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IS 2006 – Business Process Management

PROCESS ANALYSIS

University of Colombo School of Computing

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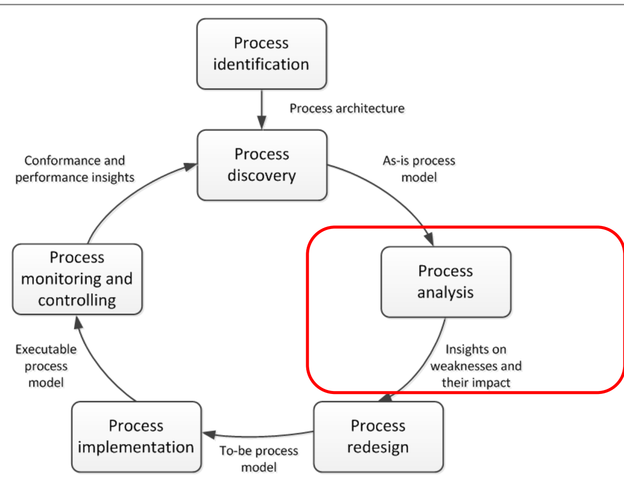
Where are we in the BPM Lifecycle..



Process Analysis Techniques

Qualitative analysis

- Value-Added Analysis
- Root-Cause Analysis
- Pareto Analysis
- Issue Register

Quantitative Analysis

- Quantitative Flow Analysis
- Queuing Theory
- Process Simulation

Qualitative Process Analysis

Quality is Free, but only to those who are willing to pay heavily for it.

(Tom DeMarco, 1940-)

Value Added Analysis

The Value added analysis consist of 2 stages:

Value Classification

Waste Elimination

Value Classification

1. Decompose the process into steps
2. Classify each step into:
   - Value-adding (VA): Produces value or satisfaction to the customer.
     - Is the customer willing to pay for this step?
   - Business value-adding (BVA): Necessary or useful for the business to run smoothly, or required due to the regulatory environment, e.g. checks, controls
     - Would the business potentially suffer in the long-term if this step was removed?
   - Non-value-adding (NVA) – everything else including handovers, delays and rework

E.g. – Equipment Rental Process

Step	Performer	Classification
Fill request	Site engineer	VA
Send request to clerk	Site engineer	NVA
Open and read request	Clerk	NVA
Select suitable equipment	Clerk	VA
Check equipment availability	Clerk	VA
Record recommended equipment & supplier	Clerk	VA
Forward request to works engineer	Clerk	VA
Open and examine request	Works engineer	BVA
Communicate issues	Works engineer	BVA
Forward request back to clerk	Works engineer	NVA
Produce PO	Clerk	BVA
Send PO to supplier	Clerk	BVA

Eliminating Waste

"All we are doing is looking at the time line, from the moment the customer gives us an order to the point when we collect the cash.

And we are reducing the time line by reducing the non-value-adding wastes "

--Taiichi Ohno

7+1 Sources of Waste

1. Unnecessary Transportation *(send, receive)*
2. Inventory *(large work-in-process)*
3. Motion *(drop-off, pick-up, go to)*
4. Waiting *(waiting time between tasks)*
5. Over-Processing *(performing what is not yet needed or might not be needed)*
6. Over-Production *(unnecessary cases)*
7. Defects *(rework to fix defects)*
8. Resource underutilization (idle resources)

Source: Seven Wastes defined by Taiichi Ohno

8th waste coined by Ben Chavis, Jr.

General Practices of elimination from the Value-Added Analysis

Minimize or eliminate NVA steps

Some NVA steps can be eliminated by automation. Automation can bring transparency into the process to its performers

Eliminate NVA performers (e.g. Remove Clerk in the Equipment Rental Process and give work to the Site Engineer, reduces handovers)

Eliminate the need of NVA steps

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Root cause Analysis

A family of techniques to help analysts to identify and understand root cause(s) of problems or undesirable events.

Commonly used in context of an accident or incident analysis

Also used in manufacturing processes to understand the root cause of defects in a product.

In the context of business process analysis root cause analysis is helpful understand and identify issues that prevent a process from having a better performance.

Root cause analysis techniques;
- Cause-Effect Diagrams
- Why-why Diagrams

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Cause-Effect (Fishbone/Ishikawa) Diagrams

Helps to identify all the likely causes of a problem.

Depicts the relationship between a given negative effect and its causes.

Negative effect is;
- A recurrent issue
- Undesirable level of process performance

Causes can be divided into causal and contributing factors

In a cause-effect diagram factors are grouped into categories and possibly sub categories

Causal vs. Contributing Factors

CAUSAL FACTORS

Factors that, if corrected, eliminated or avoided would prevent the issue from occurring.

E.g. In the context of insurance claims handling process errors in the estimation of damages lead to incorrect claim assessment. If the damage estimation issues were eliminated, a number of occurrences of the issue “Incorrect claim assessment” would be prevented.

CONTRIBUTING FACTORS

Factors that set the stage for, or that increase the chances of a given issue occurring.

E.g. In the user interface for lodging the insurance claims requires a claimant to enter a few date (e.g. date when the incident occurred), but the interface does not provide a calendar widget so that the user can easily select the date. This deficiency in the user interface may increase the chances of erroneous entering of the date by the user. Thus, it contributes to the issue “Incorrect data entry”

Steps of Drawing a Cause-Effect Diagram

Step 1: Identify the Problem

Step 2: Work Out the Major Factors Involved

Step 3: Identify Possible Causes

Step 4: Analyze Your Diagram

Source: MindTools (http://www.mindtools.com/pages/article/newTMC_03.htm)

Categorization for cause-effect analysis (6M's)

1. Machine
2. Method
3. Material
4. Man
5. Measurement
6. Milieu

6M's are usually used for the manufacturing industry
This categorization act as guidelines for brainstorming during root cause analysis

1. Machine

Factors relating to the technology used

E.g. software failures, network failures, system crashes occurs in the information system that supports a business process

Possible Sub- categories:

a. Lack of functionality in application system

b. Redundant storage of data across systems, leading double data entry

c. Low performance of IT of network systems, leading for (e.g) low response time

d. Poor user interface designs, leading for erroneous data entry and missing data

e. Lack of integration between multiple systems within the enterprise or with external systems

2. Method

Factors stemming from the way a process is defined, understood or performed

E.g. In a given process when participant A thinks participant B will send an email to the customer but participant B does not send is because he is not aware that he has to send it

Possible Sub-Categories

a. Unclear, unsuitable or inconstant assignment of decision making and processing responsibilities to process participants

b. Lack of empowerment of process participants

c. Lack of timely communication between process participants or process participants and the customer

3. Material

Factors stemming from the raw materials, consumables or data required as input by the activities in the process

E.g. incorrect data leading to wrong decision, being made during the execution of a process

4. Man

Factors related to wrong assessment or incorrectly performed step

E.g. claims handler incorrectly accepting a claim even though data in the claim and the rules used for assessing the claim require that the claim be rejected.

Possible sub-categories

a. Lack of training and clear instructions for process participants

b. Lack of incentive system to motivate process participants sufficiently

c. Expecting too much from the process participants (e.g. overly hectic schedules)

d. Inadequate recruitment of process participants.

5. Measurement

Factors related to measurements or calculations made during the process.

E.g. In context of an insurance claim, where the amount to be paid to the customer is miscalculated due to an inaccurate estimation of the damage being claimed.

6. Milieu (Setting)

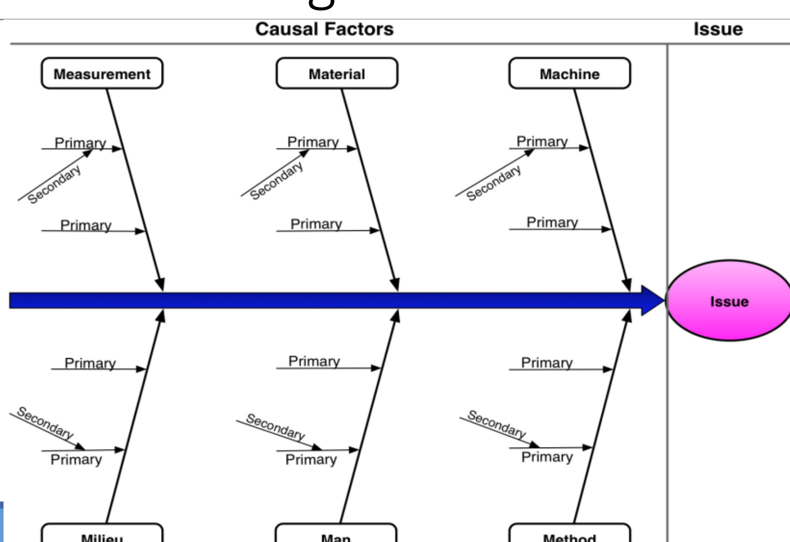
Factors stemming from environment in which the process is executed

Milieu conditions are outside the control of the process participants, process owner and other company managers

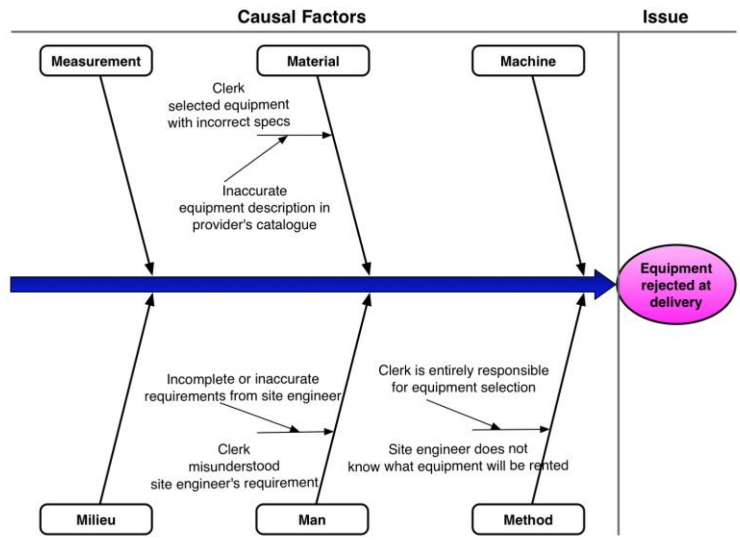
E.g. factors originating from the customer, supplier or other external actors

Possible sub-categories
  originating actor is a possible sub categorization

Case-Effect Diagram Structure



Cause-effect diagram: E.g. rejected equipment



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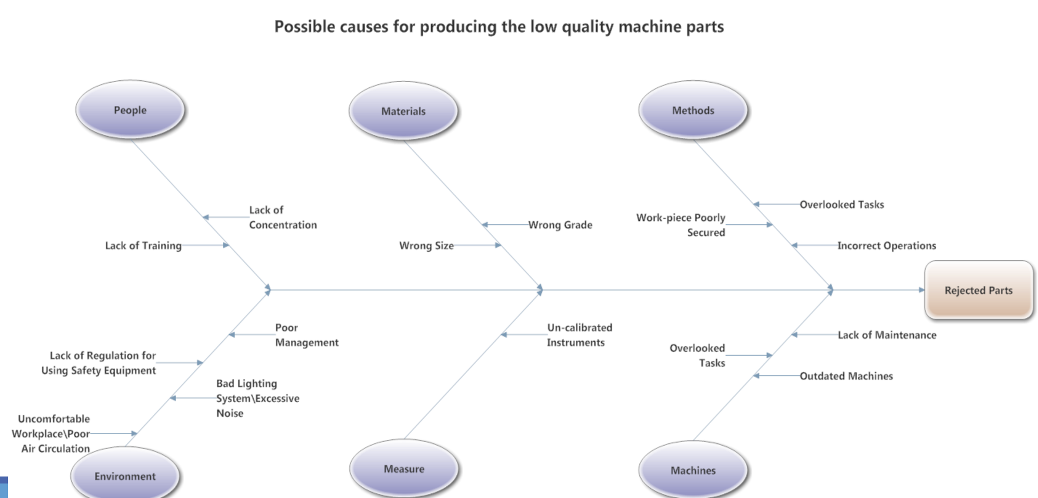
Cause-effect diagram: E.g. low quality machine parts



Exercise – Admission Process

Consider the following process for the admission of graduate students at a university. In order to apply for admission, students first fill in an online form. Online applications are recorded in an information system to which all staff members involved in the admissions process have access to. After a student has submitted the online form, a PDF document is generated and the student is requested to download it, sign it, and send it by post together with the required documents, which include: 1. Certified copies of previous degree and academic transcripts. 2. Results of English language test. 3. Curriculum vitae.

When these documents are received by the admissions office, an officer checks the completeness of the documents. If any document is missing, an e-mail is sent to the student. The student has to send the missing documents by post. Assuming the application is complete, the admissions office sends the certified copies of the degrees to an academic recognition agency, which checks the degrees and gives an assessment of their validity and equivalence in terms local education standards. This agency requires that all documents be sent to it by post, and all documents must be certified copies of the originals. The agency sends back its assessment to the university by post as well. Assuming the degree verification is successful, the English language test results are then checked online by an officer at the admissions office. If the validity of the English language test results cannot be verified, the application is rejected (such notifications of rejection are sent by e-mail). Once all documents of a given student have been validated, the admission office forwards these documents by internal mail to the corresponding academic committee responsible for deciding whether to offer admission or not. The committee makes its decision based on the academic transcripts and the CV. The committee meets once every 2 to 3 weeks and examines all applications that are ready for academic assessment at the time of the meeting.

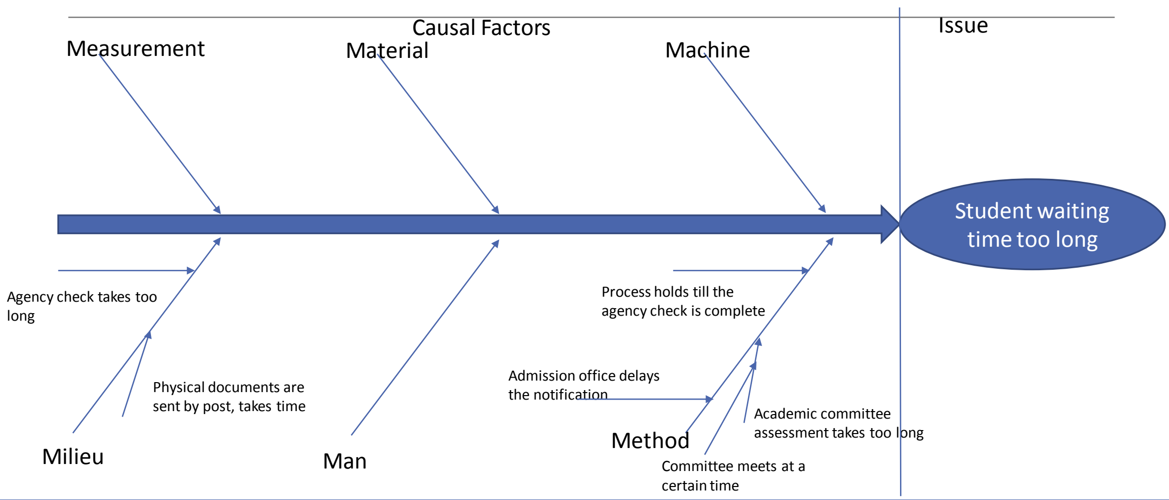
At the end of the committee meeting, the chair of the committee notifies the admissions office of the selection outcomes. This notification includes a list of admitted and rejected candidates. A few days later, the admission office notifies the outcome to each candidate via e-mail. Additionally, successful candidates are sent a confirmation letter by post.

Exercise – Admission Process (cont.)

Consider the above process. One of the issues faced by the university in the process is that students have to wait too long to know the outcome of the application (especially for successful outcomes). It often happens that by the time a student is admitted the student had decided to go to another university (students normally sends multiple applications to multiple universities).

Analyze the causes of this issue using a cause-effect diagram.

Answer



Why – Why Diagrams

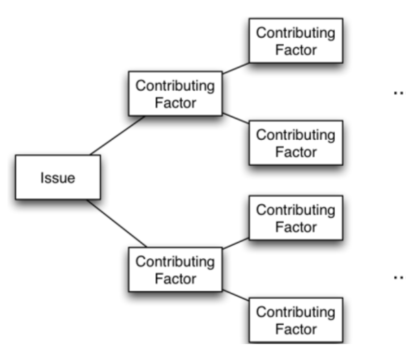
Also known as <u>tree diagrams</u>

Technique to analyze causes of negative effects

Developing the tree diagram helps you move your thinking step by step from generalities to specifics.

The basic idea is to reclusively ask the question – "Why has something happened?"

This question is asked multiple times until a factor that stakeholders perceive to be a root cause is found.



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Why-why diagram: E.g. equipment rental

Site engineers keep equipment longer, why?

Site engineer fears that equipment will not be available later when needed, why?

- time between request and delivery too long, why?
  - excessive time spent in finding a suitable equipment and approving the request, why?
    - time spent by clerk contacting possibly multiple suppliers sequentially;
    - time spent waiting for works engineer to check the requests;

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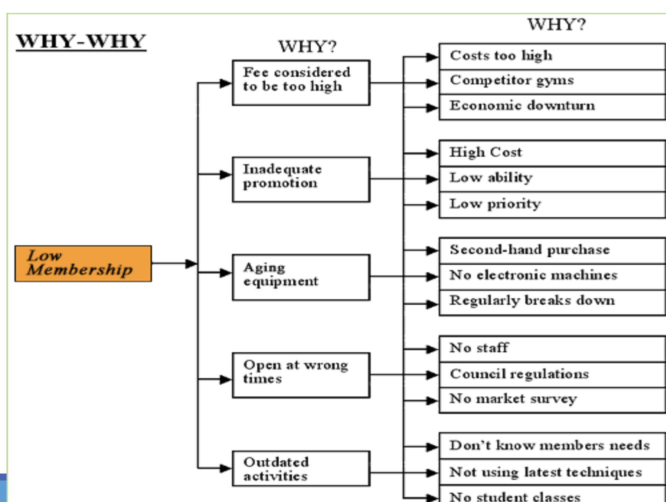
Why-why diagram: E.g. Low Membership issue of a gum



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When to use a Why-Why diagram

When an issue is known or being addressed.

When developing actions to carry out a solution or other plan.

When analyzing processes in detail.

When probing for the root cause of a problem.

When evaluating implementation issues for several potential solutions.

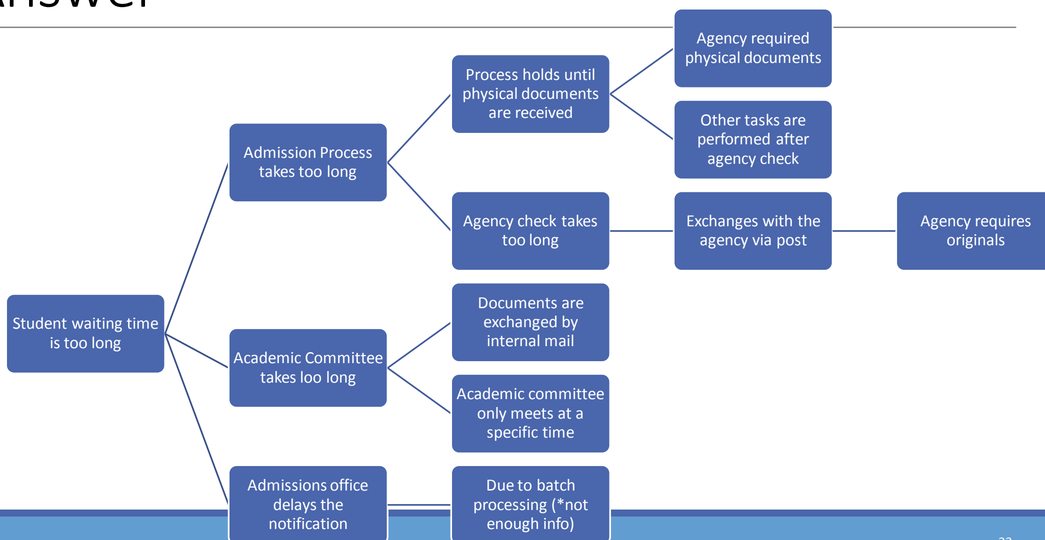
As a communication tool, to explain details to others.

Exercise – Admission Process (cont.)

Consider the Admission process.

Draw a Why-Why Diagram for the issue of Student waiting time is too long .

Answer



Issue Documentation & Impact Assessment

Once a root cause analysis identifies the factors behind a given issue building an understanding of these issues is critical to prioritize the issues.

Attention can the be put more onto the issues based on the prioritization

Complementary techniques for impact assessment

- Issue Register
- Pareto Analysis and PICK Charts

Issue Register

Purpose: to categorise identified issues as part of as-is process modelling

Usually a table with the following columns (possibly others):

- issue number
- name
- Description/explanation
- Impact: Qualitative vs. Quantitative
- Possible solution

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Issue Register: Equipment Rental

Name	Explanation	Assumptions	Qualitative Impact	Quantitative Impact
Equipment kept longer than needed	Site engineers keep the equipment longer than needed by means of deadline extensions	BuildIT rents 3000 pieces of equipment p.a. In 10% of cases, site engineers keep the equipment two days longer than needed. On average, rented equipment costs 100 per day		$0.1 \times 3000 \times 2 \times 100 =$ 60,000 p.a.
Rejected equipment	Site engineers reject delivered equipment due to non-conformance to their specifications	BuildIT rents 3000 pieces of equipment p.a. Each time an equipment is rejected due to an internal mistake, BuildIT is billed the cost of one day of rental, that is 100. 5% of them are rejected due to an internal mistake	Disruption to schedules. Employee stress and frustration	$3000 \times 0.05 \times 100 =$ 15,000 p.a.
Late payment fees	BuildIT pays late payment fees because invoices are not paid by the due date	BuildIT rents 3000 pieces of equipment p.a. Each equipment is rented on average for 4 days at a rate of 100 per day. Each rental leads to one invoice. About 10% of invoices are paid late. Penalty for late payment is 2%.		$0.1 \times 3000 \times 4 \times 100 \times 0.02 = 2400$ p.a.

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Pareto Chart

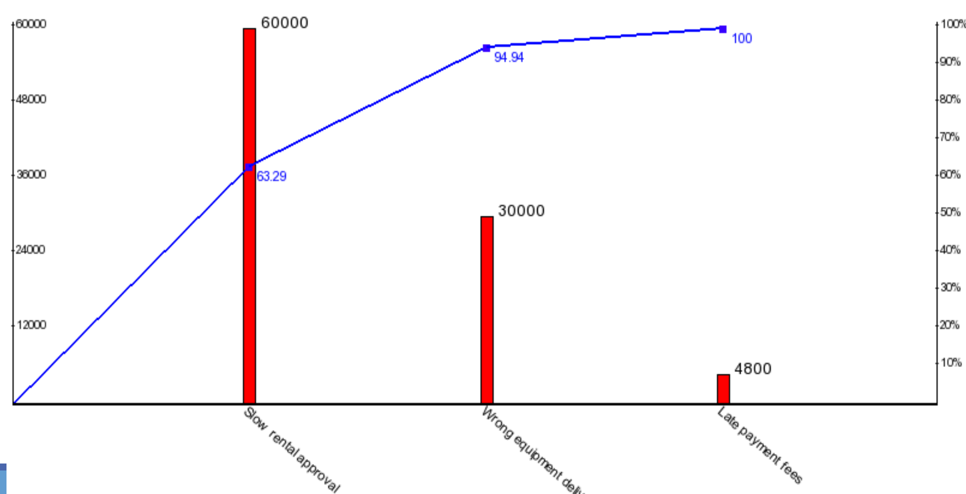
Useful to prioritize a collection of issues or factors behind an issue

Bar chart where the height of the bar denotes the impact of each issue

Bars sorted by impact

Superposed curve where the y-axis represents the cumulative percentage impact

Pareto chart (excessive rental expenses)



Quantitative Process Analysis

"It is better to be approximately right than precisely wrong"

Warren Buffet (1930-)

Qualitative vs. Quantitative

Qualitative process analysis provides systematic insights into a process.

But the results are not detailed enough to provide a solid basis for decision making

To make estimates in terms of costs, time (etc.) we need to go beyond Qualitative Analysis.

Thus Quantitative Analysis techniques identify ways of analyzing a business process quantitatively in terms of performance measures such as cycle time, total waiting time and cost.

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Process Performance Measures

Link the identified processes to measurable objectives

Quantify the benefits of improvement

2 types of performance measures;
- Process Performance Dimensions
- Balanced Scorecard

Profit maximizing firms

Maximize long term shareholder value

Maximize revenues and minimize costs

Non-profit organizations

Survive and grow while satisfying customer needs

Use resources efficiently while satisfying customer needs

Satisfy customer needs (effectiveness) in an efficient way (efficiency)

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Process Performance Dimensions

Cost
- Cost per execution
- Resource utilization
- Waste

Time
- Cycle time
- Waiting time / time spent in non-value-added tasks

Quality
- Error rates (negative outcomes, wrong info)
- Missed promise

Flexibility
- Ability to react to changes (e.g. different tasks, various cases, change structure
- Run time flexibility

Techniques used for Quantitative Process Analysis

1. Flow Analysis
2. Queuing Analysis
3. Simulation

Flow Analysis

Set of techniques that allows to estimate the overall performance of a process, given some knowledge about the performance of its activities

Applications of flow analysis

- Calculating Cycle time
- Cycle time efficiency
- Cycle time and work in progress
- Calculating cost-per-process-instance
- Calculating error rates at the process level
- Estimating capacity requirements

Cycle Time Analysis

Cycle time: Difference between a job's start and end time

Cycle time analysis: the task of calculating the ***average*** cycle time for an entire process or process fragment

- Assumes that the average activity times for all involved activities are available (activity time = waiting time + processing time)

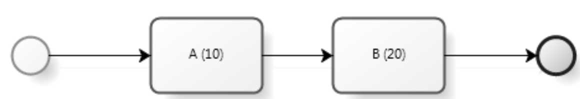
In the simplest case a process consists of a sequence of activities on a sequential path

- The average cycle time is the sum of the average activity times

… but in general we must be able to account for

- Alternative paths (XOR splits)
- Parallel paths (AND splits)
- Rework (cycles)

Calculating Cycle time of a fully sequential process



Cycle time for each activity is indicated within brackets

Since the activities are performed sequentially cycle time for this process;

10 + 20 = 30

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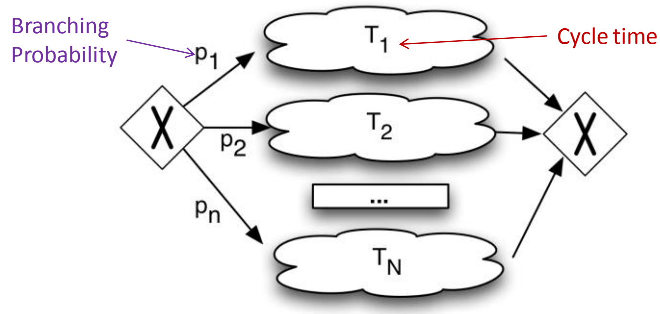
Calculating Cycle time for alternative paths



For XOR Split

$$CT = p_1T_1+p_2T_2+\ldots+p_nT_n = \sum_{i=1}^{n} p_i T_i$$

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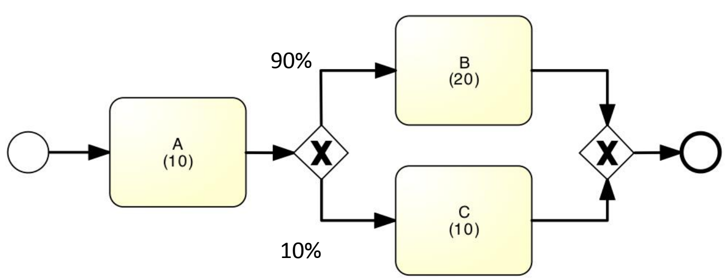
Example



Cycle time = cycle time of A + (90% * cycle time of B + 10% * cycle time of C)

CT = 10 + (0.9 * 20 + 0.1 * 10)

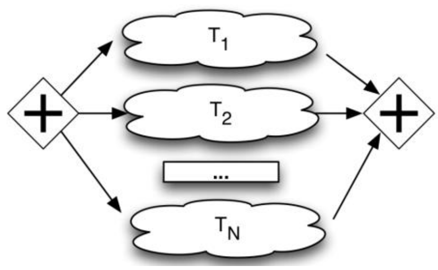
= 10 + (18 + 1)

= 10 + 19

= 29

Calculating Cycle time for parallel paths

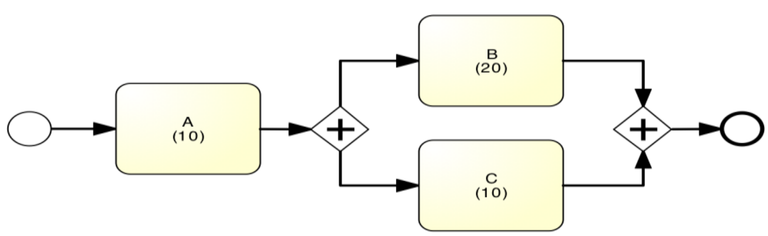
If two activities related to the same job are done in parallel the contribution to the cycle time for the job is the maximum of the two activity times.



$CT_{parallel} = Max\{T_1, T_2, \ldots, T_M\}$

For AND Split

Example



Cycle time = cycle time of A + Max cycle time from B and C (split)

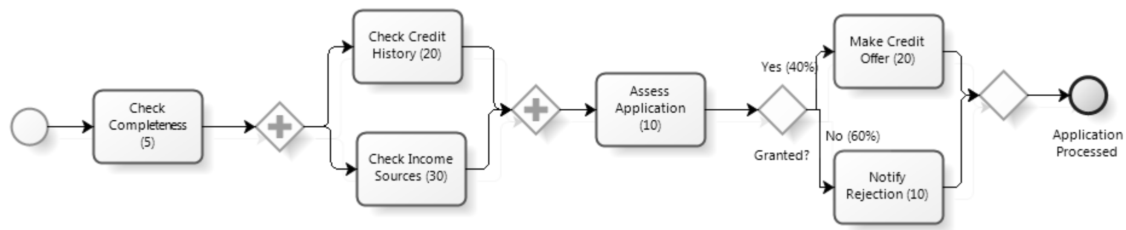
$CT = 10 + CT_{parallel}$

$= 10 + 20$

$= 30$

Exercise

Calculate the CT for the given process



CT = 5 + 30 + 10 + (0.4*20 + 0.6 * 10)
= 5 + 30 + 10 + (8 + 6)
= 59

Cycle Time Efficiency

Measured as the percentage of the total cycle time spent on value adding activities.

$$\text{Cycle Time Efficiency} = \frac{\text{Theoretical Cycle Time}}{\text{CT}}$$

Theoretical Cycle Time (TCT) is the cycle time if we only counted value-adding activities and excluded any waiting time or handover time

- Count only *processing times*

CT = cycle time as defined before

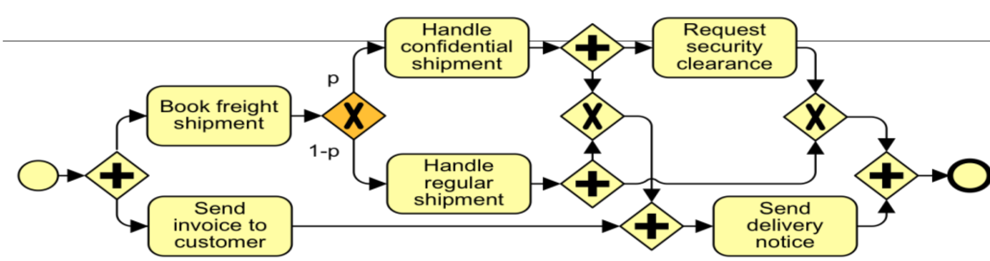
Cycle time and Work-in-Progress

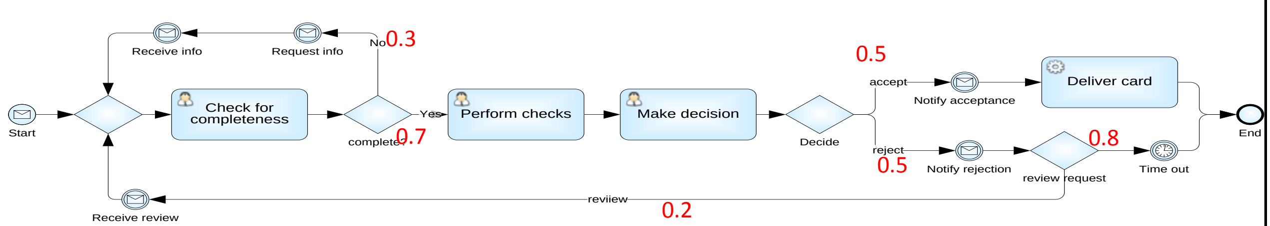
WIP = (average) Work-In-Process
- Number of cases that are running (started but not yet completed)
- E.g. # of active and unfilled orders in an order-to-cash process

Little's Formula: WIP = $\lambda \cdot CT$
- λ = arrival rate (number of new cases per time unit)
- CT = cycle time

WIP increases if the cycle time increases or if the arrival time increases.

Limitation 1: Not all Models are Structured





Limitation 2: Fixed load + fixed resource capacity

Cycle time analysis does not consider waiting times due to resource contention

Queuing analysis and simulation address these limitations and have a broader applicability

Queuing Theory

A collection of mathematical techniques to analyze systems that have resource contention/conflict

Resource contention leads to queues (as in supermarkets)

Capacity problems are very common in industry and one of the main drivers of process redesign

- Need to balance the cost of increased capacity against the gains of increased productivity and service

Queuing and waiting time analysis is particularly important in service systems

- Large costs of waiting and of lost sales due to waiting

Example –at a Hospital

Patients arrive by ambulance or by their own accord

One doctor is always on duty

More patients seeks help $\Rightarrow$ longer waiting times

- ***<u>Question</u>*: *Should another position be instated?***

Drawbacks of queuing theory

Generally not applicable when system includes parallel activities

Requires case-by-case mathematical analysis

Assumes “steady-state” (valid only for “long-term” analysis)

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Process Simulation

Process Simulator generates a large number of hypothetical instances of a process, execute step-by-step and record each step of execution.

Run a large number of process instances, gather data (cost, duration, resource usage) and calculate statistics from the output.

The output of a simulator is includes logs of the simulation as well as statistics related to the cycle times, waiting times and resource utilization.

Process simulation is more versatile (also more popular).

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Steps in evaluating a process with simulation

1. Model the process (e.g. BPMN)
2. Enhance the process model with simulation info → simulation model
   - Based on assumptions or better based on data (logs)
3. Run the simulation
4. Analyze the simulation outputs
   1. Process duration and cost stats and histograms
   2. Waiting times (per activity)
   3. Resource utilization (per resource)
5. Repeat for alternative scenarios

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Elements of a simulation model

The process model including:
- Events, activities, control-flow relations (flows, gateways)
- Resource classes (i.e. lanes)

Resource assignment
- Mapping from activities to resource classes

Processing times
- Per activity or per activity-resource pair

Costs
- Per activity and/or per activity-resource pair

Arrival rate of process instances

Conditional branching probabilities (XOR gateways)

Tools for Process Simulation

ITP Commerce Process Modeler for Visio
- Models presented earlier are made with ITP Commerce

Progress Savvion Process Modeler

IBM Websphere Business Modeler

Oracle BPA

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Simple Online Simulator

BIMP: http://bimp.cs.ut.ee/

Accepts standard BPMN 2.0 as input

Link from Signavio Academic Edition to BIMP

- Open a model in Signavio and push it to BIMP using the flask icon

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References

Dumas, M., La Rosa, M., Mendling, J., & Reijers, H. A. (2013). Fundamentals of business process management, pp. 185-252. Berlin: Springer.