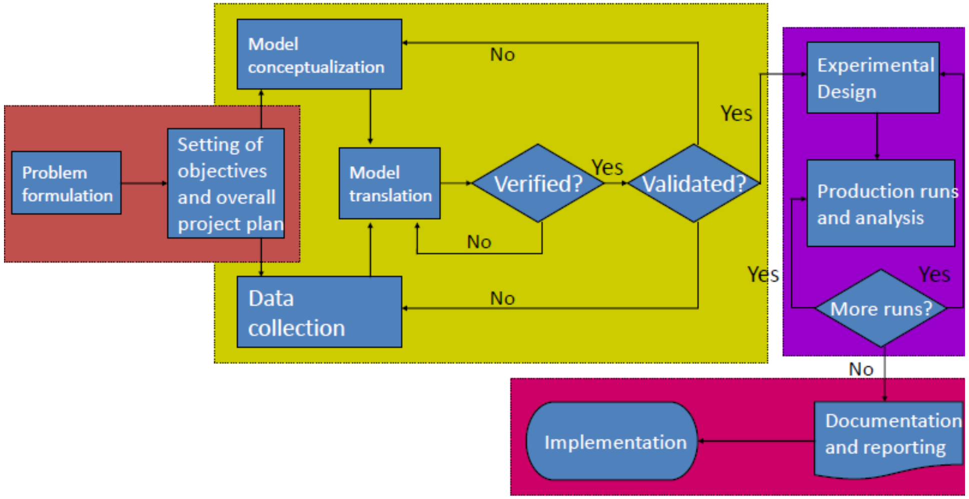


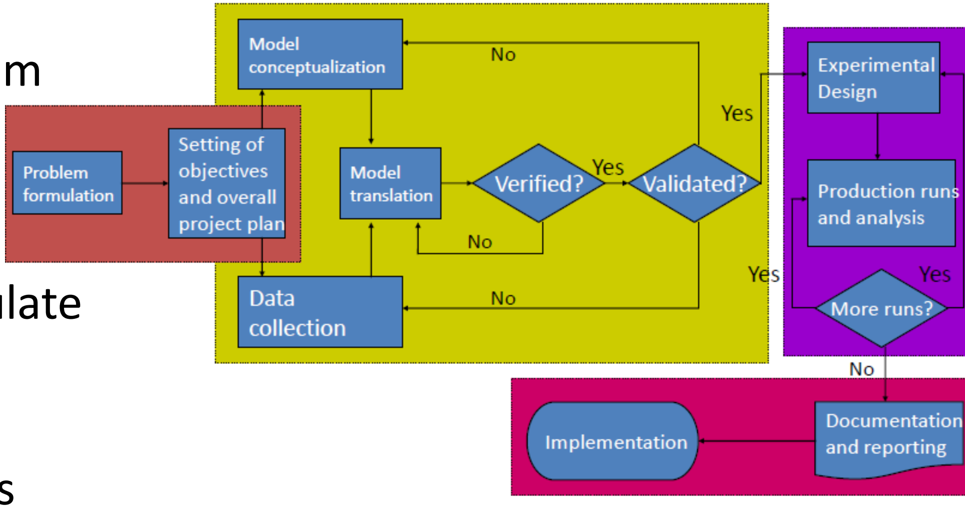
Life-cycle of a Simulation Project

1. **Problem Formulation**
   - Statement of the problem
2. **Set Objectives & Project Plan**
   - Questions to be answered
   - Is simulation appropriate?
   - Methods, alternatives
   - Allocation of resources
3. **Model Conceptualization**
   - Requires experience
   - Begins simple and adds complexity
   - Captures essence of system
   - Involves the user
4. **Data Collection**
   - Time consuming, begin early
   - Determine what is to be collected



Life-cycle of a Simulation Project

5. **Model translation**
   - Computer form
   - general purpose vs. special purpose languages
6. **Verification**
   - Does the program represent the model and run properly? Common sense
7. **Validation and Calibration**
   - Compare model to actual system
   - Does model replicate system?
   - How to calibrate the model?
8. **Experimental Design**
   - Determine alternatives to simulate
   - Time, initializations, etc.
9. **Production & Analysis**
   - Actual runs + Analysis of results
   - Determine performance measures
10. **More Runs?**



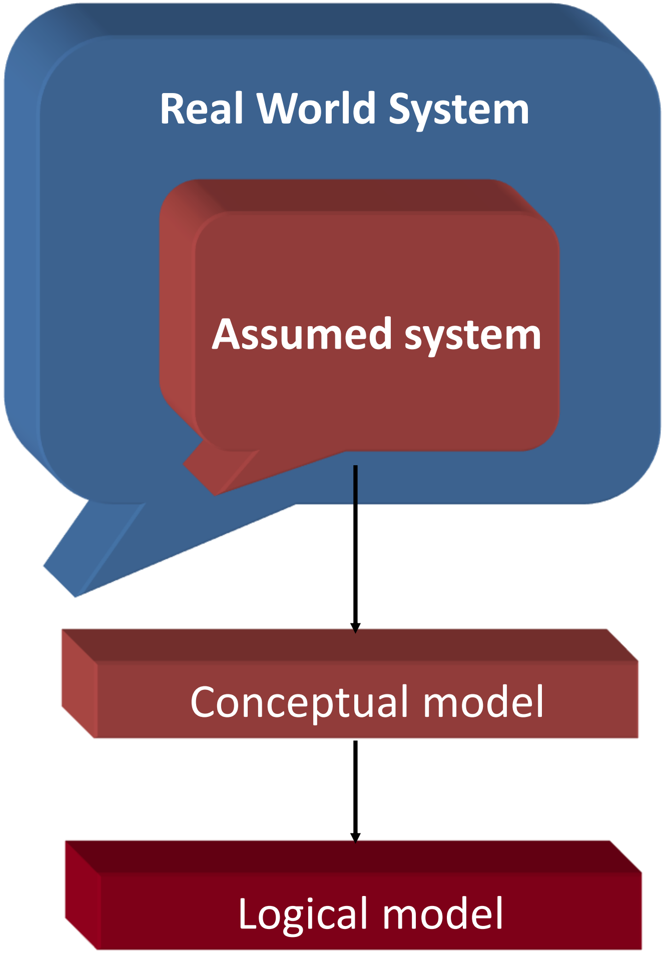
Problem formulation

- **A statement of the problem**
  - the problem is clearly understood by the simulation analyst
  - the formulation is clearly understood by the client
  - All involved elements and their characteristics, as well as behaviours and interactions are well identified

Setting of objectives & project plan

- **Project proposal**
  - Determine the questions that are to be answered
  - Identify scenarios to be investigated
  - Decision criteria
  - Determine the end-user
  - Determine data requirements
  - Determine hardware, software, & personnel requirements
  - Prepare a time plan
  - Cost plan and billing procedure

Model Conceptualisation



Conceptual Model

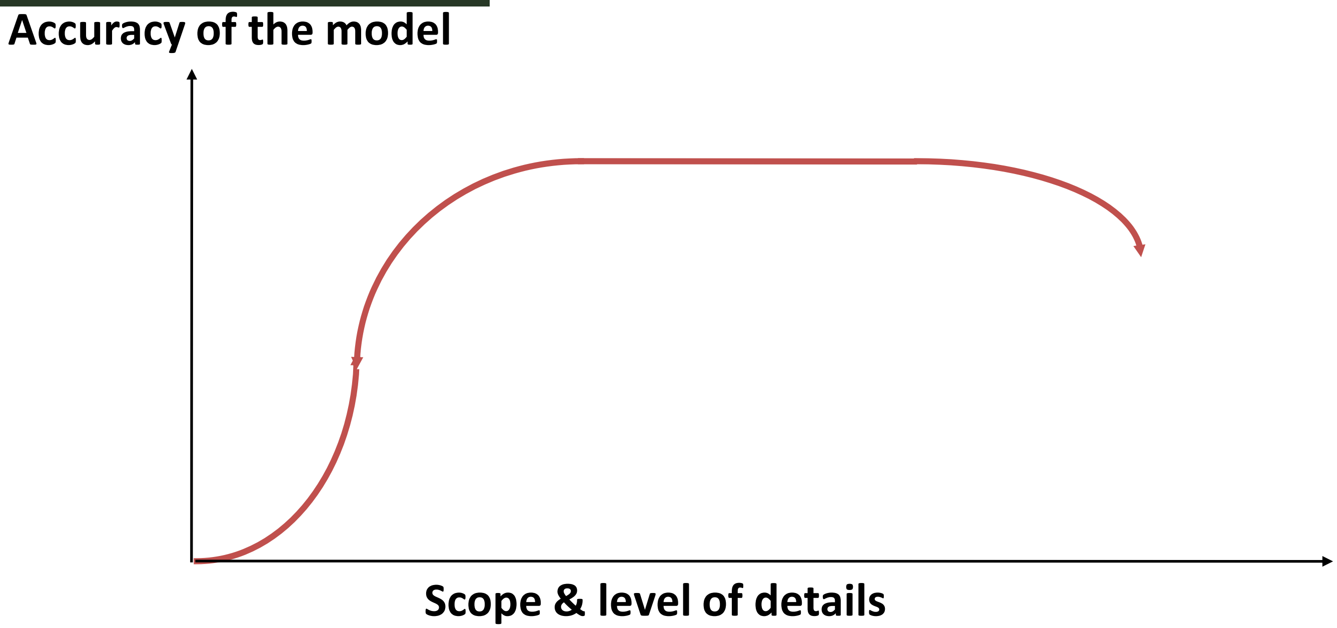
- **Abstract essential features**
  - Events, activities, entities, attributes, resources, variables, and their relationships
  - Performance measures
  - Data requirements

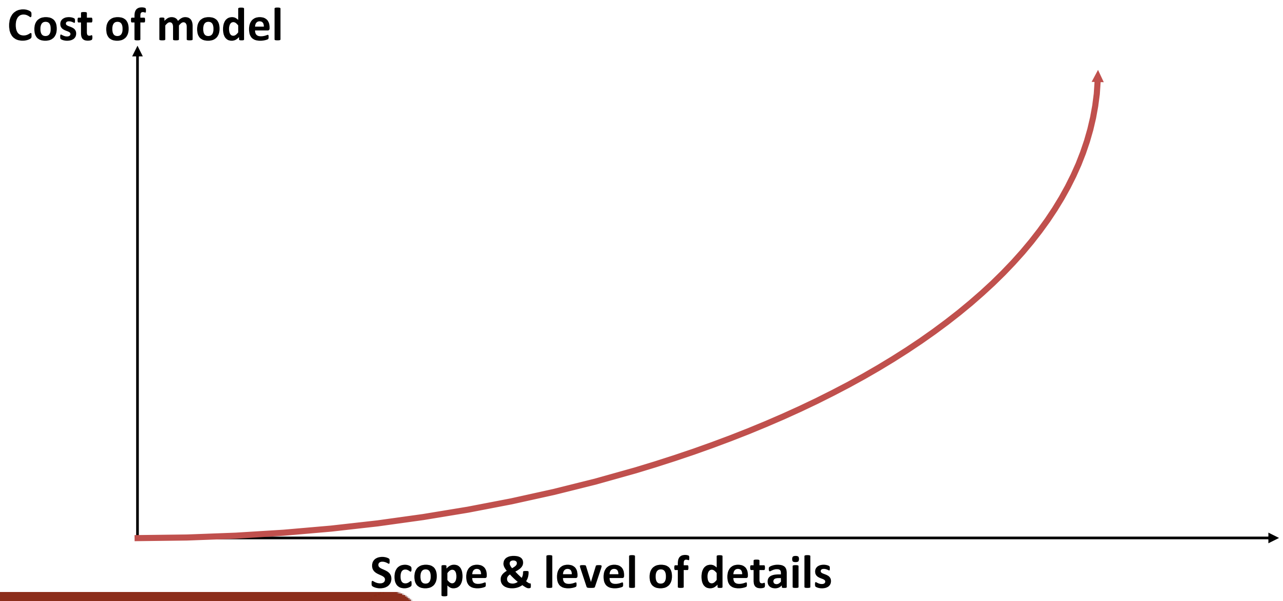
- **Select correct level of details (assumptions)**

Level of Details

- **Low levels of detail may result in loosing information and goals cannot be accomplished**

- **High levels of detail require:**
  - more time and effort
  - longer simulation runs
  - more likely to contain errors
  - more available data required for validation and verification


Accuracy of the model
Scope & level of details


Cost of model
Scope & level of details

Components of a System

- ***Entity*: is an object of interest in the system**
  - *Dynamic objects* – get created, move around, change status, affect and are affected by other entities, leave (maybe)
  - Usually have multiple *realizations* floating around
  - Can have different types of entities concurrently

Example: Health Centre

Physicians?

Patients

Visitors

Components of a System

- ***Attribute*: is a characteristic of all entities, but with a specific value "local" to the entity that can differ from one entity to another**

Example: Patient

Type of illness,

Age,

Gender,

Temperature,

Blood Pressure

Components of a System

- ***Resources*: ...what entities compete for!**
  - Entity *seizes* a resource, *uses* it, *releases* it
  - Think of a *resource being assigned to an entity*, rather than an entity “belonging to” a resource
  - “A” resource can have several *units* of capacity which can be changed during the simulation

Example: Health Centre

Doctors, Nurses

X-Ray Equipment

Components of a System

- ***Variable*: A piece of information that reflects some characteristic of the whole system, not of specific entities**
  - Entities may access and change some variables
  - Other variables are changed as a result of the system dynamics

Example: Health Centre

Number of patients in the system,

Number of idle doctors,

Current time

Components of a System

- ***State*: A collection of variables that contains all the information necessary to describe the system at any time**

Example: Health Center

{Number of patients in the system,

Status of doctors (busy or idle),

Number of idle doctors,

Status of Lab equipment, etc...}

Components of a System

- ***Event*: An instantaneous occurrence that changes the state of the system**

Example: Health Centre

Arrival of a new patient,

Completion of service (i.e., examination)

Failure of medical equipment, etc...

Components of a System

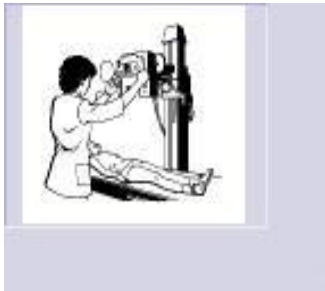
- ***Activity*: represents a time period of specified length**

Example: Health Centre

Surgery,

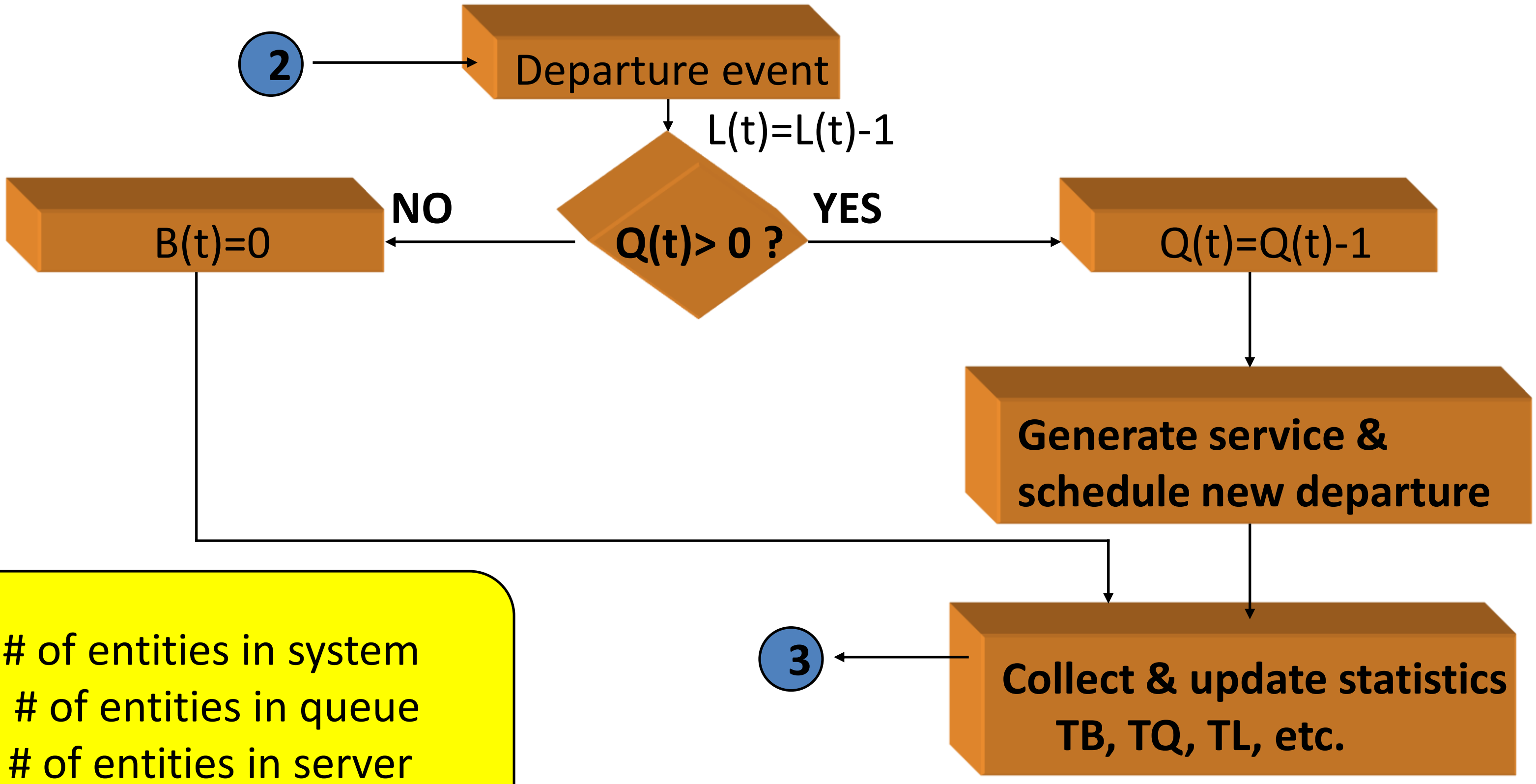
Checking temperature,

X-Ray.



Logical Model

- **Shows the logical relationships among the elements of the model (flowchart)**


2
Departure event
L(t)=L(t)-1
Q(t)> 0 ?
NO
B(t)=0
YES
Q(t)=Q(t)-1
Generate service & schedule new departure
Collect & update statistics TB, TQ, TL, etc.
3

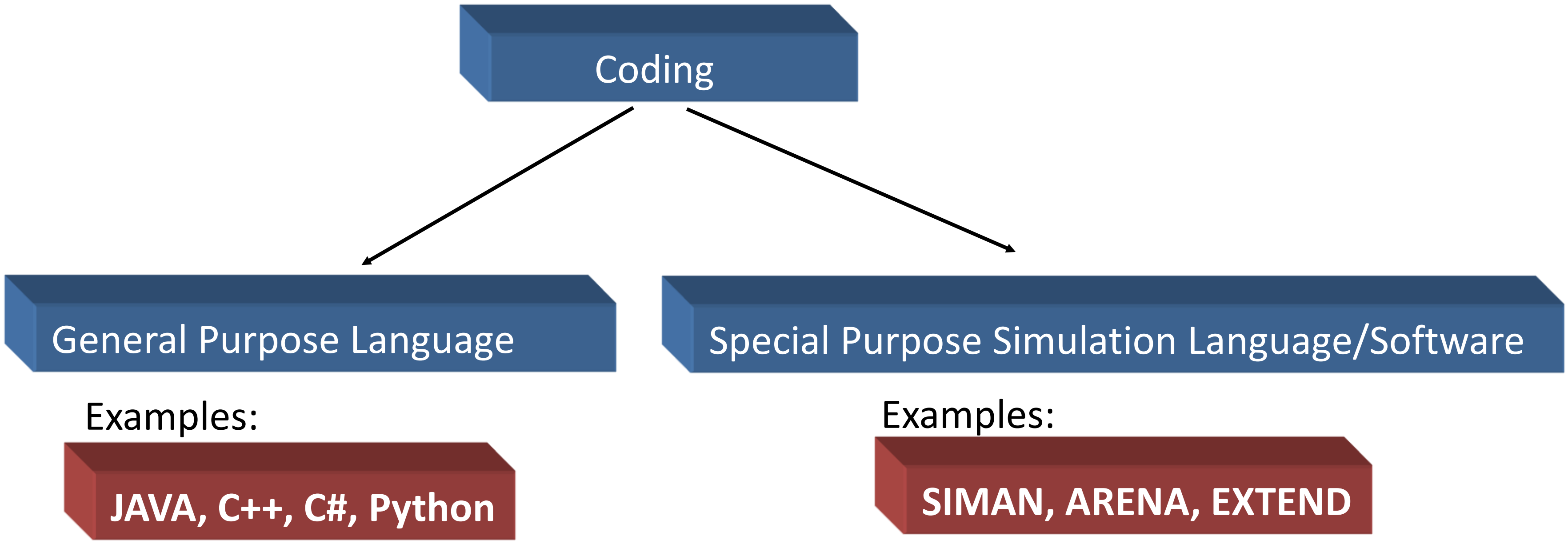
L : # of entities in system
Q : # of entities in queue
B : # of entities in server

Data Collection & Analysis

- **Collect data for input analysis and validation**
- **May require the help of subjects**
  (e.g. Measures, survey forms/questionnaires such as SP)
- **Analysis of the data**
  - Determine the random variables
  - Fit distribution functions

Model Translation

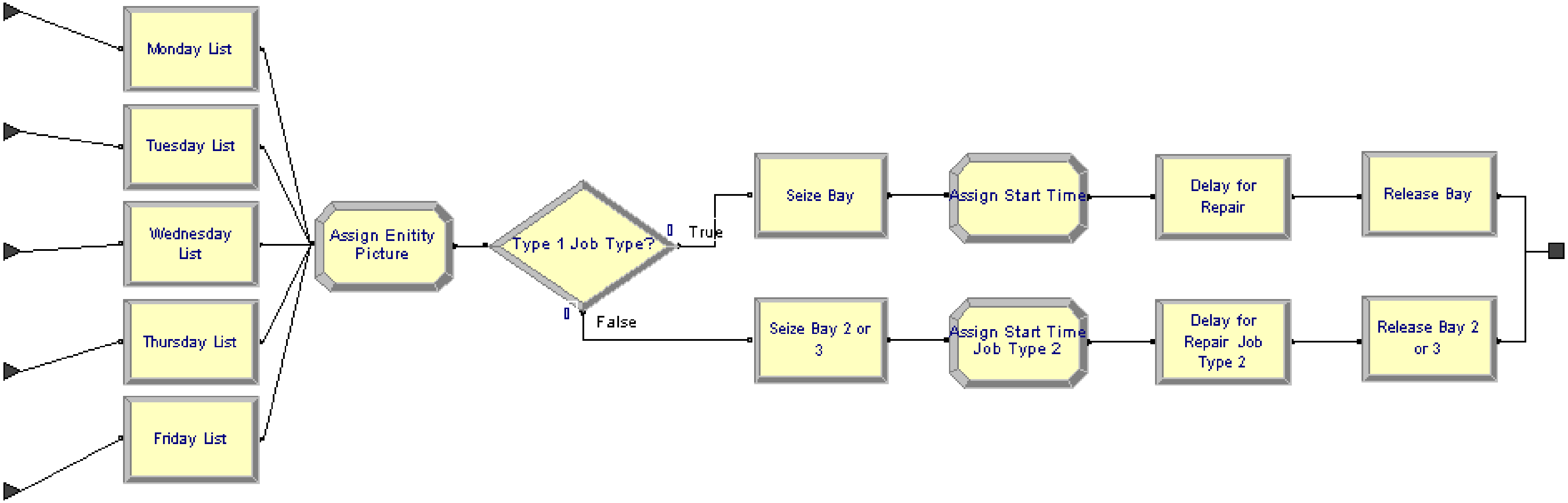
- **The simulation model executes the logic contained in the flow-chart model**



Model Translation

- **Visual Interactive Modelling & Simulation**

- **IDE example: Arena**



Model Translation

- **General purpose languages**
- **Example: Java**

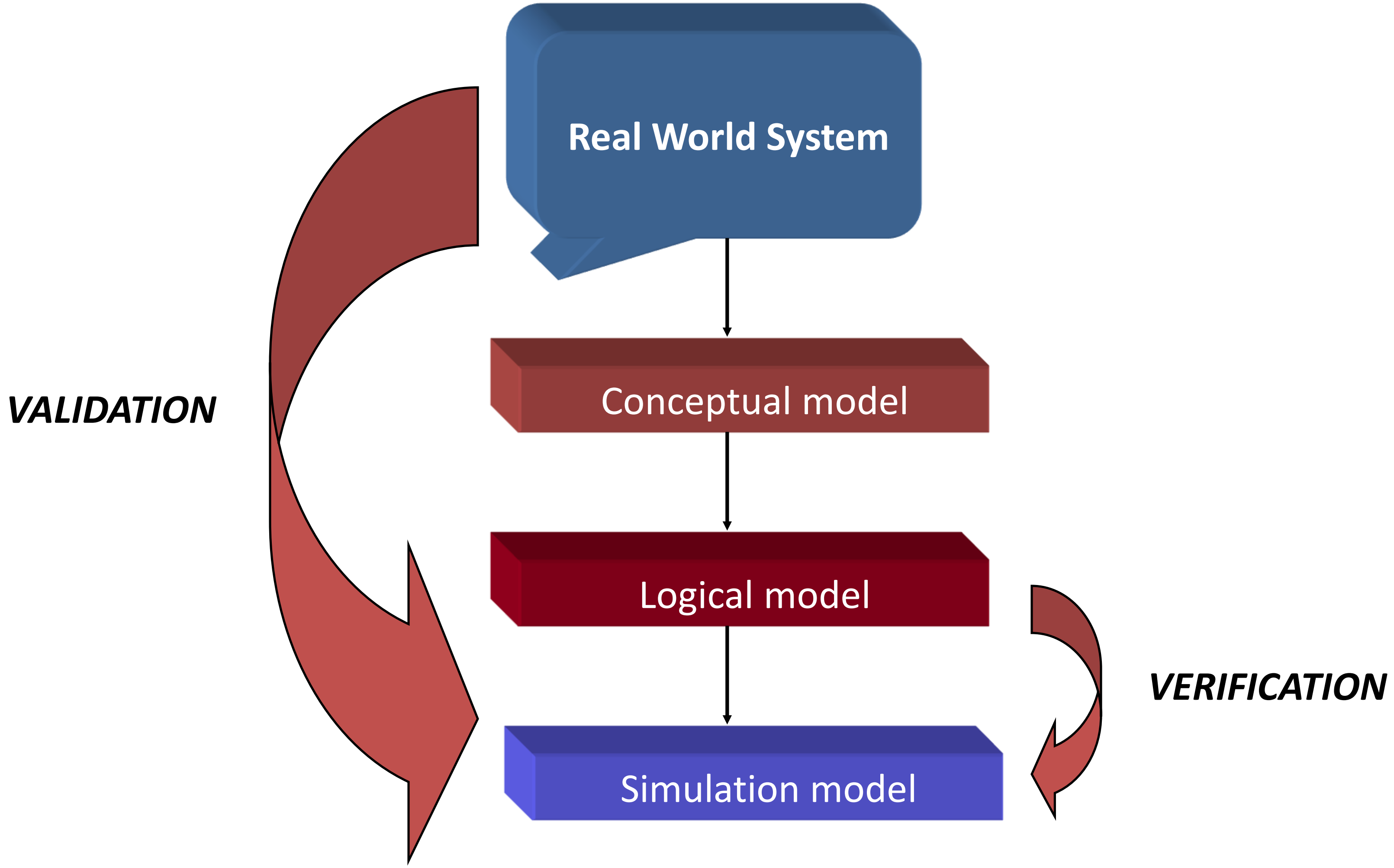
```
public static void main(String argv[])
{
        Initialization();

        //Loop until first "TotalCustomers" have departed
        while (NumberofDepartures < TotalCustomers)
        {
                Event evt = FutureEventList[0]; //get imminent event
                removefromFEL(); //be rid of it
                Clock = evt.get_time(); //advance in time
                if (evt.get_type() == arrival) ProcessArrival();
                else ProcessDeparture();
        }

        ReportGeneration();
}
```

Verification & Validation

- ***Verification*****: the process of determining if the operational logic is correct.**
  - Debugging the simulation software

- ***Validation*****: the process of determining if the model accurately represents the system.**
  - Comparison of model results with collected data from the real system

Verification & Validation



Experimental Design

- **Alternative scenarios to be simulated**
  - *Calibration* is necessary to guarantee the scenario is accurate
- **Type of output data analysis**
  (steady-state vs. terminating simulation analysis)
- **Number of simulation runs**
- **Length of each run**
- **The manner of initialization (warm-ups)**
- **Variance reduction**

Result Analysis

- **Statistical tests for significance and ranking**
  - Point Estimation
  - Confidence-Interval Estimation
  - others...

- **Interpretation of results**

- **More runs?**

Documentation & Reporting

- **Program Documentation**
  - Allows future modifications
  - Creates confidence

- **Progress Reports**
  - Frequent reports (e.g. monthly) are suggested
  - Alternative scenarios
  - Performance measures or criteria used
  - Results of experiments
  - Recommendations

Implementation

- **Deployment of results…**