



Pusan National University

E-biz Integration Lab. <http://e-biz.re.pusan.ac.kr>

Web-service based integration of multi-organizational logistic process

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LDIC 2007 conference
Prof. Hyerim Bae



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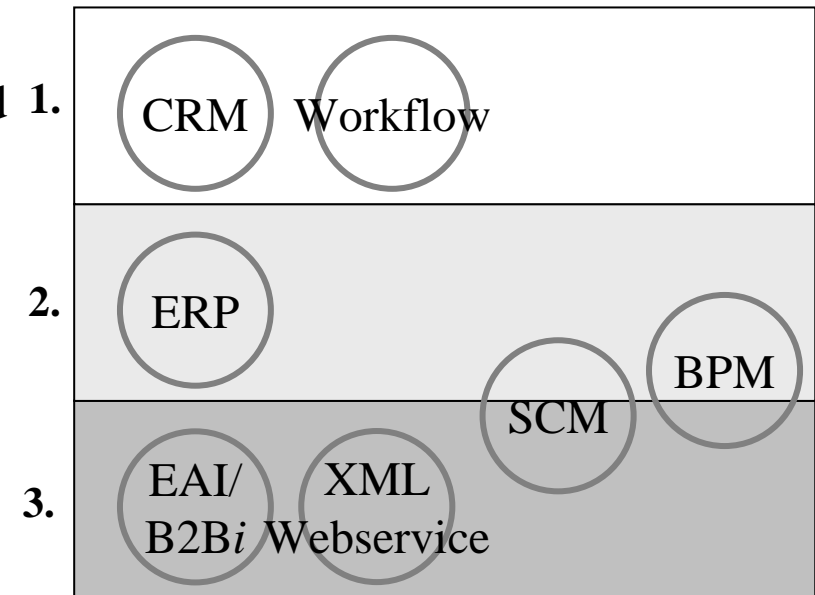
Introduction

- Changes in business computing environments
 - Companies are facing keen competition
 - Scope of business area is widened
 - Business activities are getting more complex

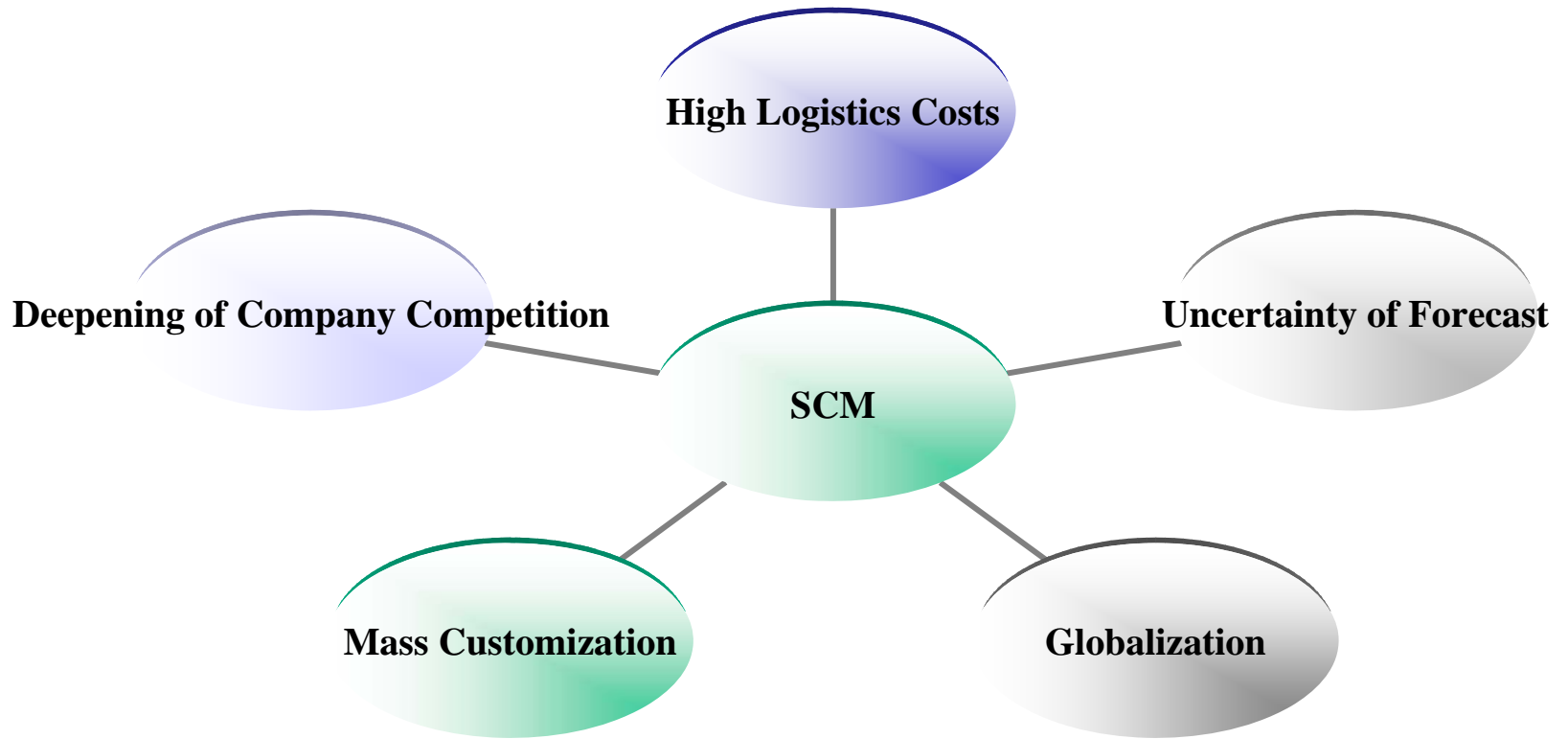
- Changes in business processes
 - Multi-organizational processes become common
 - Frequent change needs to be supported
 - BP is getting more complex



- IT trends
 - IT system provides
 1. quick response to changes
 1. Flexibility
 2. functions related to visualization and control
 3. Inter-communication methods



- SCM's rationale
 - SCM is getting more rationales because of



- SCM has perspectives
 - Flow perspective
 - Value chain perspective
 - Process perspective
 - IT perspective

- BPM system is related to the perspectives

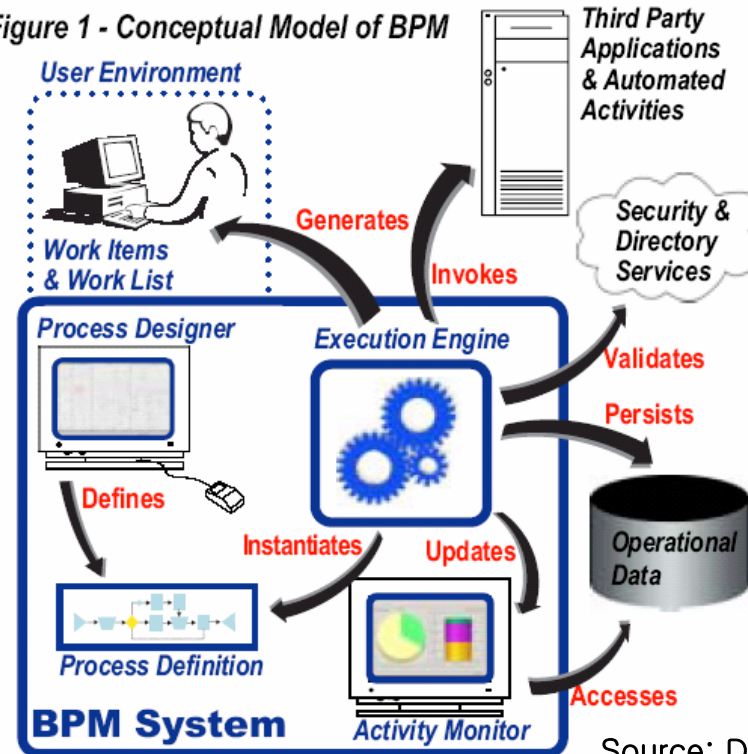
Backgrounds: BPM

BPM overview

BPM is an **integrated methodology** to **design, manage and improve** business processes, in order to **enhance productivity**. Sometimes, it means a software systems to support the methodology

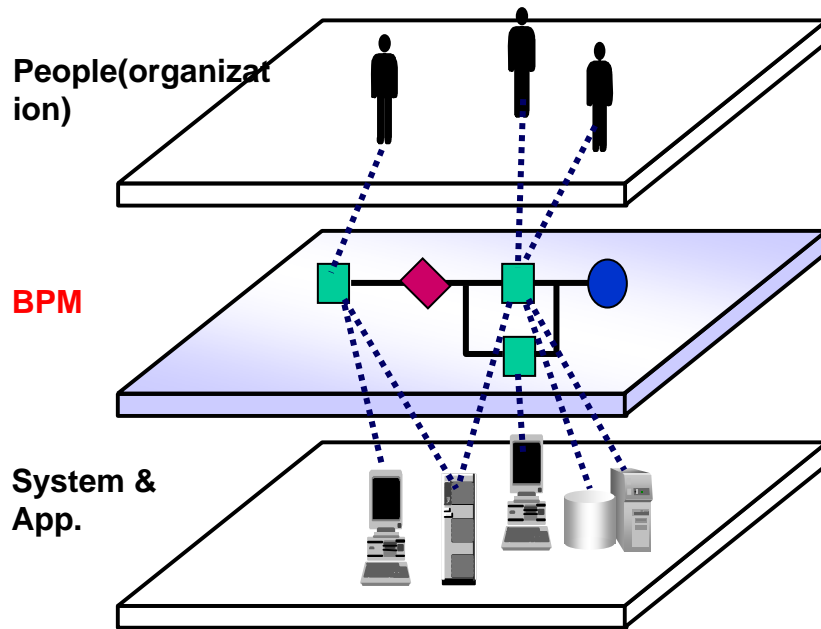
- Process Designer
 - User can define process
- Process Engine
 - Interpret process model
 - Control, schedule, manage
- Process Monitor
 - Monitor process during and after execution
- Process Analysis & Report
 - Analyze and report process with process-related data

Figure 1 - Conceptual Model of BPM



Source: Delphi group

■ Role of BPM



Source: Handysoft

Process lifecycle management

Business Integration

Continuous Improvement

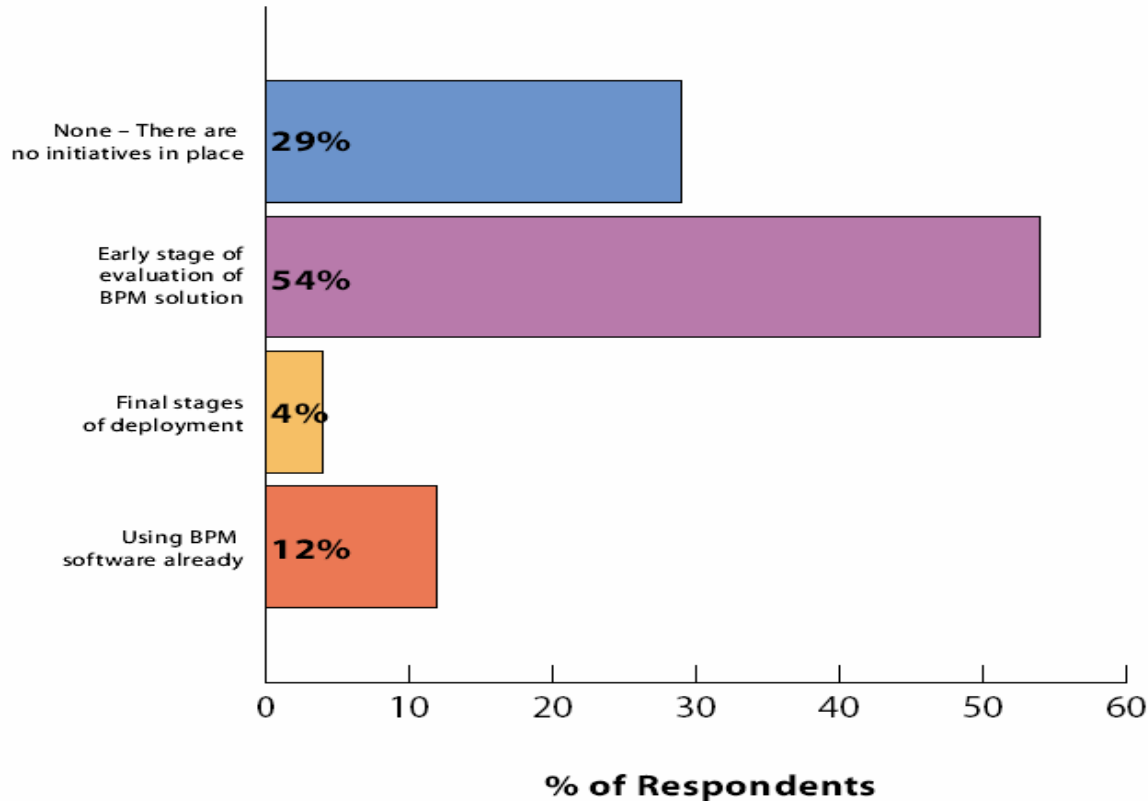
- BPMS is a S/W solution providing the functions
 - Automation of process and sharing of resources:
 - Coordination (Orchestration)
 - Basis of integration
 - Basis of visibility
 - Basis of improvement

- Status of BPM

- Gartner group

- Over 70% of enterprises are already using or are planning to use BPM

Status of BPM



▪ Global BPM market

Total Revenue & Growth Rate (SW License & Maintenance) [\$B]

Source : IDC, Gartner, Ovum

| 분야 | 지표 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | CAGR | Major Player |
|-------------|-------------|------|------|------|------|------|------|-------|--|
| BPM | Revenue | 1.0 | 1.4 | 2 | 3.2 | 5 | 7.8 | | Handysoft, Filenet, Staffware |
| | Growth Rate | - | 41% | 45% | 61% | 55% | 54% | 50.9% | |
| ERP | Revenue | 24 | 25 | 27 | 29 | 32 | 35 | | SAP (Leader), PeopleSoft, Oracle |
| | Growth Rate | - | 4% | 8% | 9% | 10% | 9% | 8.2% | |
| CRM | Revenue | 6.2 | 6.8 | 7.7 | 8.8 | 10 | 10.9 | | Siebel, SAP, Oracle |
| | Growth Rate | - | 1% | 13% | 14% | 14% | 9.6% | 9.6% | |
| SCM | Revenue | 1.9 | 2 | 2.2 | 2.4 | 2.7 | 3.1 | | SAP, Ariba, i2 |
| | Growth Rate | - | 5% | 10% | 9% | 13% | 15% | 9.5% | |
| DBMS | Revenue | 17 | 18 | 19 | 20 | 22 | 23 | | Oracle, MS, IBM |
| | Growth Rate | - | 6% | 6% | 5% | 10% | 5% | 7.0% | |
| BI | Revenue | 3.9 | 4.3 | 4.9 | 5.5 | 6.2 | 6.8 | | Cognos, Business Objects |
| | Growth Rate | - | 10% | 14% | 12% | 13% | 13% | 10.3% | |

- While market of other EISs reach stable status, BPM market is growing very rapidly
- Korean solution vendor is ranked high position in BPM market

- Drivers for BPM (by Gartner, 2005)
 - 11 Money-Relevant Reasons to Start
 1. Build Better New Processes Faster
 2. Know What You're Doing (Right or Wrong) Through Current Process Understanding
 3. Avoid Friction During Mergers and Acquisitions
 4. Get Someone Else to Do the Dull Stuff With Business Process Outsourcing
 5. Buy Software and Implement Packages Better
 6. Get Control of Parallel Processes by Consolidating to Core Processes
 7. Get Idiot Work Away From People Through the Automation of Manual Processes
 8. Value/Supply Chain Creation/Maintenance and Other Process Fusion
 9. Do Things Better With Optimized Processes
 10. Stay Out of Trouble by Staying Ahead of Compliance
 11. Stay Hungry: Move Faster Through Scenario Building for Agility and Policy Management

Did you already catch why BPM has to be applied to SCM

Why BPM in SCM?

1. BPM is an integration tool and SCM needs integration!

■ Importance of process

- Process will be separated from App.
 - Give flexibility
- BPM can be so called
 - BOS (Business Operating System)

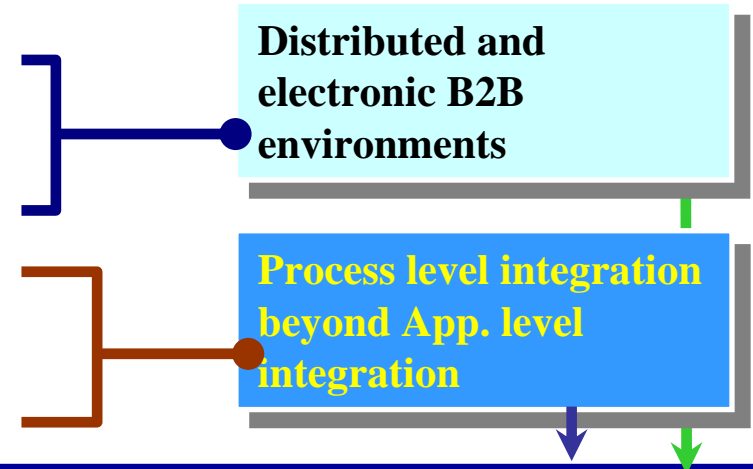
“Process Automation provides the ultimate in flexibility” (D. S. Lithicum, eAI Journal, 2000)

■ Trend in IT

- Advancement of Network technology->
- Electronic interaction b/w companies
- * e-Business -> ERP, SCM, CRM

■ Keyword: **Integration**

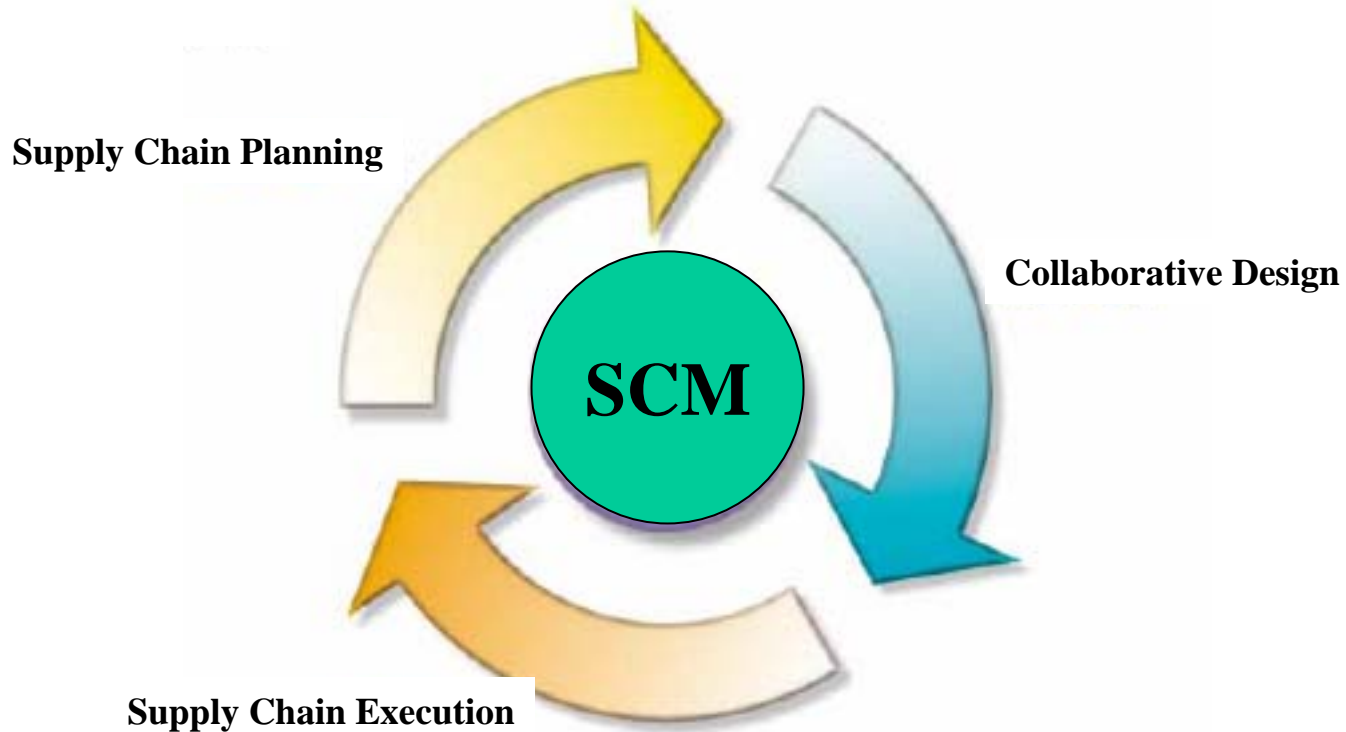
- * XML based framework: ebXML, BizTalk
- * EAI (B2Bi), Webservice



“Process-based integration for distributed and heterogeneous computing environments”

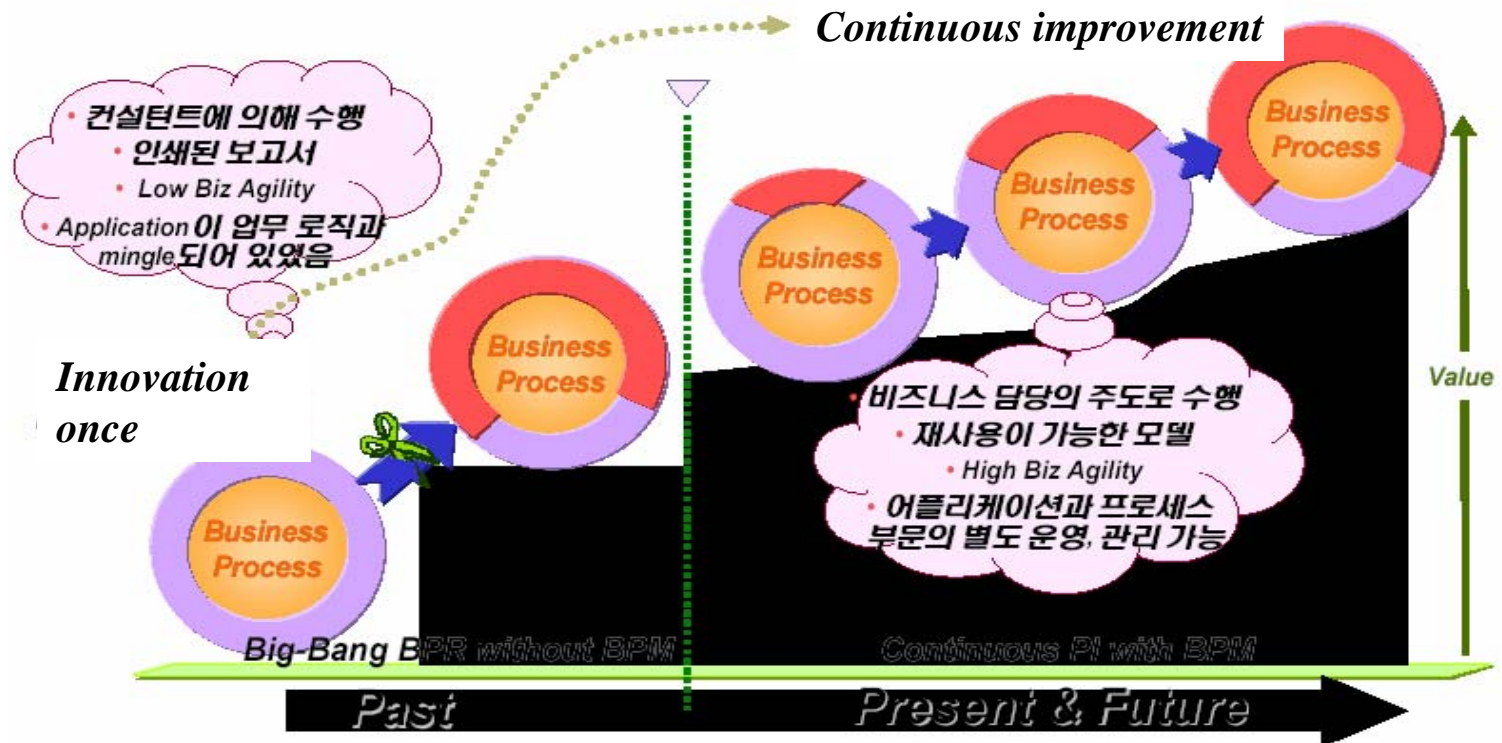
- SCM is a typical domain integrated by BPM
 - Supply chain processes
 - Many companies are involved: manufacturer, retailer, warehouse, transporter
 - They use heterogeneous system
 - A global SC process includes inner-processes
 - BPM is a concept for process-based integration among heterogeneous systems

2. SCM requires execution methodology
 - SCM includes variety of issues: SCP, CD, SCE
 - For SCE,
 - there has not been a good solution

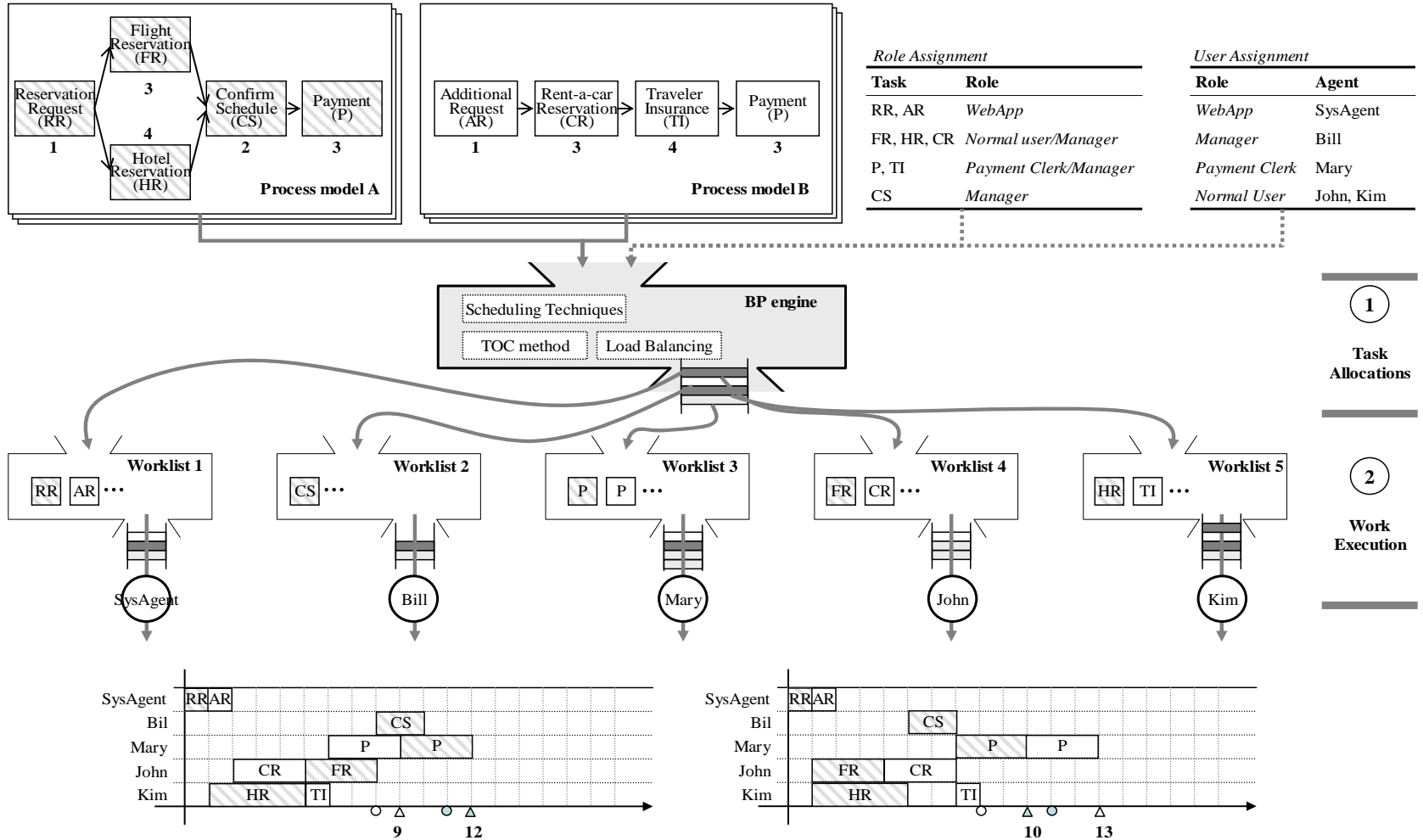


3. Supply Chain Process should be improved

- Information of processes in supply chain need to be recorded in a proper manner
- The information should be analyzed, which can contribute to improve processes
- BPM
 - Support continuous improvement of processes by analyzing process related information



Business process efficiency

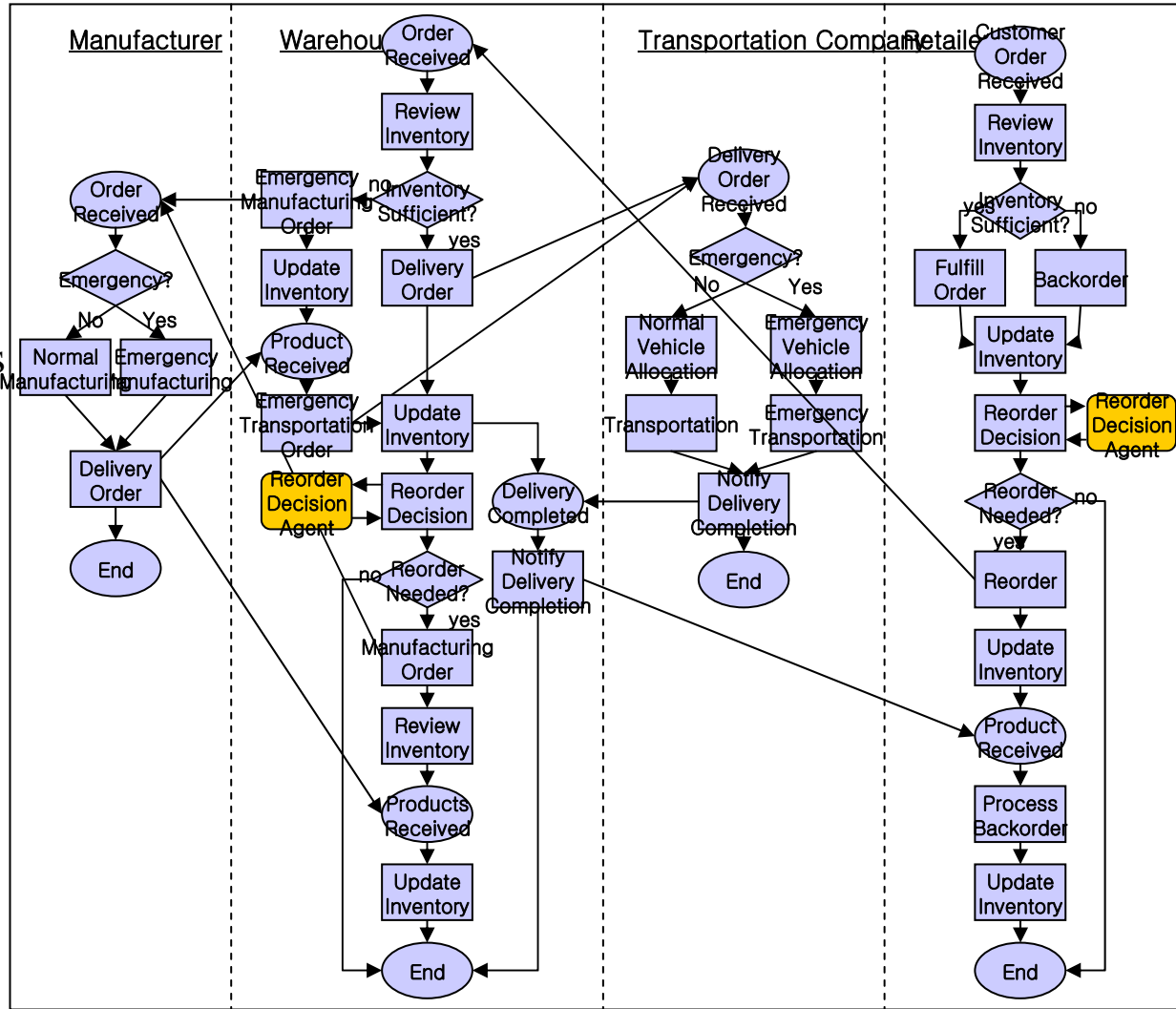


- If FR is assigned to Bill, not John ?
- Different priority can generate different efficient results.

SCP Representation

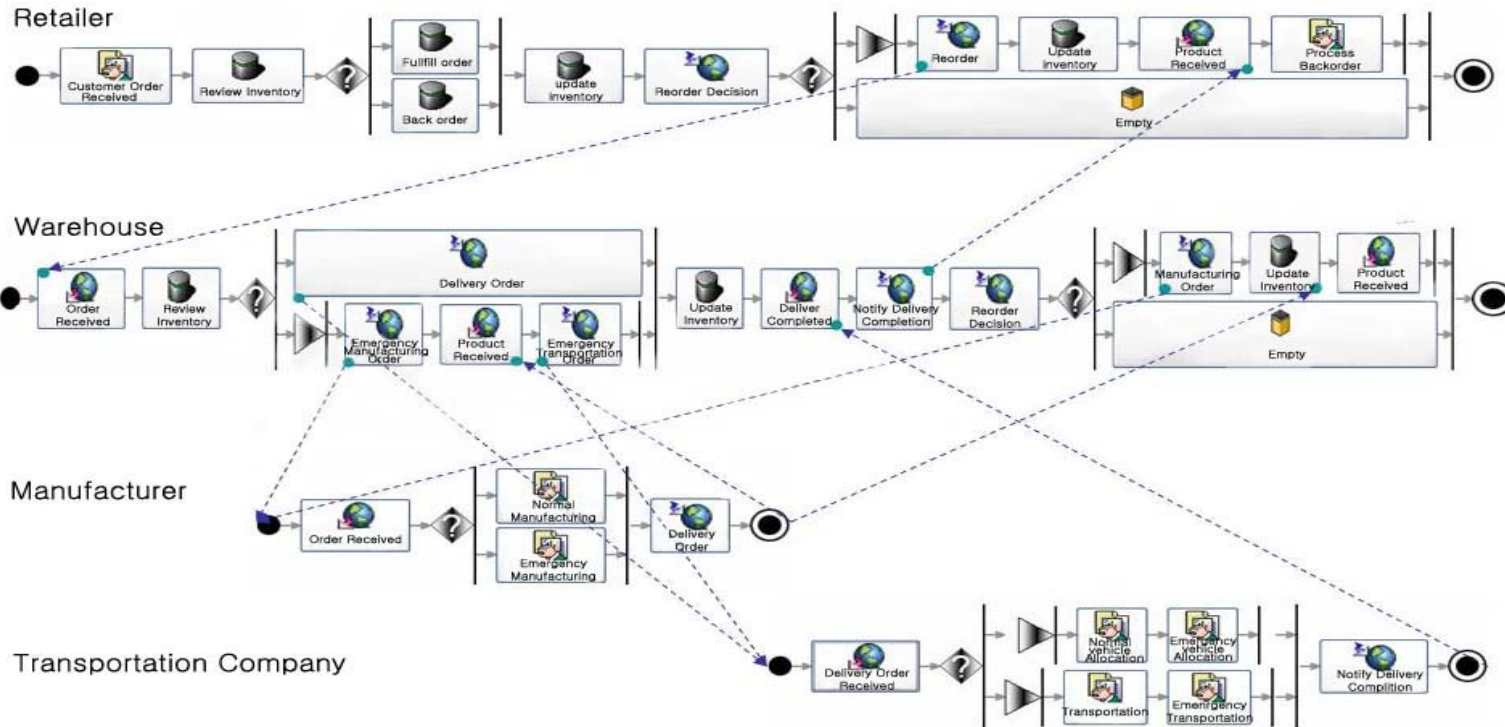
Supply Chain process has features

- Multiple participants are involved
- Each has its own process
- The processes interacts
- Forms a global process



■ Transform to BPM model

- The SC processes are converted to BPM process model
- Make them ready for being executed by BPM engine



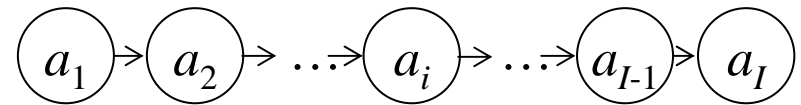
- For multiple parties to intercommunicate
 - Standardized process modeling language is required
 - BPEL4WS

- BPEL modeling
 - BPEL's expressive power is not bad! ([Aalst])
 - Using transform rules

| 패턴 | Graph | (Structured) BPEL |
|------------------------------|-------|--|
| 직렬 (sequence) | | <code><sequence> <A> </sequence></code> |
| 조건분기 (switch) | | <code><switch> <case condition="조건식"><A></case> <case condition="조건식"></case> </switch></code> |
| 병렬 (flow) | | <code><flow> <X> <Y> </flow></code> |
| 반복 (loop) | | <code><loop condition="조건식"> <A> </loop></code> |
| 조건분기-직렬 (switch-sequence) | | <code><switch> <case condition="조건식"> <sequence> <A></sequence> </case> <case condition="조건식"> <sequence> <C><D></sequence></case> </switch></code> |
| 복잡예제 | | <code><loop> <switch><case> <sequence><A> </sequence></case><case></case> </switch> </loop> 또는 <loop> <switch> <case> <A> </case></switch> </loop></code> |

■ SC Process

- Increasing efficiency of overall process is difficult
- Traditional BPM focuses mainly on correct automation itself



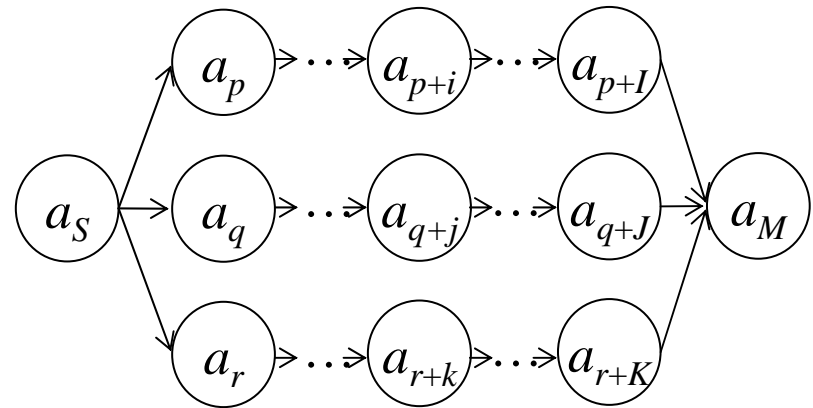
serial

■ Process structure

- Activities and their precedence relations

■ Process type

- Serial
- AND-parallel
- OR-parallel
 - NOR
 - POR
 - COR



parallel

- Task assignment
 - Engine assigns tasks to participants
 - To an excellent worker
 - To a worker whose workload is not heavy

- Performing tasks
 - At a certain point of time
 - Users have a lot of tasks in their worklist
 - They have priority
 - Dispatching Rule
 - FIFO, SPT, Random
 - Least Slack Time: a reasonable dispatching rule
 - We propose
 - Should complete more urgent task

LST rule using PERT/CPM method

- PERT/CPM for business process
 - A traditional project mgt. method
 - Slack time/critical path
- But
 - There exists difference
 - A process in BPMS can have alternative path
 - OR-parallel
 - Expectation time

1. NOR

NOR: After the split activity, some of the branches can be executed. When one of them reaches the merge task successfully, the process proceeds to the subsequent task of the merge task while ignoring the other branches that have not yet reached the merge task.

2. POR

POR: A priority is assigned to each path. After the split activity, the path with the highest priority is performed first. If this successfully reaches the merge task, all the other paths are ignored. Otherwise, the path with the next highest priority is tried until a successful one is found.

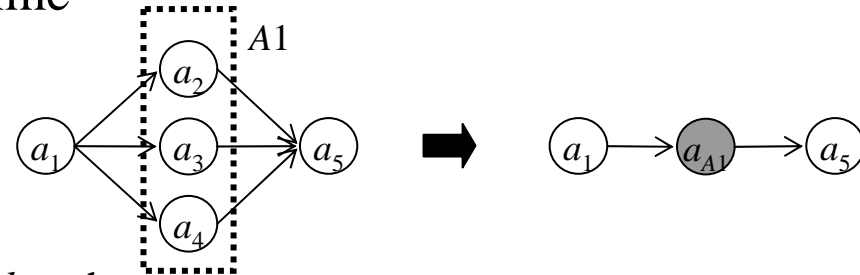
3. COR

COR: Each path is associated with a set of conditions. After the split task, the conditions are assessed, and only the paths that satisfy the conditions are carried out. The condition satisfaction is determined at or prior to the split task. Notice that this block can be used as an XOR block that allows only one path to execute.

Expected path/expected processing time

1. NOR

- We suppose
 - Distribution of processing time of i -th path



$$X_i \sim EXP(i), (i = 1, 2, 3)$$

- The probability that i -the path (r_i) completes first

$$P_1 = P(X_1 < X_2) \cdot P(X_1 < X_3)$$

$$P(X_1 < X_2) = \int_0^{\infty} P(X_1 < x | X_2 = x) \cdot P(X_2 = x) dx = \int_0^{\infty} (1 - \exp(-\lambda_1 x)) \cdot \lambda_2 \cdot \exp(-\lambda_2 x) dx = \frac{\lambda_1}{\lambda_1 + \lambda_2}$$

$$P(X_1 < X_3) = \frac{\lambda_1}{\lambda_1 + \lambda_3} \quad P_1 = \frac{\lambda_1}{\lambda_1 + \lambda_2} \cdot \frac{\lambda_1}{\lambda_1 + \lambda_3}$$

$$\begin{aligned} ET &= ET_1 P_1 + ET_2 P_2 + ET_3 P_3 \\ &= \left(\frac{\lambda_1}{\lambda_1 + \lambda_2} \cdot \frac{\lambda_1}{\lambda_1 + \lambda_3}\right) ET_1 + \left(\frac{\lambda_2}{\lambda_1 + \lambda_2} \cdot \frac{\lambda_2}{\lambda_2 + \lambda_3}\right) ET_2 + \left(\frac{\lambda_3}{\lambda_1 + \lambda_3} \cdot \frac{\lambda_3}{\lambda_2 + \lambda_3}\right) ET_3 \end{aligned}$$

- Finally,

$$ET = \sum_{i=1}^n \prod_{j=1, j \neq i}^n \left(\frac{\lambda_i}{\lambda_i + \lambda_j}\right) ET_i$$

2. POR

□ P_i that r_i completes first

From the past data,

□ POR

$ET =$

$$\begin{cases} P_1 \cdot ET_1 & , n = 1 \\ P_1 \cdot ET_1 + \sum_{i=2}^n [\{\prod_{j=1}^{i-1} (1 - P_j)\} P_i \cdot \{\sum_{k=1}^i ET_k\}] & , n \geq 2 \end{cases}$$

$$P_i = \frac{\text{the number of process instances that the } i\text{-th priority task has succeeded}}{\text{the number of process instances that has reached to the } i\text{-th priority task}}$$

Without loss of generality, we can assume that the priority of r_i is always higher than that of r_{i+1} .

3. COR

- P_i that r_j is selected

$$P_i = \frac{\text{the number of instances that the } i\text{-th path has been executed}}{\text{the total number of process instances}}$$

- COR

$$ET = \sum_{i=1}^n (P_i \cdot ET_i)$$

■ Calculation of initial slack time

- Use expected time

$$ET_{A1} = P_6 \times 4 + (1 - P_6) \times P_7 \times (4 + 3.5)$$

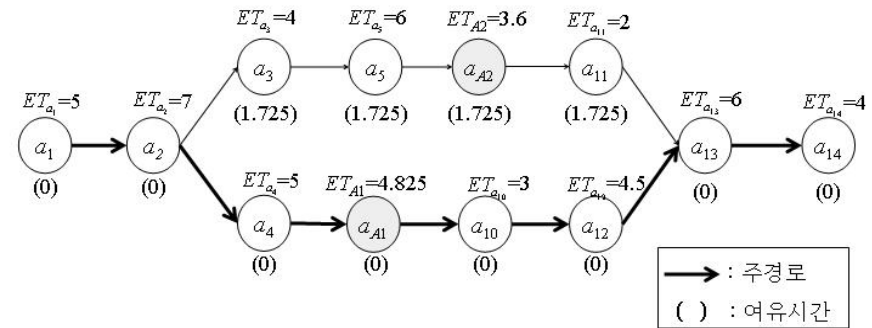
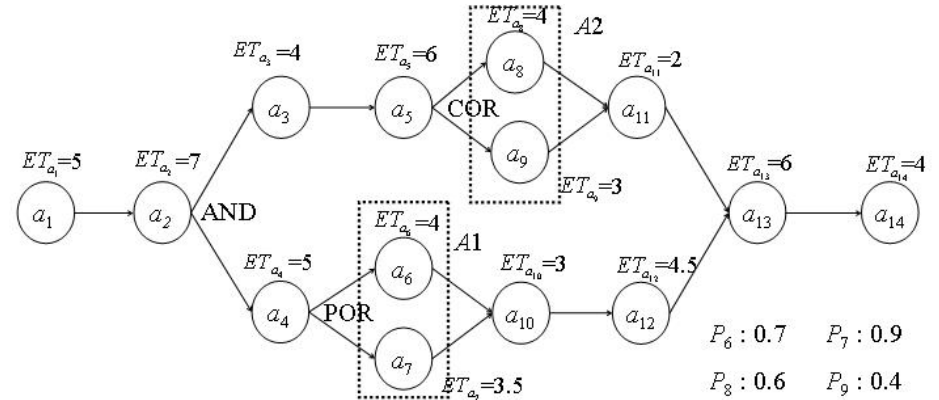
$$= 0.7 \times 4 + 0.3 \times 0.9 \times 7.5 = 4.825$$

$$ET_{A2} = P_8 \times 4 + P_9 \times 3$$

$$= 0.6 \times 4 + 0.4 \times 3 = 3.6$$

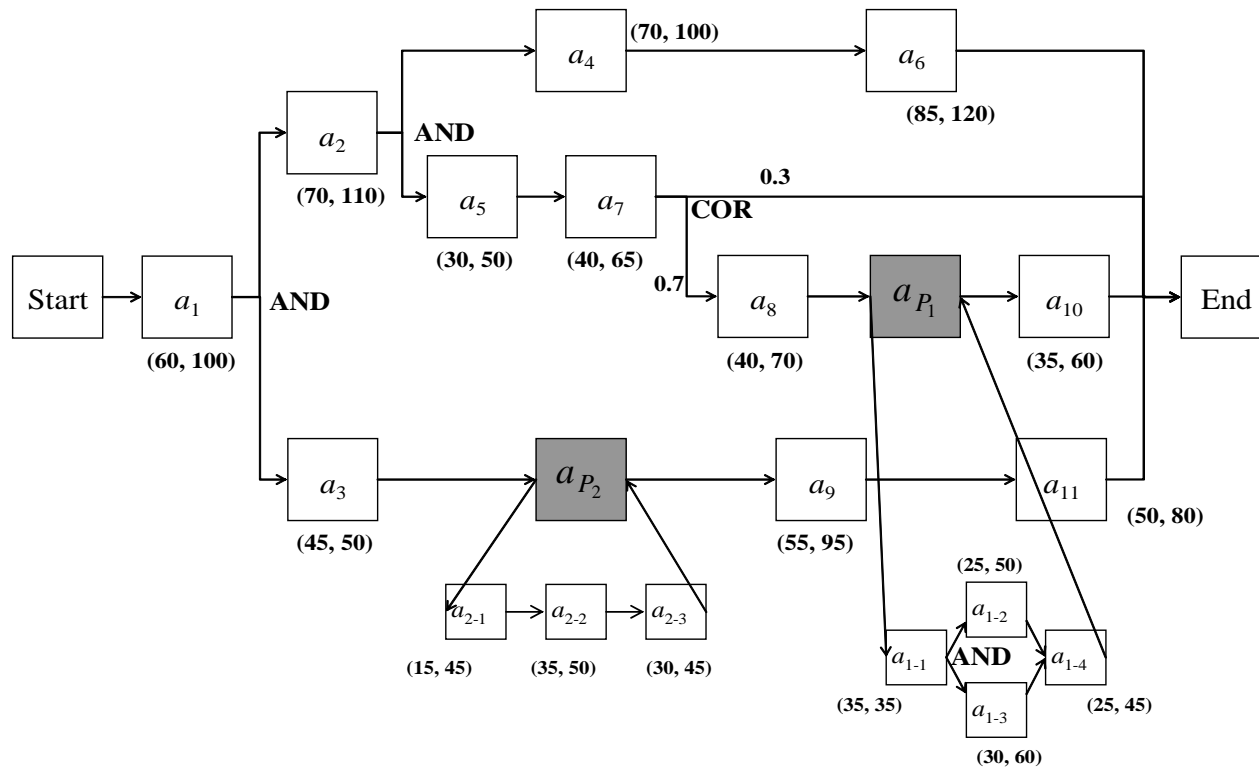
■ Recalculation at run-time

- Modify slack time
- Use actual processing time



- Task performer
 - Each task performer has a lot of tasks in his worklist
 - He can use LST (Least Slack Time) rule
 - Improve efficiency

- We extend LST rule to SC process: S-LST
 - SC process have nested process



- Expected processing time of nested process P_s with n -path

$$ET_{a_{P_s}} = \text{Max}\{ET_i | 1 \leq i \leq n, i \text{ is a natural number,}$$

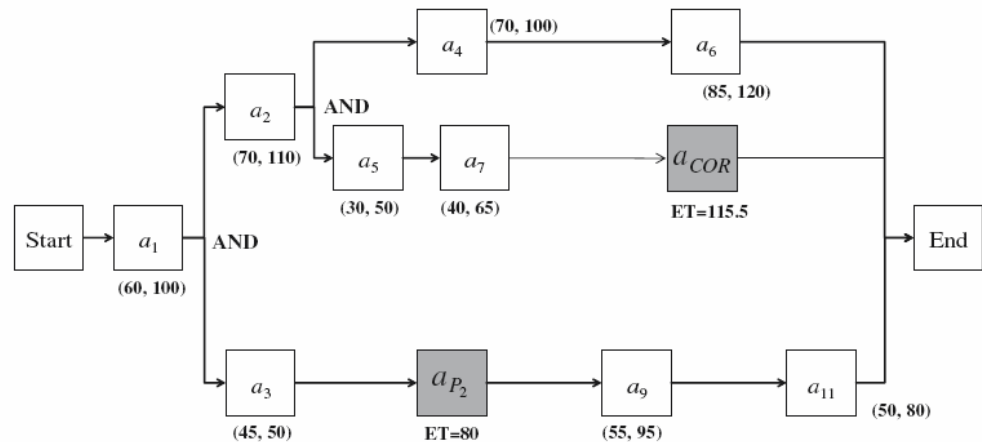
$$\text{and } n \text{ is the number of paths in } P_s\}.$$

- The slack time of activity a_i in process P : ST^P_{aj}

- The slack time of activity in the nested process

$$ST^P_{a_{li}} = ST^P_{a_{P1}} + ST^{P1}_{a_{li}}$$

- the slack times of the constituent activities in the nested process are calculated using the slack time of the nested process.



- **BPEL:** A process designed using BPEL

```
<process name="Urgent Production Process" targetNamespace="http://abc.com/supplychain"
suppressJoinFailure="yes" xmlns:tns="http://abc.com/supplychain"
xmlns="http://schemas.xmlsoap.org/ws/2003/03/
business-process/" xmlns:bpelx="http://schemas.oracle.com/bpel/extension"
xmlns:ora="http://schemas.oracle.com/xpath/extension" xmlns:factory="http://abc.com/factory"
xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <partnerLinks>
    <partnerLink name="globalSCM" partnerLinkType="tns:supplychain" myRole="supplychainProvider"
      partnerRole="supplychainRequester"/>
  </partnerLinks>
  <variables>
    <variable name="input" messageType="tns:supplychainRequestMessage"/>
    <variable name="output" messageType="tns:supplychainResponseMessage"/>
    <variable name="pv_slacktime" type="xsd:string"/>
    <variable name="pv_overall_slacktime" type="xsd:string"/>
  </variables>
  <sequence name="main">
    <receive name="Receive Request" partnerLink="lobalSCM" portType="tns:supplychain" operation="initiate"
      variable="input" createInstance="yes"/>
    <invoke name="Production"/>
    <invoke name="Dispatch Products"/>
    <invoke name="callback SCM" partnerLink="lobalSCM" portType="tns:supplychainCallback"
      operation="onResult"
      inputVariable="output"/>
  </sequence>
</process>
```

Process Variable Declaration

■ SOAP message among processes

```

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
xmlns:xsd="http://www.w3.org/1999/XMLSchema"
xmlns:SOAP-
ENV="http://schemas.xmlsoap.org/soap/envelope/"
xmlns:xsi="http://www.w3.org/1999/XMLSchema-
instance">
<SOAP-ENV:Header>
<Request encoding="java"></Request>
</SOAP-ENV:Header>
<SOAP-ENV:Body>
<ns1:eReceiveGlobalSlackTime
xmlns:ns1="urn:com-bpm-adapter-SCMeIntegrator"
SOAP-
ENV:encodingStyle="http://schemas.xmlsoap.org/so
ap/encoding/">
<ProcessID xsi:type="xsd:string">
497
</ProcessID>
<ProcessName xsi:type="xsd:string">
SCM_Seoul_R00003
</ProcessName>
<NestedProcessID xsi:type="xsd:string">
498
</NestedProcessID>
<GlobalSlackTime xsi:type="xsd:string">
101:2^102:3.3^103:5.6^104:2
</GlobalSlackTime>
</ns1:eReceiveGlobalSlackTime>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

(a) SOAP message to the nested process

```

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope
xmlns:xsd="http://www.w3.org/1999/XMLSchema"
xmlns:SOAP-
ENV="http://schemas.xmlsoap.org/soap/envelope/" x
xmlns:xsi="http://www.w3.org/1999/XMLSchema-
instance">
<SOAP-ENV:Header>
<Request encoding="java"></Request>
</SOAP-ENV:Header>
<SOAP-ENV:Body>
<ns1:eSendLocalSlackTime xmlns:ns1="urn:com-
bpm-adapter-SCMeIntegrator"
SOAP-
ENV:encodingStyle="http://schemas.xmlsoap.org/soa
p/encoding/">
<ProcessID xsi:type="xsd:string">
498
</ProcessID>
<ProcessName xsi:type="xsd:string">
SCM_Seoul_R00003_out
</ProcessName>
<ParentProcessID xsi:type="xsd:string">
497
</ParentProcessID>
<NestedSlackTime xsi:type="xsd:string">
101:0^102:1.3^103:3.6^104:0
</NestedSlackTime>
</ns1:eSendLocalSlackTime>
</SOAP-ENV:Body>
</SOAP-ENV:Envelope>

```

(b) SOAP message to the global process

Simulation experiments

- Comparison of S-LST (our method) with
 - EDD (Earliest due date), FIFO, Random
 - Performance index
 - PE1: Process completion time
 - PE2: The number of completed instance
 - Simulation environments
 - Replication time: 30,000
 - Repeat 30 times
 - Warm up period: 3,000

Table 2 Comparison of process efficiency

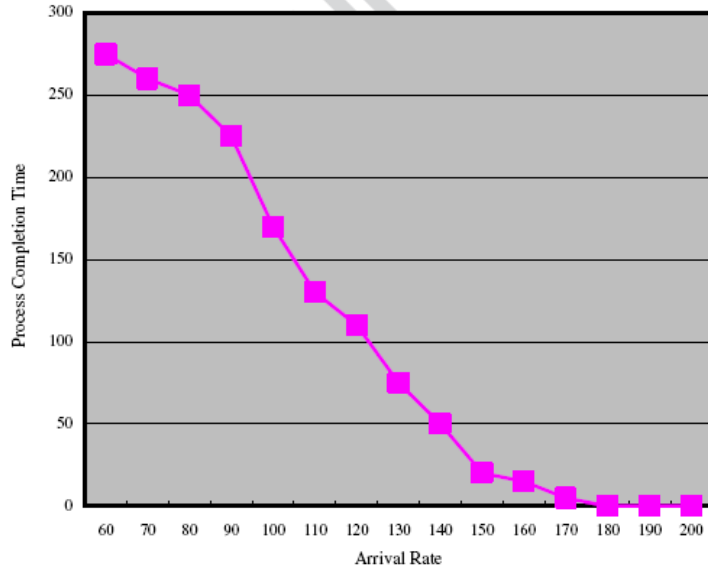
| Performance | EDD | FIFO | Random | S-LST |
|-------------|--------|----------|----------|----------------------------|
| PE1 | 750.90 | 1,008.25 | 1,102.77 | 537.61 (28.4) ^a |
| PE2 | 243.56 | 127.00 | 130.91 | 306.78 (26.0) ^a |

■ Influence of workload

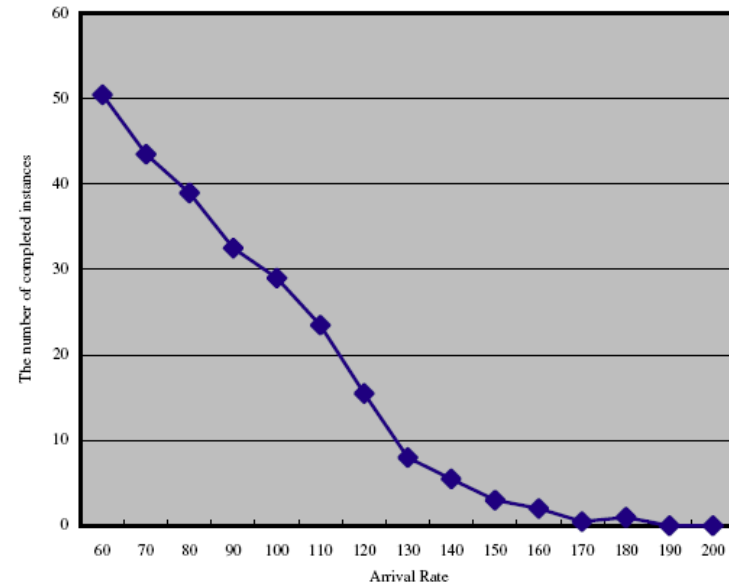
H0: $(PE_i \text{ of the second rule}) - (PE_i \text{ of the best rule}) = c,$

H1: $(PE_i \text{ of the second rule}) - (PE_i \text{ of the best rule}) > c',$

$i=1 \text{ and } 2, c=0.$



(a) PE1: S-LST - EDD

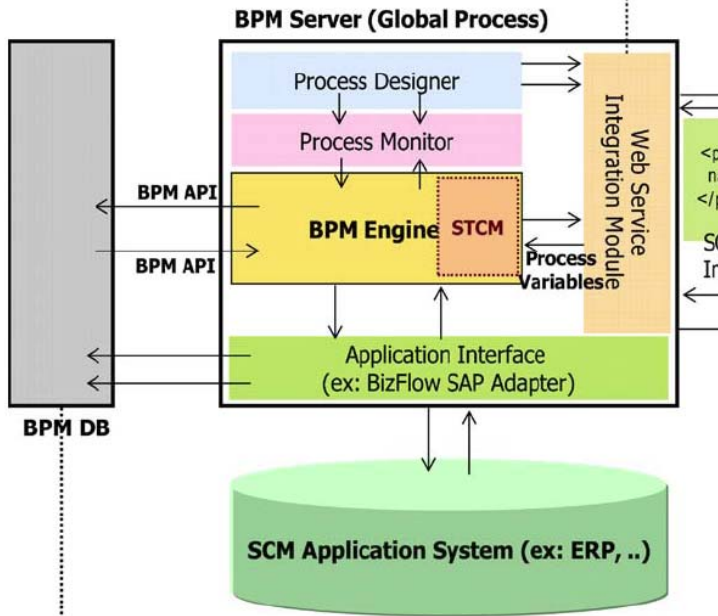


(b) PE2: S-LST - EDD

- Process efficiency that S-LST produces are affected by the workload.
- As the arrival rate decreases, the improvement tends to increase.

System architecture

1. Web Service Invoking
2. Message (BPEL, SOAP) Construction
3. Message Parsing



BPM DB deals with relevant data such as process, activity, instance, participants, process variables, interface

| Receive NO | Activity | local process ST | Deadline | Order Receiver | Receive Date | Status | Priority (Global ST) |
|--------------------------|-------------------------|------------------------------------|----------|----------------|-------------------------------|---------|----------------------|
| <input type="checkbox"/> | Supply Chain Management | Shipping products in stocks | 0 | 이승현 | 2005/05/05 06:05:56 GMT-01:00 | Created | 0 |
| <input type="checkbox"/> | Supply Chain Management | Request for production of shortage | 0 | 이승현 | 2005/05/05 06:05:56 GMT-01:00 | Created | 0 |
| <input type="checkbox"/> | SCM_Seoul_R00001 | Update quantity of stocks | 0 | road0930 | 2005/05/05 05:56:59 GMT-01:00 | Created | 0 |
| <input type="checkbox"/> | SCM_Seoul_R00001 | Request for production of shortage | 0 | road0930 | 2005/05/05 05:49:52 GMT-01:00 | Created | 0 |
| <input type="checkbox"/> | SCM_Tokyo_R00001 | Shipping products in stocks | 0.1 | road0930 | 2005/05/05 05:50:24 GMT-01:00 | Created | 0.1 |
| <input type="checkbox"/> | SCM_Seoul_R00002 | Shipping products in stocks | 0.35 | road0930 | 2005/05/05 05:50:13 GMT-01:00 | Created | 0.35 |
| <input type="checkbox"/> | SCM_Shanghai_R01010 | Confirm stocks | 1.3 | 이승현 | 2005/05/05 05:54:02 GMT-01:00 | Created | 1.3 |

Notify Popup - Microsoft Internet Explorer

| | |
|--------------|-----------------------------|
| Process Name | Supply Chain Management |
| Activity | Shipping products in stocks |
| Created Date | 2005/05/05 06:05:56 |
| Initiator | 이승현 |

Buttons: Open, Close

UDDI (Service Repository)

Nested Process 2 (BPEL-based process)

STCM : Slack Time Calculation Module

→ : data flow line

.....→ : explanatory line

Conclusions

- BPM for SCM
 - BPM provide integrated method for managing SC processes
 - Process modeling
 - Process execution
 - Process monitoring
 - Process Analysis
 - Our research purposes
 - Improving efficiency of SC processes
- SCP performance
 - We develop S-LST rule for SCP
 - Increase of process efficiency
- Web service and SOA
 - In multi-organizational process
 - SOAP message can be exchanged to share process information