프로세스 마이닝 실습

https://github.com/yongzzai/LGPracticum

부산대학교
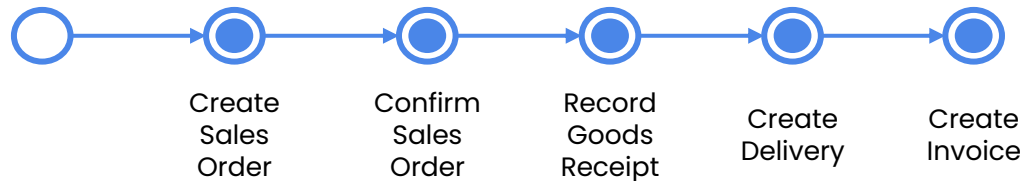PUSAN NATIONAL UNIVERSITY

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Bigdata Analytics & Engineering

04.

Object-Centric Process Mining

소 속 : 부산대학교 산업공학과
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3.1 Case Centric Process Mining

Recap: 이벤트 로그 구조

Order No.	Activity	Time	User	Quantity
10001	Create purchase order	01-01-2009, 8:35 am	Sara Jones	1
10001	Print and send purchase order	03-01-2009, 12:13 am	Sara Jones	1
10001	Goods receipt	07-01-2009, 07:01 am	Pete Scott	1
10001	Scan invoice	09-01-2009, 2:00 pm	Sara Jones	1
10001	Book invoice	10-01-2009, 10:30 am	Carol Hope	1
10002	Create purchase requisition	02-02-2009, 1:17 pm	John Farmer	15
10002	Create purchase order	04-02-2009, 9:15 am	Sara Jones	15
10002	Print and send purchase order	07-02-2009, 4:41 pm	Sara Jones	15
10002	Goods receipt	27-02-2009, 6:53 am	Frank Miller	15
10002	Scan invoice	28-02-2009, 1:00 pm	Sara Jones	15
10002	Book invoice	13-03-2009, 11:59 am	Carol Hope	15
...	...	...	...	...

Event

Trace

Sales Order Activity

Create Sales Order → Confirm Sales Order → Record Goods Receipt → Create Delivery → Create Invoice
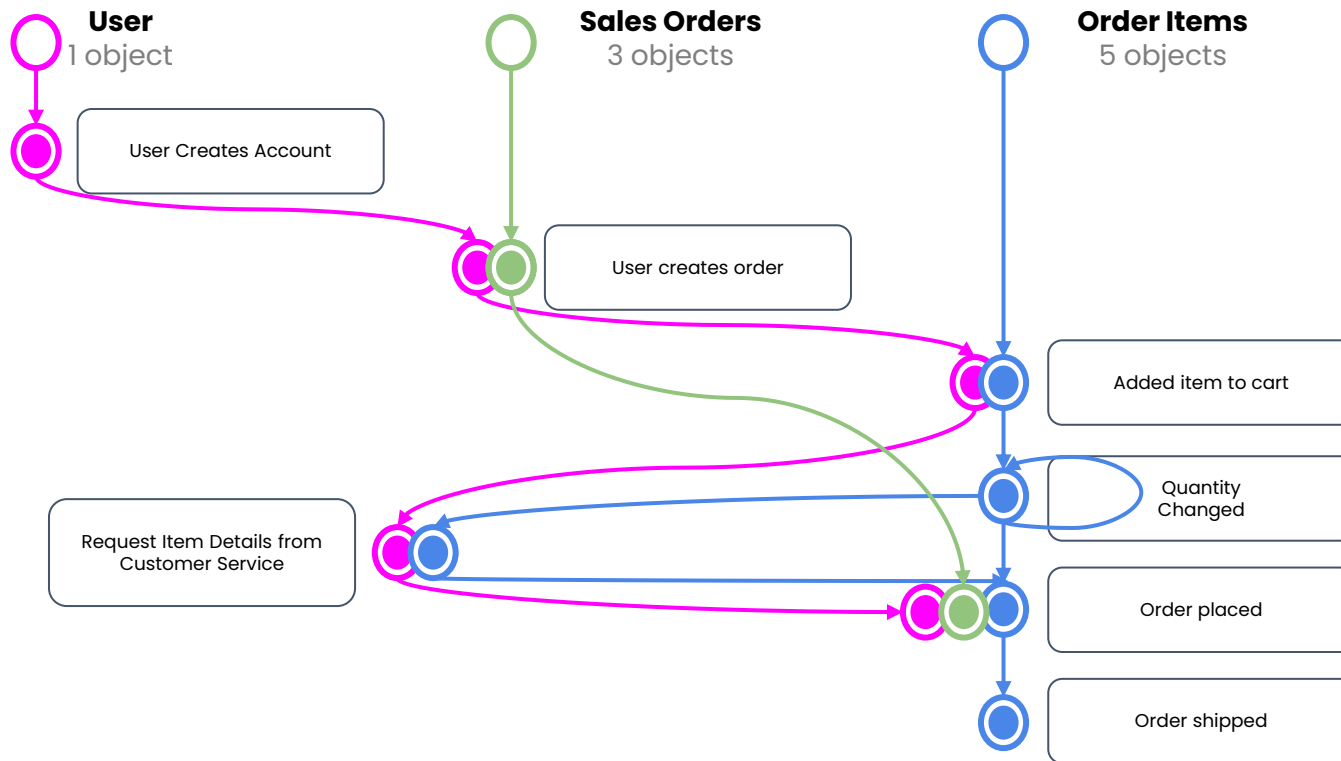
3.1 Case Centric Process Mining
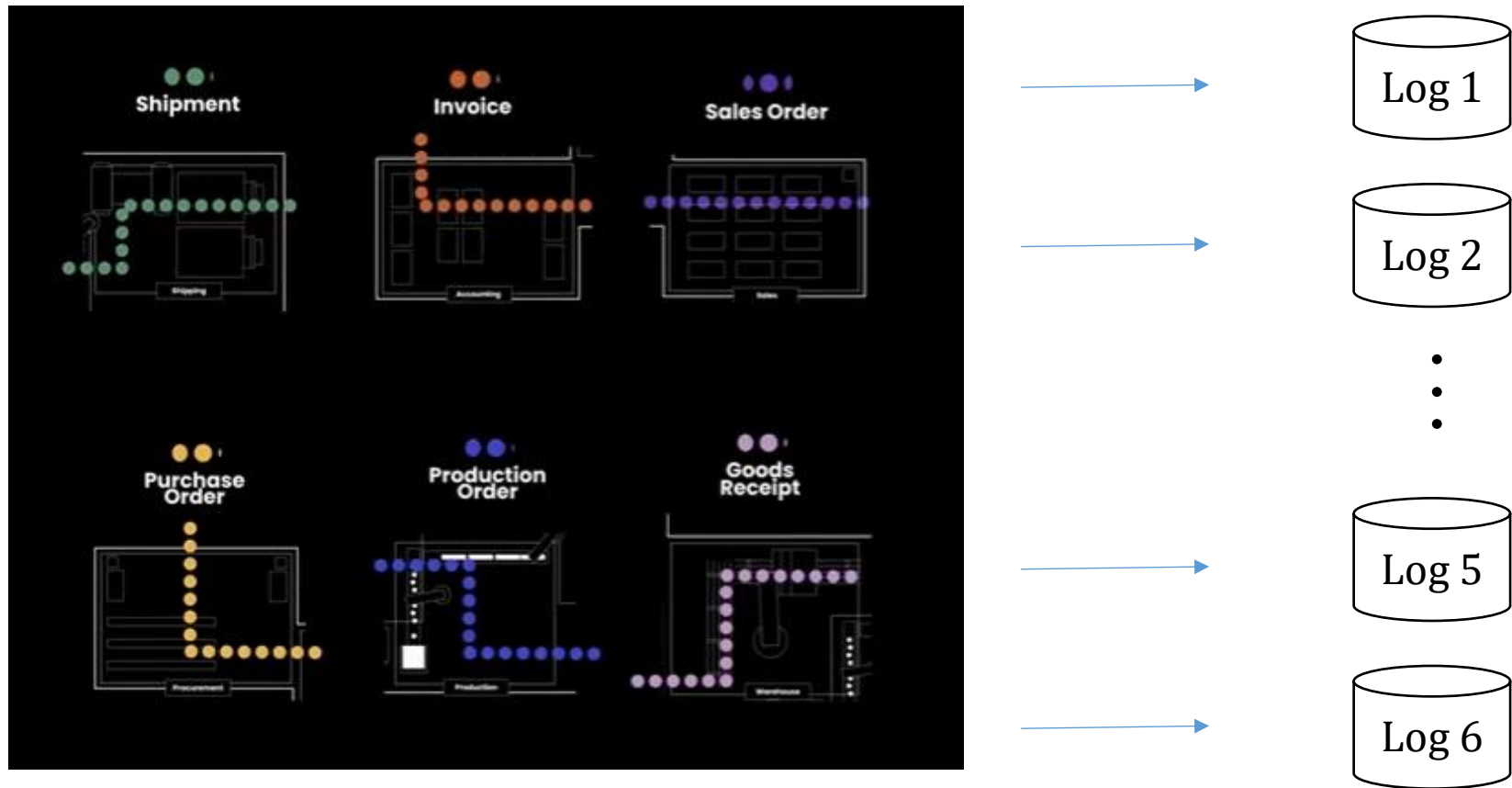
실제 프로세스와의 차이

- 실제 비즈니스 프로세스는 여러 프로세스들이 얽혀있음.
- 예시에서 고객 프로세스, 주문 프로세스, 물품 이동 프로세스가 하나의 큰 프로세스로서 이루어짐.

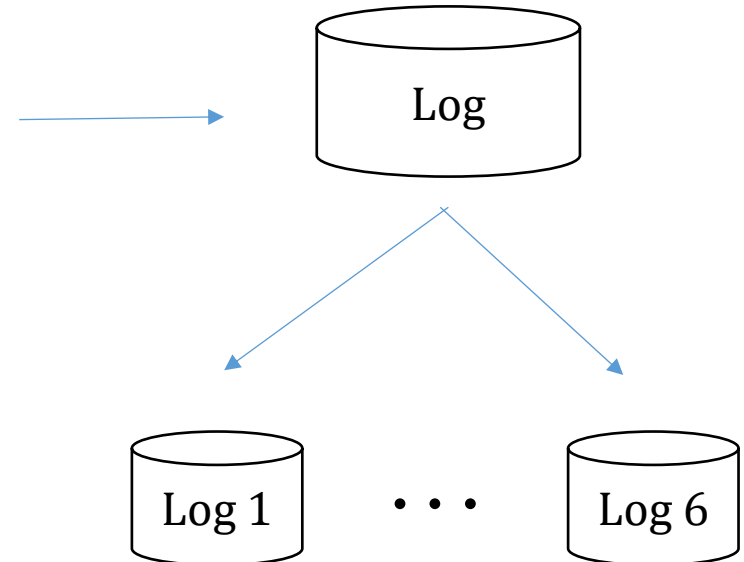# 3.1 Case Centric Process Mining
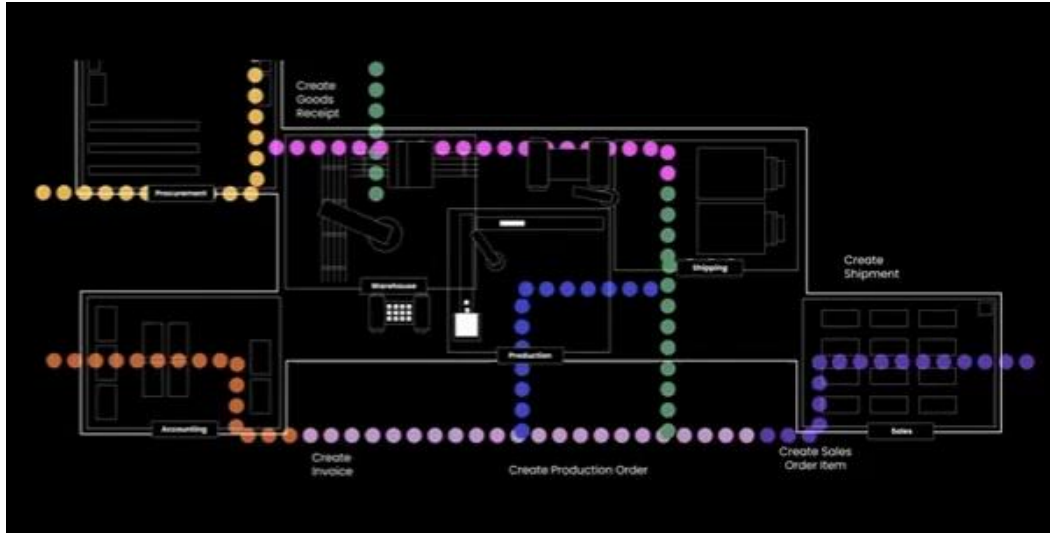
실제 프로세스와의 차이

- 각 프로세스를 독립적으로 처리하며 각 프로세스에서 이벤트 로그를 추출한다고 가정

3.1 Case Centric Process Mining

실제 프로세스와의 차이

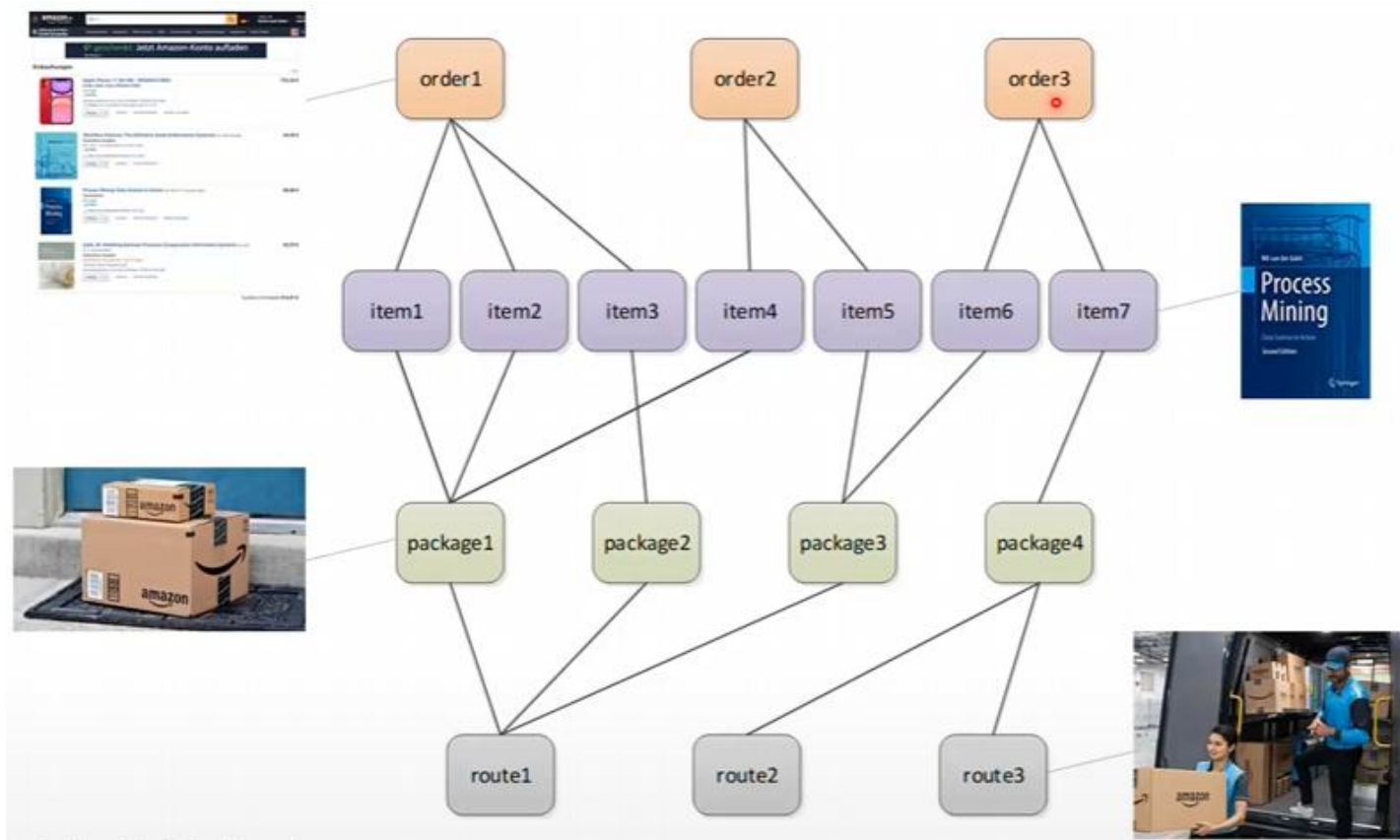- 실제론 큰 하나의 로그로 기록이 되어짐.
- 이것을 각 프로세스를 나타내도록 했을 때, 기존의 이벤트 로그가 됨

실제 비즈니스 프로세스를 더 반영할 수 있는 방법 필요

3.1 Case Centric Process Mining

실제 프로세스와의 차이

- 실제론 큰 하나의 로그로 기록이 되어짐.
- 이것을 각 프로세스를 나타내도록 했을 때, 기존의 이벤트 로그가 됨

https://www.youtube.com/watch?v=NbiM8hvaKVg&t=1734s

3.2 Object Centric Process Mining

객체중심 프로세스 마이닝 (OCPM)

- 실제 비즈니스 프로세스에 더욱 가까운 프로세스 마이닝이 제안됨.

activity	time	orders	items	packages	customers	products	price	weight
pick item	2019-12-26 12:04:46	{991224}	{884803}	{}	{Wil van der Aalst}	{iPhone 8}	529.0	0.21
reorder item	2019-12-26 12:37:26	{991271}	{885002}	{}	{Mohammadreza Fani Sani}	{Kindle Paperwhite}	129.0	0.495
place order	2019-12-26 12:44:23	{991283}	{885038,885039}	{}	{Luis Santos}	{MacBook Air,iPad}	2700.0	1.733
pick item	2019-12-26 14:01:16	{991266}	{884983}	{}	{Marco Pegoraro}	{MacBook Air}	2200.0	1.25
create package	2019-12-26 14:01:16	{991265}	{884975,884974,884978,884971,884970,884973}	{660798}	{Seran Uysal}	{Fire Stick 4K,iPad Pro,iPad Pro,iPad Pro,Fire Stick,Kindle}	3506.97	2.412
send package	2019-12-26 14:16:11	{991265}	{884975,884974,884978,884971,884970,884973}	{660798}	{Seran Uysal}	{Fire Stick 4K,iPad Pro,iPad Pro,iPad Pro,Fire Stick,Kindle}	3506.97	2.412
pick item	2019-12-26 14:16:48	{991279}	{885027}	{}	{Claudia Graf}	{iPhone 11}	799.0	0.166
confirm order	2019-12-26 14:26:01	{991283}	{885038,885039}	{}	{Luis Santos}	{MacBook Air,iPad}	2700.0	1.733
reorder item	2019-12-26 14:32:43	{991251}	{884912}	{}	{Tobias Brockhoff}	{Fire Stick}	39.99	0.2
confirm order	2019-12-26 14:32:44	{991282}	{885036,885037}	{}	{Lisa Mannel}	{Echo,Echo Dot}	134.98	1.16
pick item	2019-12-26 14:33:28	{991278}	{885024}	{}	{Junxiong Gao}	{MacBook Pro}	2500.0	1.37
place order	2019-12-26 14:48:33	{991284}	{885040,885041,885042,885043,885044}	{}	{Christine Dobbert}	{iPhone X,Fire Stick,MacBook Air,Echo Show 8,iPhone 11 Pro}	4222.98	2.79
failed delivery	2019-12-26 15:04:53	{991240,99116...}	{884879,884561,884873,884913,884876,884938,884914,884941,...}	{660790}	{Tobias Brockhoff}	{iPad Air,Echo Studio,Echo Studio,Kindle,Kindle,Echo,iPad mini,iPad Pro,iPad Pr...}	5982.95	7.642
pick item	2019-12-26 15:20:05	{991278}	{885025}	{}	{Junxiong Gao}	{iPhone X}	699.0	0.172
confirm order	2019-12-26 15:25:00	{991258}	{884938,884939,884940,884941,884942,884943}	{}	{Tobias Brockhoff}	{Echo,Fire Stick,iPad mini,iPad Pro,iPad Pro,iPad Air}	3267.98	2.666
send package	2019-12-26 15:26:49	{991247,99125...}	{884902,884922,884923,885004,885005,884901}	{660796}	{Mohammadreza Fani Sani}	{MacBook Air,iPad mini,iPad Pro,iPhone 11 Pro,iPad Pro,MacBook Pro}	8496.0	4.054
failed delivery	2019-12-26 15:36:16	{991265}	{884975,884974,884978,884971,884970,884973}	{660798}	{Seran Uysal}	{Fire Stick 4K,iPad Pro,iPad Pro,iPad Pro,Fire Stick,Kindle}	3506.97	2.412
confirm order	2019-12-26 15:40:51	{991274}	{885008,885009,885010,885011}	{}	{Junxiong Gao}	{Kindle,iPhone X,Fire Stick,iPhone 8}	1352.98	1.065
failed delivery	2019-12-26 15:46:21	{991128,99125...}	{884424,884932,884999,885008,885009,885011,884903}	{660797}	{Junxiong Gao}	{Echo Show 8,Kindle Paperwhite,iPad mini,Kindle,iPhone X,iPhone 8,Echo Shov...}	2145.97	3.6
payment reminder	2019-12-26 15:54:44	{991169}	{884565,884566,884567,884568}	{}	{Gyunam Park}	{iPhone 8,Echo Plus,iPad Air,iPad mini}	1608.99	2.21
pick item	2019-12-26 15:55:38	{991201}	{884717}	{}	{Seran Uysal}	{Echo Show 8}	129.99	0.98
pick item	2019-12-26 16:00:38	{991251}	{884912}	{}	{Tobias Brockhoff}	{Fire Stick}	39.99	0.2
reorder item	2019-12-26 16:04:42	{991265}	{884977}	{}	{Seran Uysal}	{Fire Stick 4K}	89.99	0.28
payment reminder	2019-12-26 16:11:39	{991164}	{884542,884543,884544,884545,884546,884547}	{}	{Junxiong Gao}	{Kindle Paperwhite,iPad Air,iPhone 11,MacBook Air,iPad mini,Echo Dot}	4087.99	3.011
pick item	2019-12-26 16:22:04	{991241}	{884882}	{}	{Lisa Mannel}	{iPhone 8}	529.0	0.21
create package	2019-12-26 16:22:04	{991263,99126...}	{884967,884964,884966}	{660799}	{Luis Santos}	{iPad Air,iPhone 8,iPad}	1500.0	1.133

Activity   Time   **Objects**   **Attributes**

- 기존 이벤트 로그는 Case ID, Activity, Timestamp, Attributes로 구성됨.
- 반면, 객체 중심 이벤트 로그는 Activity, Timestamp, **Objects**, Attributes로 구성됨.

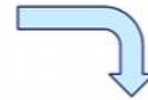개별 프로세스를 구분하기 위한 Case ID를 OCPM에선 어떻게 정의할지 고려해야함.

3.2 Object Centric Process Mining

Case ID 선정 문제

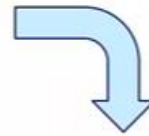- Case ID를 Objects중 하나로 정하는 경우 (Flatten), 3가지 문제가 발생함.

Problem 1: Convergence

3.2 Object Centric Process Mining

Case ID 선정 문제

- Case ID를 Objects중 하나로 정하는 경우 (Flatten), 3가지 문제가 발생함.

Problem 2: Deficiency

3.2 Object Centric Process Mining

Case ID 선정 문제

- Case ID를 Objects중 하나로 정하는 경우 (Flatten), 3가지 문제가 발생함.

Problem 3: Divergence

Pick Item → Pick Item
Pack Item → Pack Item
선, 후행 관계 오류

3.2 Object Centric Process Mining

기존 이벤트 로그로의 **Flatten**하는 경우 발생되는 문제점

Convergence

Events referring to multiple objects of the selected type are replicated, possibly leading to **unintentional duplication.**

Deficiency

Events in the original event log that have no corresponding events in the flattened event log may **unintentionally disappear** from the data set.

Divergence

Two events referring to two **different objects** of a type not selected as the case notion many be considered to be **causally related** but are not.

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3.2 Object Centric Process Mining

- Flatten없이 전체 프로세스를 있는 그대로 분석할 수 있도록 함.
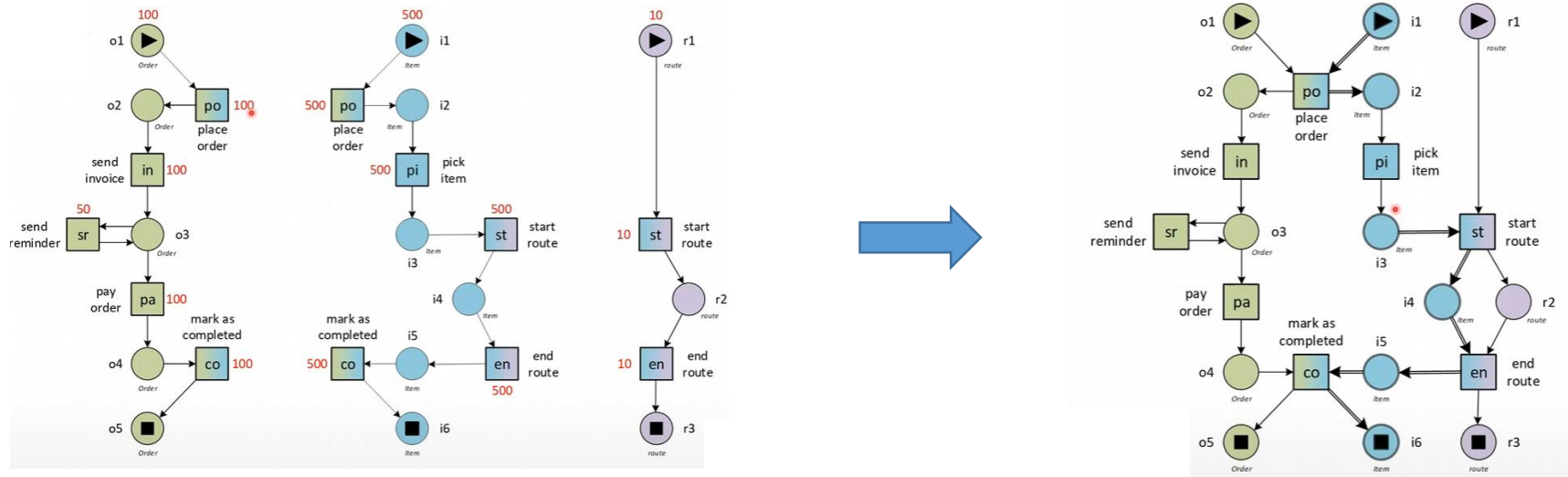
3.2 Object Centric Process Mining

Case Centric vs. Object Centric

OCPM: Unlocks new categories of use-cases

Single Process: Find opportunities by looking at all objects that make up a single process rather than anchoring on one.

Cross Process: Find opportunities by analyzing relationships between objects and events across entire value chains
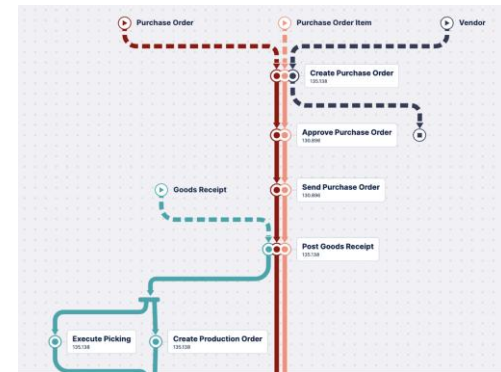
OCPM: Accurate representation of counts & times without modeling artifact

No modeling artifacts are used, therefore creating real **event and object counts**.

Example: 20 Purchase Orders are made for 30 PO Items total – both numbers will be reflected

Throughput time calculations: 100% precision throughput time aggregates in comparison to the unavoidably weighted method in case-centric.

3.2 Object Centric Process Mining

Case Centric vs. Object Centric

OCPM: Enables faster time-to-value

|	
Implementation	Provides flexible low code set up. No repetitive coding and transformation required.
Data validation & user enablement	Reduces data validation and user training as numbers are not interpreted differently.
Analysis generation	Enables quick analysis generation for different processes and objects.

OCPM: True end-to-end analysis

Business processes run end-to-end, and with a holistic view from OCPM, the main performance drivers can be identified.
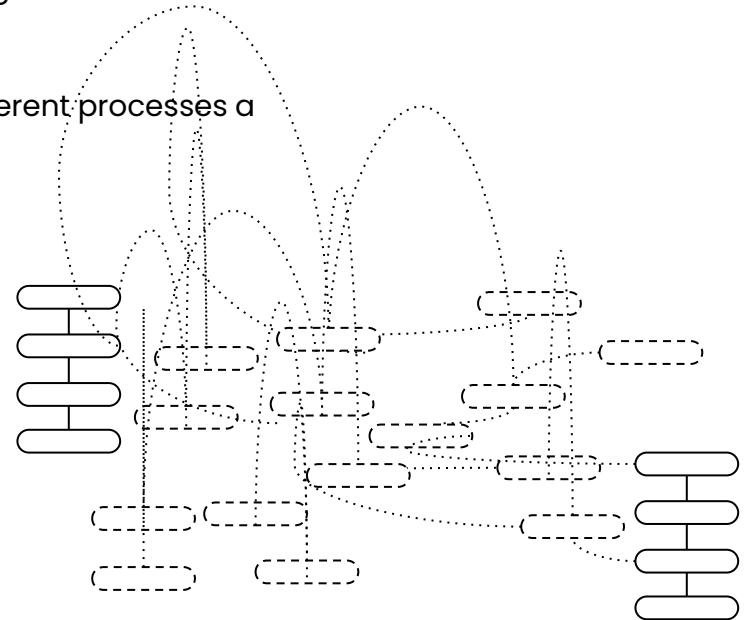
3.2 Object Centric Process Mining

Case Centric vs. Object Centric

Case-centric process mining

Case-centric process mining lines up all the objects and events that make up your processes behind a predetermined case ID.

One model per process

Procure-ment   Accounts Payable   Order Management   Accounts Receivable
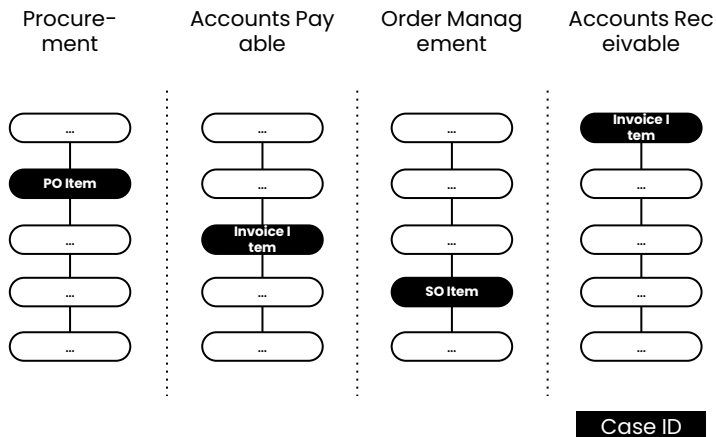
Object-centric process mining

OCPM captures objects without the imposition of a case ID, enabling the accurate analysis of processes as they truly run.

One scalable data model

Procure-ment   Accounts Payable   Order Management   Accounts Receivable

Case ID

All Objects

Object-Centric Process Mining: Dealing With Divergence and Convergence in Event Data

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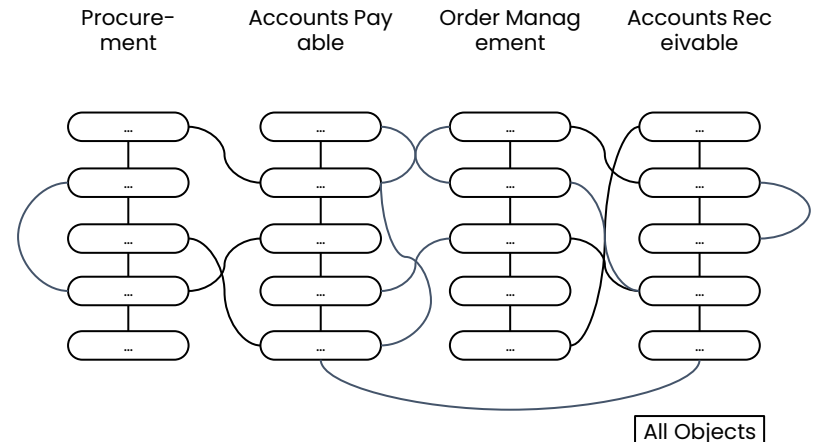
3.3 Case Study

독일 OEM 엔진 생산성 향상 예시
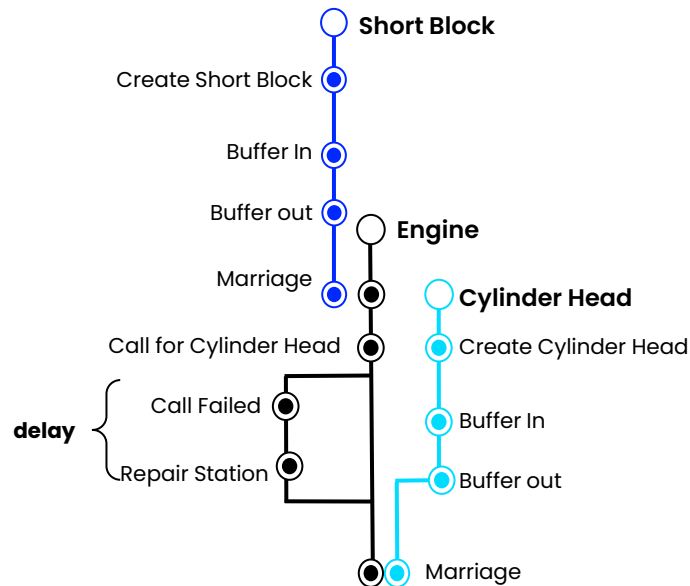
With the PI Graph, the shopfloor team achieved **end-to-end production line transparency** by connecting the objects needed to assemble an engine.

- The production team were facing challenges with **production interruption** from **failed material calls**
- This meant that the materials they needed to continue production **weren't available on time**
- They were unsure of the root cause as the materials were part of **separate processes,** meaning **no upstream visibility** of where hold-ups came from.
- The shopfloor team now leverages Celonis to instantly surface hold-ups. This enables the teams to quickly resolve bottlenecks, **fine-tune planning** and ensure that **assembly lines are in sync.**

~ 30%

Reduction in failed material calls
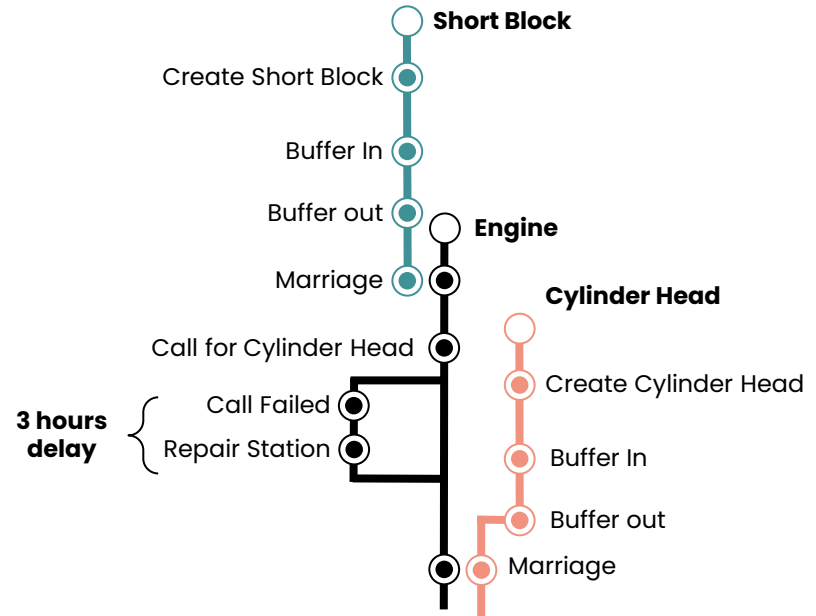
3.3 Case Study

제조업체 생산라인 통합 예시

The production team were facing challenges with **production int erruption** from **failed material calls** (where materials weren't at t he station when needed)**,** but were unsure of the root cause as th e materials were part of **separate processes,** meaning **no upstre am visibility** of where hold-ups came from.

With Celonis,, the shopfloor team achieved **end-to-end producti on line transparency** into the process by connecting the objects needed to assemble an engine such as the **short block, engine a nd cylinder head.**

This allowed the team to see **which materials were reaching stat ions too late** and delaying production leading to overtime shifts t o achieve production targets.

The shopfloor team now leverages Celonis to instantly surface hol d-ups. This enables the teams to quickly resolve bottlenecks, **fine -tune planning** and ensure that **assembly lines are in sync.**

Short Block
Create Short Block
Buffer In
Buffer out — **Engine**
Marriage
Call for Cylinder Head — **Cylinder Head**
Create Cylinder Head
Call Failed
Repair Station — Buffer In
3 hours delay
Buffer out
Marriage

Systems

- Connection via Data Lake (Cl oud Data Hub on AWS)

Key Metrics

- Failed Cylinder Head Calls per Week
- Assembly TPT

Value

~ 40%	+4000 p.a.
Less failed engine production	More engine production capacity per year

3.3 Case Study

다국적 제조업체 초과 재고 감소 예시

01 The supply chain teams were facing challenges **with an €100M increase in spare parts inventory over the past 8 years.** They lacked visibility into their current stock levels and the impact of purchasing decisions on them as these were two separate processes.

02 With Celonis, **in only 2 months they linked together inventory management with procurement.** This link allowed them to see how purchasing decisions led to the significant increase
of spare parts inventory.

03 They found that **10% of all purchase orders** were raised for spare parts that they already have in stock and that they had **€58 m
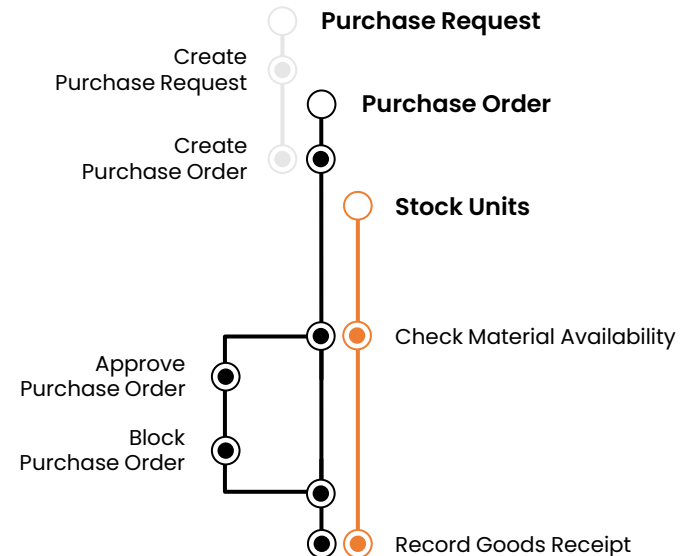of spare parts that had not been used in over 10 years.**

04 The team now leverages Celonis to proactively **block unnecessary spend on spare parts they already have in stock,** and provide a view for the procurement teams to review materials that have not been used for more than 8 years.

Purchase Request
Create Purchase Request
Purchase Order
Create Purchase Order
Stock Units
Check Material Availability
Approve Purchase Order
Block Purchase Order
Record Goods Receipt

Systems

SAP ECC

Key Metrics

• Excess Spend
• Obsolete Stock

Value Framed

€70 m
P&L & WC framed by blocking excess spend and reducing aging inventory

€250 k
Value Realised in first month of deployment

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Process Mining기반 Process Intelligence 추진 기업

Technology

Financial Services & Insurance

Life Sciences & Chemicals

Consumer & Retail

Manufacturing

TeleCo & Media

Energy & Utilities

Oil & Gas

3.5 Quiz

1. signup.celonis.com 접속
2. 이메일 주소 등록
3. 초대 이메일을 열고 학생으로 등록
4. 계정 접속

3.5 Quiz

Quiz A.1
가장 많이 발생된 Objects는?

A - Sales Orders

B - Sales Order Items

C - Deliveries

D - Invoices
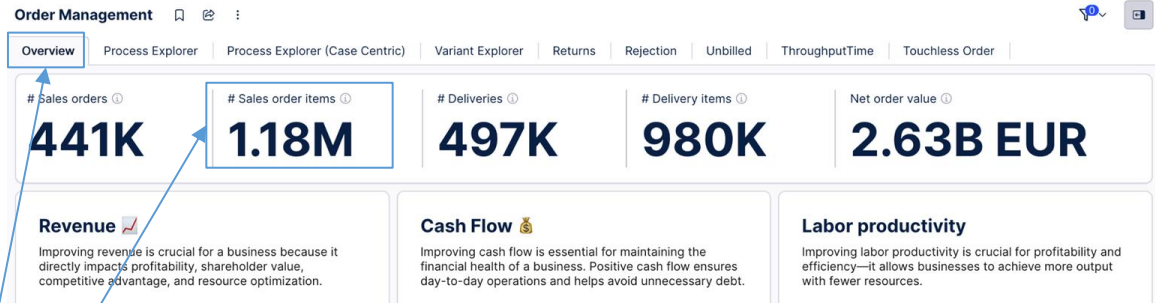
3.5 Quiz

Quiz A.1
가장 많이 발생된 Objects는?

A – Sales Orders

B – Sales Order Items

C – Deliveries

D – Invoices

(0a) Tab Overview

(1a) Compare Values

(0b) Tab Process Explorer

(1a) Compare Objects

Quiz A.2

Sales Orders에 대해 가장 많이 발생된 첫 이벤트는?

A – Create Sales Order Item

B – Create Purchase Order

C – Create Sales Order

D – Create Invoice

Quiz A.2

Sales Orders에 대해 가장 많이 발생된 첫 이벤트는?

A - Create Sales Order Item

B - Create Purchase Order

C - Create Sales Order

D - Create Invoice

Order Management

Overview | **Process Explorer** | Process

(0a) Tab Process Explorer

Sales Order
441K objects

(1a) Check First Event

441K

Create Sales Order
441K Times

Process Explorer (Case Centric) | **Variant Explorer** | Returns | Rejection

(0b) Tab Variant Explorer

(1b) Check First Event

#

Variant Explorer

Sales Order

12% | objects covered
1 of 300 variant
52.5K of 441K objects

Apply Filter ∨

	Variant	Count	Coverage	Avg TPT
☑	#1	52.5K	12%	33 d
☐	#2	42.9K	10%	10 d

Start
52.5K objects

52.5K

Create Sales Order
52.5K Times

52.5K

Create Sales Order Item
145K Times

Quiz A.3

Sales Order가 처리한 인보이스의 개수는?

A – All

B – 938k

C – 441k

D – 100

3.5 Quiz

Quiz A.3

Sales Order가 처리한 인보이스의 개수는?

A – All

B – 938k

C – 441k

D – 100

(0) Tab Process Explorer

(1) Filter on Event

(2) Check number of Sales Order objects

실습 강의 종료

고생하셨습니다