



## Automatic generation of simulation models using process templates

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AIG Investments

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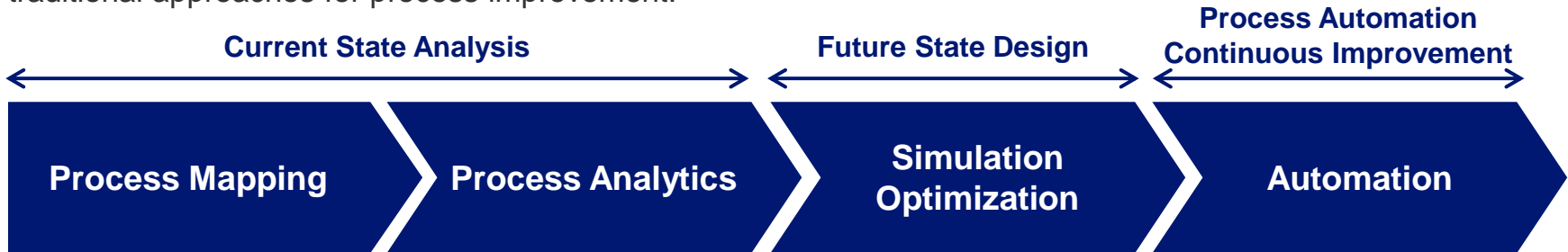
# Disclaimer

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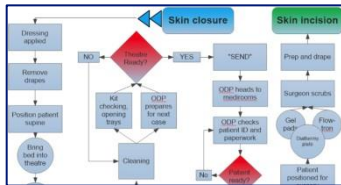
# Process Wind Tunnel : A novel process improvement capability

Process Wind Tunnel (PWT) is a data-driven process improvement framework. PWT utilizes novel process analytics and simulation modeling techniques to deliver significantly better business results, compared to traditional approaches for process improvement.



## End-to-end process mapping

- Activities and constraints
- Systems and data flows



## Data collection and wrangling

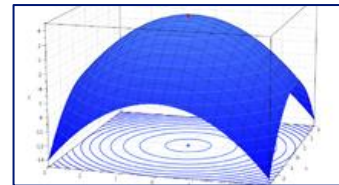
Operational and business insights through

- Process mining
- Descriptive statistics
- Predictive analytics



## Data-driven discrete-event simulation

- Model development
- Scenario analysis
- Process redesign
- Scheduling

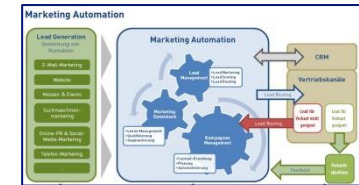


## Process Automation Continuous Improvement

### Automation

Robotic process automation (RPA)

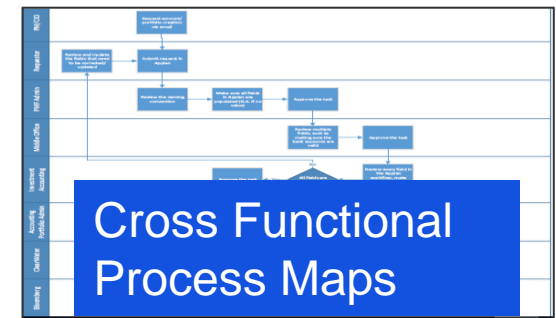
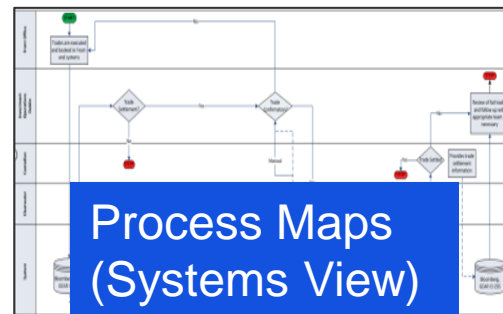
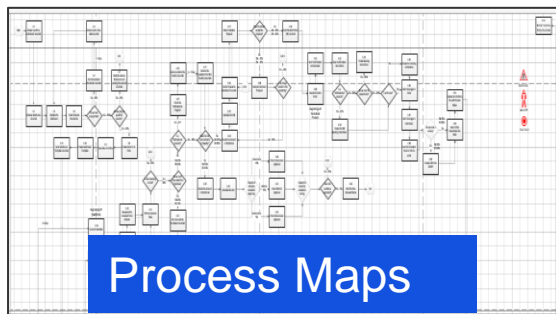
*Digital Twin* for continuous improvement and adaptive processes



# Data-Driven Discrete Event Business Process Simulation Modeling

Modeling requires highly skilled individuals in simulation and analytics

- Modeler works with business process domain expert to understand process flow, activities and their characteristics



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	
<b>9 am mail run</b>		Mon 30	Tue 1	Wed 2	Thurs 3	Fri 4	Sat	Sun	Mon 7	Tue 8	Wed 9	Thurs 10	Fri 11	Sat	Sun	Mon 14	Tue 15	Wed 16		
		408	63	503	893		838	603	63	58	793		652	471	48					
		195	55	506	960		1850	257	35	58	957		1380	36	16					
		59	8	55	62		325	59	10	15	86		326	34	10					
		33	14	85	82		237	56	2	57	88		267	102	2					
<b>11 am mail run</b>			38	9	77	53		194	18	9	57	61		101	27					
			22	6	54	15		83	28	6	49	45		224	22					
			17	9	30	23		73	10	6	12	37		20	15					
			13	12	31	55		107	7	26	44	60		48	24					
<b>UPS</b>			50	18	102	53		59	50	42	60	50		57	48	34				
			43	3	86	44		45	37	48	42	33		48	36	36				
			18	1	20	8		22	18	17	8	14		12	12	12				
			52	6	117	43		68	52	67	77	65		64	63	64				
<b>FedEx</b>																				33
																				8
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<b>Daily Totals</b>																				1043
																				222

**Task/ Job Arrivals**

Product / Activities	BaseDeliv	BaseDeliv	Who performs task?	Flow/Fact/Task	Who performs task?	Flow/Fact/Task	Who performs task?	Flow/Fact/Task	Who performs task?
BaseDeliv consist with UP									
UP (delivered to customer companies)									
Deliver information on filing of submission									
UP file submission									
File assessment and related tasks to determine whether to quote									
Send to SCS (Data or AGES) (Send/Release)									
Task/Job development									
Quote/assessment of UP for submission									
Quote/assessment of Data/Deal for submission									
Determine if position is fully									
Follow-up activities that result in production of quote									
Validate quote/assessment									
Value the quote/assessment									
The order will be a complete									
The quote/assessment									
Policy for development									
Book/quote/assessment									
Book/quote/assessment									
Quote/assessment									

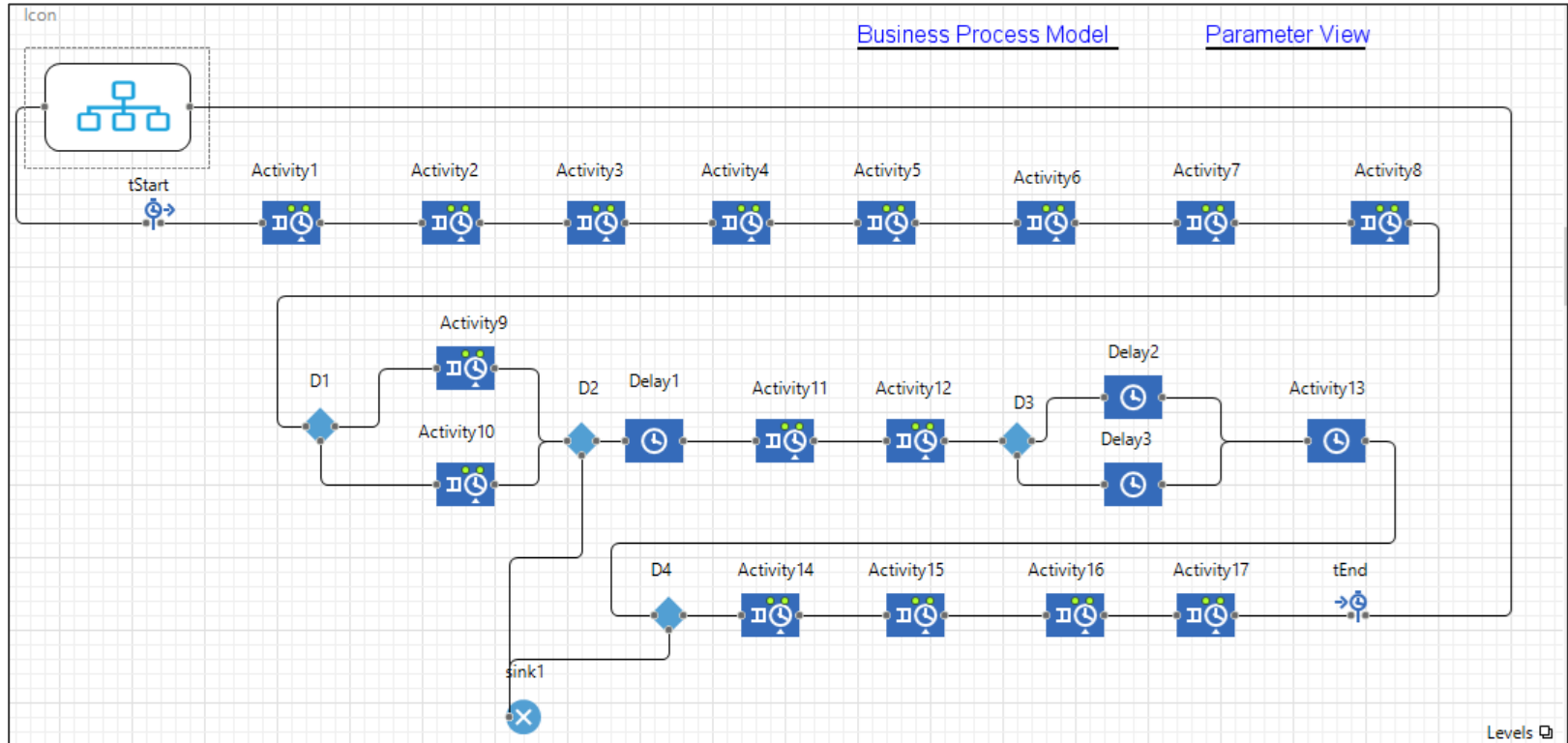
**Activity time and resource**

PVID	SUBM#	POLICY	QUOTE	QUOTE	CLIENT	PRODUC	CRED	ESTART	ESTART	ESTART	ESTART	STATUS	AGGREG	STATUS
V-55876	6E+00	FLO000N	2333-RE	1	CU-4193	1276	IT	596	SME	2333	MAJWCF	1648	K	Bound
V-55871	6E+00	FLO000N	2333-RE	1	CU-4235	1248	IT	595	LOWER	2333	MAJWCF	3020	K	Bound
V-55874	2E+00	INALL	2333-RE	INULL	CU-4319	3111	IT	596	SME	2333	MAJWCF	3028	V	Void
V-55891	2E+00	INALL	2333-RE	INULL	CU-4041	1175	IT	592	MAJCF	2333	MAJWCF	3020	V	Void
V-55876	7E+00	FLO000N	2333-RE	1	CU-4235	1935	IT	596	SME	2333	MAJWCF	1648	K	Bound
V-55871	7E+00	FLO000N	2333-RE	1	CU-4241	9465	IT	596	SME	2333	MAJWCF	3810	K	Bound
V-55874	4E+00	FLO000N	2333-RE	1	CU-4235	100	IT	595	LOWER	2333	MAJWCF	3810	K	Bound
V-55874	6E+00	INALL	2333-RE	INULL	CU-4278	9360	IT	595	LOWER	2333	MAJWCF	3030	V	Void
V-55871	5E+00	FLO000N	2333-RE	1	CU-4156	1037	IT	595	LOWER	2333	MAJWCF	1648	K	Bound
V-55866	6E+00	INALL	2333-RE	INULL	CU-4106	3111	IT	596	SME	2333	MAJWCF	3660	V	Void
V-55845	8E+00	INALL	2333-RE	INULL	CU-4246	9402	IT	596	SME	2333	MAJWCF	1648	V	Void
V-55871	6E+00	FLO000N	2333-RE	1	CU-4193	1276	IT	596	SME	2333	MAJWCF	1647	K	Bound
V-55872	6E+00	FLO000N	2333-RE	1	CU-4193	1442	IT	595	LOWER	2333	MAJWCF	3029	K	Bound
V-55891	6E+00	INALL	2333-RE	INULL	CU-4106	3111	IT	595	LOWER	2333	MAJWCF	1648	V	Void
V-55881	6E													Void
V-55877	2E													Void
V-55886	7E													Void
V-55862	5E													Void
V-55864	9E													Void
V-55854	7E													Void
V-55875	6E													Void
V-55877	7E													Void
V-55877	7E													Void
V-55874	4E													Void
V-55865	6E													Void
V-55874	4E													Void
V-55877	5E													Void
V-55874	4E													Void
V-55891	1E													Void

**Historical Activity Execution Data**

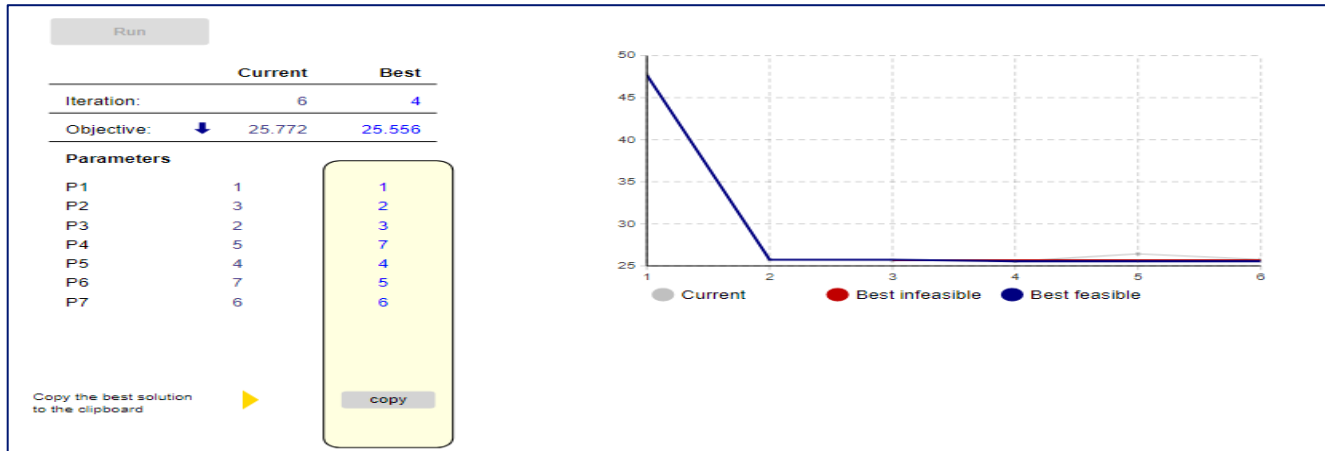
# Simulation Model Development in Anylogic

Modeler develops the simulation model



# Analysis and Interpretation of Model Output

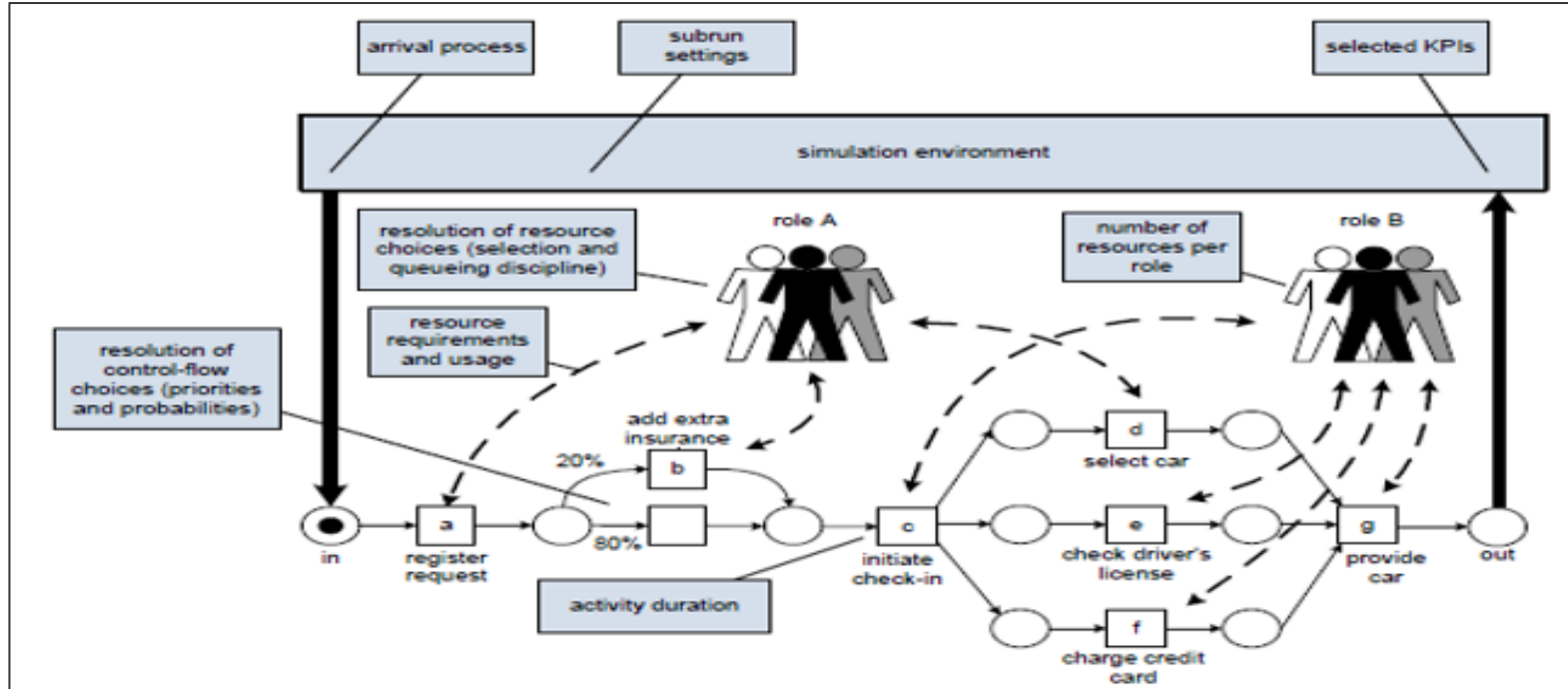
Modeler and domain expert utilize the simulation model to perform scenario analysis and optimization



# Simulation modeling requires significant information gathering

The process of simulation modeling requires gathering of data related to process flows and parameters

- Two types of information needed to build a simulation model
  - Process flow information including business rules and constraints
  - Information on the activity blocks, resources etc.



# Variations in Process Structure and Parameters across the same family of processes

A variety of factors could lead to structural differences in processes belonging to the same family of processes

- Within an enterprise, multiple instances of a process type exist with similar basic structure but with variations across instances

Process Type	Causes of Variations
Underwriting	Geographical location, service type, staffing, business applications, schedules, ...
Claims	
Finance	
IT	
...	



# Propose decoupling process information gathering from simulation model development

Through the use of pre-defined templates for gathering information, one can decouple the task for information gathering from simulation model development

- Parameter variations across models can be easily implemented. However, structural variations in process are difficult to update automatically
  
- The use of standard templates to capture process modeling information is proposed
  - Templates can capture information elements related to:
    - Arrival information
    - Activity time distributions
    - *Model graphs – how the activity blocks are linked*
    - Resource schedules
    - Business rules
  
  - Template information is utilized to automatically generate Anylogic discrete-event simulation models

# An example of a data collection template (1)

Business process data as required by the simulation modelers is collected from the subject matter experts in customized data collection template

1	Parameter	Value	C	D	E
2	Model Name	Business Process			
3	Simulation Time Units	Day			
4	Job Dispatching Policy	FIFO			
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

GENERAL ARRIVAL DISTRIBUTION ACTIVITY TIME DISTRIBUTION

Name	Value	ID	Arrival Date	Type
Arrival Distribution Type	Non-Parametric	1001	5/1/2015 0:00	Type2
Inter arrival time distribution		1002	5/4/2015 0:00	Type1
Mean Interarrival time		1003	5/4/2015 0:00	Type1
Time unit		1004	5/4/2015 0:00	Type2
		1005	5/4/2015 0:00	Type2
		1006	5/4/2015 0:00	Type2
		1007	5/4/2015 0:00	Type1
		1008	5/5/2015 0:00	Type2
		1009	5/5/2015 0:00	Type2
		1010	5/5/2015 0:00	Type1
		1011	5/5/2015 0:00	Type1
		1012	5/5/2015 0:00	Type1
		1013	5/5/2015 0:00	Type1
		1014	5/5/2015 0:00	Type2
		1015	5/5/2015 0:00	Type2
		1016	5/5/2015 0:00	Type2
		1017	5/5/2015 0:00	Type1
		1018	5/6/2015 0:00	Type2
		1019	5/6/2015 0:00	Type2

GENERAL ARRIVAL DISTRIBUTION ACTIVITY TIME DISTRIBUTION MODEL GRAPH RESOURCE SCHEDULE

Name	Value	C	D	E	F	G	H	I
Activity Time Distribution Type	Triangular							
Time Unit	minute							

Activity No	Activity Name	Type	Min	Max	Mode	Mean	Sigma	Alpha
1	Activity1	Type1	10	15	20			
2	Activity2	Type1	4	7	5			
2	Activity2	Type2	15	25	20			
3	Activity3	Type1,Type2	5	10	8			
4	Activity4	Type1,Type2	8	12	10			
5	Activity5	Type1	8	12	10			
5	Activity5	Type2	160	200	180			
6	Activity6	Type1,Type2	1	3	2			
7	Activity7	Type1,Type2	50	70	60			
8	Activity8	Type1	20	40	30			
8	Activity8	Type2	20	40	30			
9	Activity9	Type1,Type2	10	20	15			
10	Activity10	Type2	25	40	30			

GENERAL ARRIVAL DISTRIBUTION ACTIVITY TIME DISTRIBUTION MODEL GRAPH RESOURCE SCHEDULE





# Approach to automated Anylogic model development

Different approaches can be utilized to develop the Anylogic simulation model from the template

- Anylogic recommends using in-built Java-functions to programmatically construct simulation models within the Anylogic environment
  - From within Anylogic read the Excel templates and programmatically instantiate the building blocks and connectors
- In this work, we chose to create the .xml model files (.alp files) directly using software modules written in Java outside of the Anylogic environment

```

<?xml version="1.0" encoding="UTF-8" ?>
<!-- .....
AnyLogic Project File
..... -->
<AnyLogicWorkspace WorkspaceVersion="1.9" AnyLogicVersion="8.5.2.202001241833" AlpVersion="8.5.1">
  <Model>
    <Id>1478238189528</Id>
    <Name><![CDATA[IntegratedModelSimOutput]]></Name>
    <EngineVersion>6</EngineVersion>
    <JavaPackageName><![CDATA[IntegratedModel]]></JavaPackageName>
    <ModelTimeUnit><![CDATA[Day]]></ModelTimeUnit>
    <ActiveObjectClasses>
      <!-- ..... Active Object Class ..... -->
      <ActiveObjectClass>
        <DifferentialEquationsMethod>EULER</DifferentialEquationsMethod>
        <MixedEquationsMethod>RK45_NEWTON</MixedEquationsMethod>
        <AlgebraicEquationsMethod>MODIFIED_NEWTON</AlgebraicEquationsMethod>
        <AbsoluteAccuracy>1.0E-5</AbsoluteAccuracy>
        <FixedTimeStep>0.001</FixedTimeStep>
        <RelativeAccuracy>1.0E-5</RelativeAccuracy>
        <TimeAccuracy>1.0E-5</TimeAccuracy>
      </ActiveObjectClass>
    </ActiveObjectClasses>
    <Database>
    <RunConfiguration ActiveObjectClass>
    <Experiments>
    <JavaClasses>
    <ModelResources>
    <RequiredLibraryReferences>
    </Model>
  </AnyLogicWorkspace>
    
```

Anylogic xml Model Code

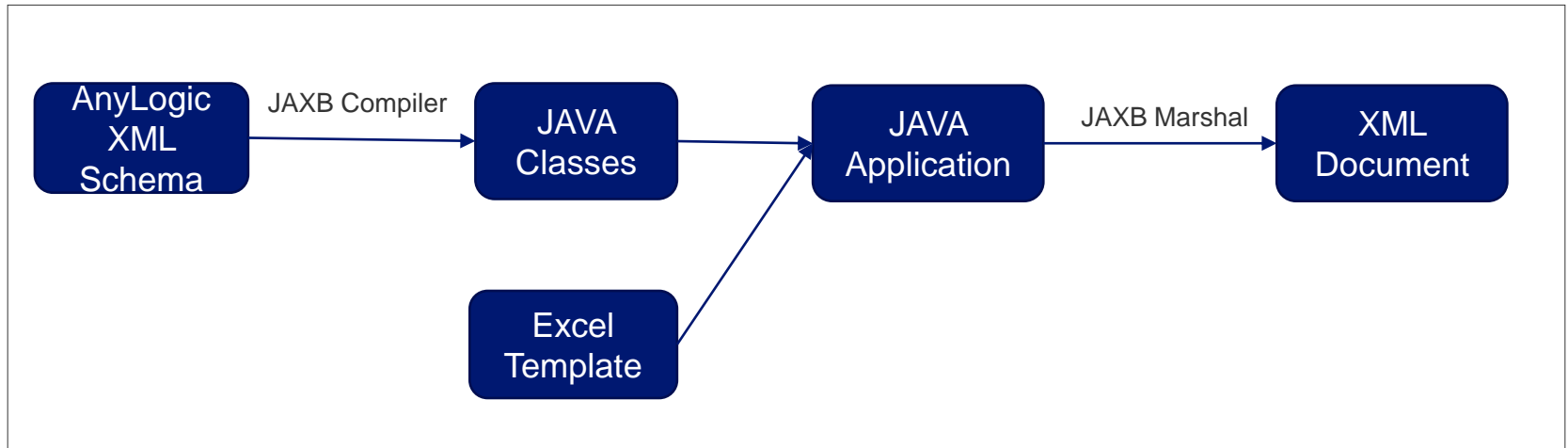
```

XML Schema
<AnyLogicWorkspace WorkspaceVersion="1.9"
AnyLogicVersion="7.3.5.201608171904" AlpVersion="7.3.3">
  <Model>
    <Id></Id>
    <Name><![CDATA[Model1]]></Name>
    <EngineVersion>6</EngineVersion>
    <JavaPackageName><![CDATA[]]></JavaPackageName>
    <ModelTimeUnit><![CDATA[]]></ModelTimeUnit>
  <ActiveObjectClasses>
    <ActiveObjectClass>
      <ClientAreaTopLeft>
      <GenericAgent extends
    </ActiveObjectClass>
  </ActiveObjectClasses>
</AnyLogicWorkspace>
    
```

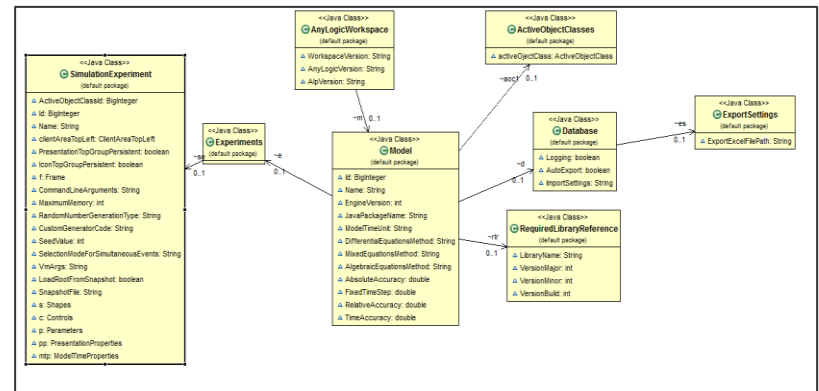
Anylogic xml Schema

# Simulation Automation Architecture

Java application instantiates Java classes, reads the Excel template and creates the Anylogic simulation model automatically



XML Schema	JAXB Binding
<pre> &lt;AnyLogicWorkspace WorkspaceVersion="1.9" AnyLogicVersion="7.3.5.201608171904" AlpVersion="7.3.3"&gt; &lt;Model&gt;   &lt;Id&gt;1485436692726&lt;/Id&gt;   &lt;Name&gt;&lt;![CDATA[Model1]]&gt;&lt;/Name&gt;   &lt;EngineVersion&gt;6&lt;/EngineVersion&gt;   &lt;JavaPackageName&gt;&lt;![CDATA[Model1]]&gt;&lt;/JavaPackageName&gt;   &lt;ModelTimeUnit&gt;&lt;![CDATA[Hour]]&gt;&lt;/ModelTimeUnit&gt; &lt;/ActiveObjectClasses&gt;   &lt;ActiveObjectClass&gt; &lt;ClientAreaTopLeft&gt;&lt;X&gt;0&lt;/X&gt;&lt;Y&gt;0&lt;/Y&gt;&lt;/ClientAreaTopLeft&gt; &lt;GenericParameterValue Class="CodeValue"&gt;   &lt;Code&gt;&lt;![CDATA[T extends Agent]]&gt;&lt;/Code&gt;           &lt;/GenericParameterValue&gt;           </pre>	<pre> AnyLogicWorkspace.java Model.java ActiveObjectClasses.java ClientAreaTopLeft.java GenericParameterValue.java           </pre>



# DEMO

ItalyModelTemplateWithNodeCondition [Compatibility Mode] - Microsoft Excel

File Home Insert Page Layout Formulas Data Review View

Clipboard Font Alignment Number Styles Cells Editing

Parameter	Value
Model Name	
Time Units	Day
Dispatching Rule	FIFO

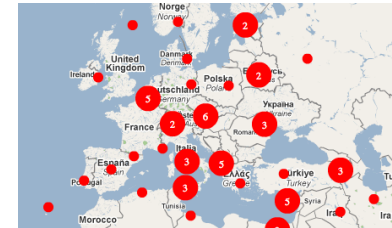
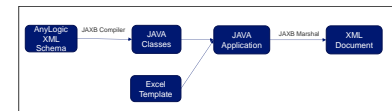
Simulation Model Data

GENERAL ARRIVAL-DISTRIBUTION ACTIVITYTIME-DISTRIBUTION MODEL\_GRAPH RESOURCE\_SCHEDULE Sheet1

Ready 100% 12:57 PM

# Summary

- In this talk, we addressed the problem of scalability of discrete-event modeling technology to improve and optimize multiple instances of a class of business processes
- The use of pre-defined templates to capture information required for modeling was proposed that can be customized for business domain experts
- Software to automatically interpret the templated information and generate discrete-event simulation models was discussed and demonstrated
- The use of the above approach can enable broader scalability and adoption of discrete-event simulation modeling technology within business enterprises by de-skilling and decoupling the task of simulation modeling.

A screenshot of a web-based data entry form. It has a header with a title and a table with several columns and rows. The table contains numerical data.A screenshot of a data table with multiple columns and rows. The columns are labeled with various categories, and the rows contain numerical values.

*Thank you!*