MTAT.03.231 Business Process Management

Lecture 6
Quantitative Process Analysis

Part 1: Flow Analysis

Marlon Dumas
Professor of Information Systems @ University of Tartu
Co-Founder of Apromore
Process Analysis

- Process identification
  - Process architecture
  - Conformance and performance insights

- Process discovery
  - As-is process model

- Process monitoring and controlling
  - Executable process model

- Process implementation
  - To-be process model
  - Process redesign

- Process analysis
  - Insights on weaknesses and their impact
Process Analysis Techniques

Qualitative analysis
- Value-Added & Waste Analysis
- Root-Cause Analysis
- Pareto Analysis
- Issue Register

Quantitative Analysis
- Flow analysis
- Queuing analysis
- Simulation
Process performance

If you had to choose between two services, you would typically choose the one that is:

• F…
• C…
• B…
Process performance

If you had to choose between two services, you would typically choose the one that is:

• Faster
• Cheaper
• Better
Process performance
Time measures

- Processing time
- Waiting time
- Time taken by value-adding activities
- Time taken by non-value-adding activities
- Time between start and completion of a process instance
Cycle time efficiency

\[
\frac{\text{Processing Time}}{\text{Cycle Time}} = \text{Cycle Time Efficiency}
\]
Cost measures

- Processing cost
- Cost of value-adding activities
- Cost of non-value-adding activities
- Cost of waste
- Cost of a process instance

Per-Instance Cost

Cost measures include the cost of processing, cost of value-adding activities, cost of non-value-adding activities, cost of waste, and the cost of a process instance. These components contribute to the overall per-instance cost of a process.
Typical components of cost

**Material cost**
- Cost of tangible or intangible resources used per process instance

**Resource cost**
- Cost of person-hours employed per process instance
Resource utilization

Resource utilization = 60%
➔ on average resources are idle 40% of their allocated time
Resource utilization vs. waiting time

Typically, when resource utilization > 90%
  ➔ Waiting time increases steeply
Quality

Product quality

• Defect rate

Delivery quality

• On-time delivery rate
• Cycle time variance

Customer satisfaction

• Customer feedback score
For each performance measure, define targets

ST_{30} > 99%

For each objective, identify variable(s) and aggregation method ➔ performance measure

| Variable: customer served in < 30 min. | Aggregation method: percentage | Measure: ST_{30} = \% of customers served in < 30 min. |

For each process, formulate process performance objectives

Customer should be served always in a timely manner

Identifying performance measures
Flow Analysis
Flow analysis

Process model

Performance of each activity

Process performance
Flow analysis of cycle time

Cycle time = X days
Sequence – Example

- What is the average cycle time?

Cycle time = 10 + 20 = 30
Example: Alternative Paths

• What is the average cycle time?

\[
\text{Cycle time} = 10 + 0.9 \times 20 + 0.1 \times 10 = 29
\]
Example: Parallel paths

- What is the average cycle time?

Cycle time $= 10 + 20 = 30$
Example: Rework loop

- What is the average cycle time?

Cycle time = $10 + 20 = 30$

Cycle time = $10 + 20/0.01 = 2010$

Cycle time = $10 + 20/0.8 = 35$
Flow analysis equations for cycle time

CT = T₁ + T₂ + ... + Tₙ

CT = p₁ * T₁ + p₂ * T₂ + ... + pₙ * Tₙ

CT = max(T₁, T₂, ..., Tₙ)

CT = T / (1 - r)
Flow analysis of cycle time

Cycle time = 1.25 + 3 + 3 + 1.4 = 8.65 days
Flow analysis of processing time

Processing time = 2.5 + 3 + 2 + 1.4 = 8.9 hours

Cycle time efficiency = 8.9 hours / 8.65 days = 12.9%
Exercise: Calculate CTE of the following process

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cycle time</th>
<th>Processing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register ministerial enquiry</td>
<td>2 days</td>
<td>30 mins</td>
</tr>
<tr>
<td>Investigate ministerial enquiry</td>
<td>8 days</td>
<td>12 hours</td>
</tr>
<tr>
<td>Prepare ministerial response</td>
<td>4 days</td>
<td>4 hours</td>
</tr>
<tr>
<td>Review ministerial response</td>
<td>4 days</td>
<td>2 hours</td>
</tr>
</tbody>
</table>
Flow analysis: scope and limitations

- Flow analysis for cycle time calculation
- Other applications:
  - Calculating cost-per-process-instance
  - Calculating error rates at the process level
  - Estimating capacity requirements
- But it has its limitations…
Limitation 1: Not all Models are Structured
Limitation 2: Fixed arrival rate capacity

- Cycle time analysis does not consider:
  - The rate at which new process instances are created (arrival rate)
  - The number of available resources

- Higher arrival rate at fixed resource capacity
  - high resource contention
  - higher activity waiting times (longer queues)
  - higher activity cycle time
  - higher overall cycle time

- The slower you are, the more people have to queue up…
  - and vice-versa
Cycle Time & Work-In-Progress

- **WIP = (average) Work-In-Process**
  - Number of cases that are running (started but not yet completed)
  - E.g. # of active and unfilled orders in an order-to-cash process

- **WIP is a form of waste (cf. 7+1 sources of waste)**

- **Little’s Formula: WIP = \( \lambda \cdot CT \)**
  - \( \lambda \) = arrival rate (number of new cases per time unit)
  - CT = cycle time
Exercise

A fast-food restaurant receives on average 1200 customers per day (between 10:00 and 22:00). During peak times (12:00-15:00 and 18:00-21:00), the restaurant receives around 900 customers in total, and 90 customers can be found in the restaurant (on average) at a given point in time. At non-peak times, the restaurant receives 300 customers in total, and 30 customers can be found in the restaurant (on average) at a given point in time.

1. What is the average time that a customer spends in the restaurant during peak times?
2. What is the average time that a customer spends in the restaurant during non-peak times?
Exercise (cont.)

3. The restaurant plans to launch a marketing campaign to attract more customers. However, the restaurant’s capacity is limited and becomes too full during peak times. What can the restaurant do to address this issue without investing in extending its building?
Next week: queuing theory & simulation