Process Mining Research in Korea

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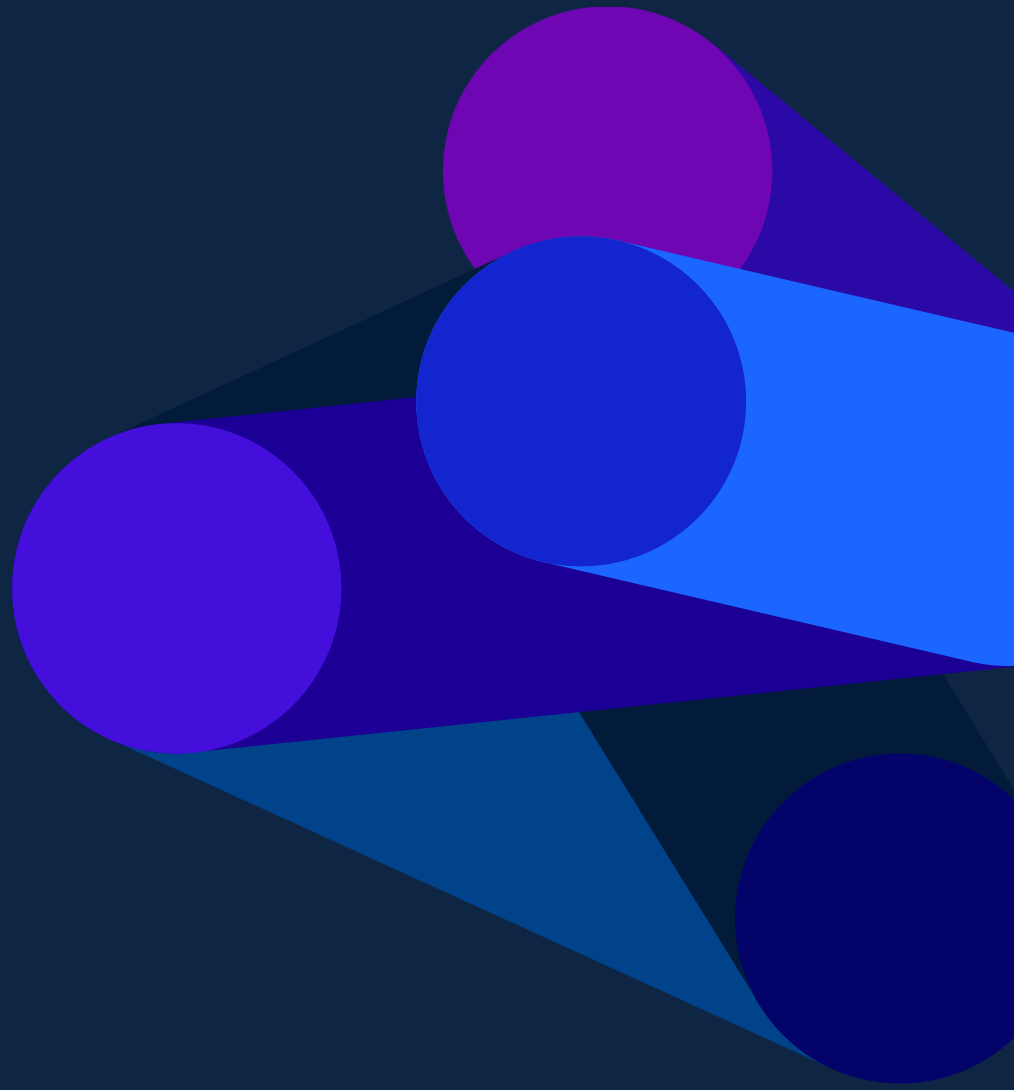
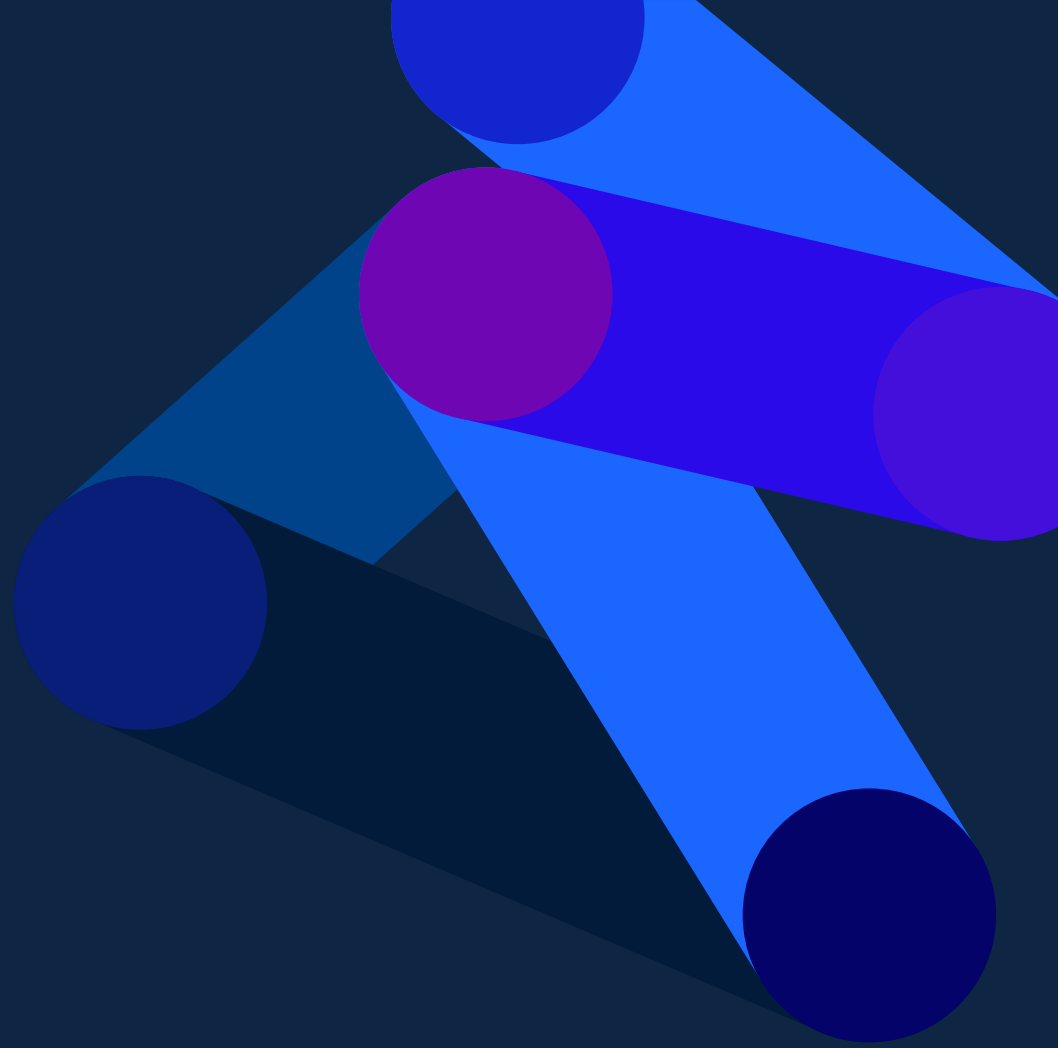
INDUSTRIAL AND MANAGEMENT ENGINEERING

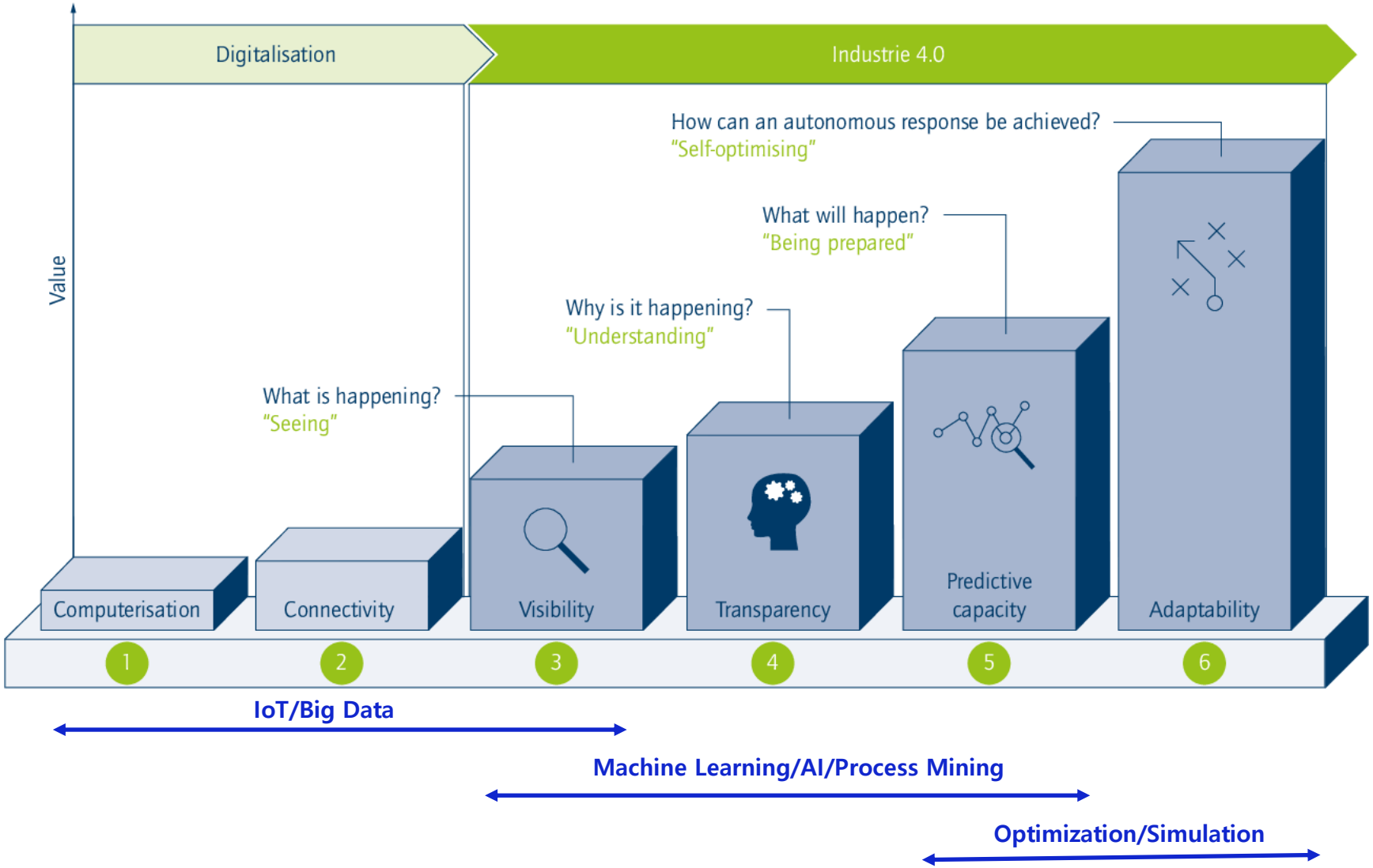


Contents

- Introduction
- Process Mining
- Cases
- Conclusion



Stages in the Industrie 4.0 development path



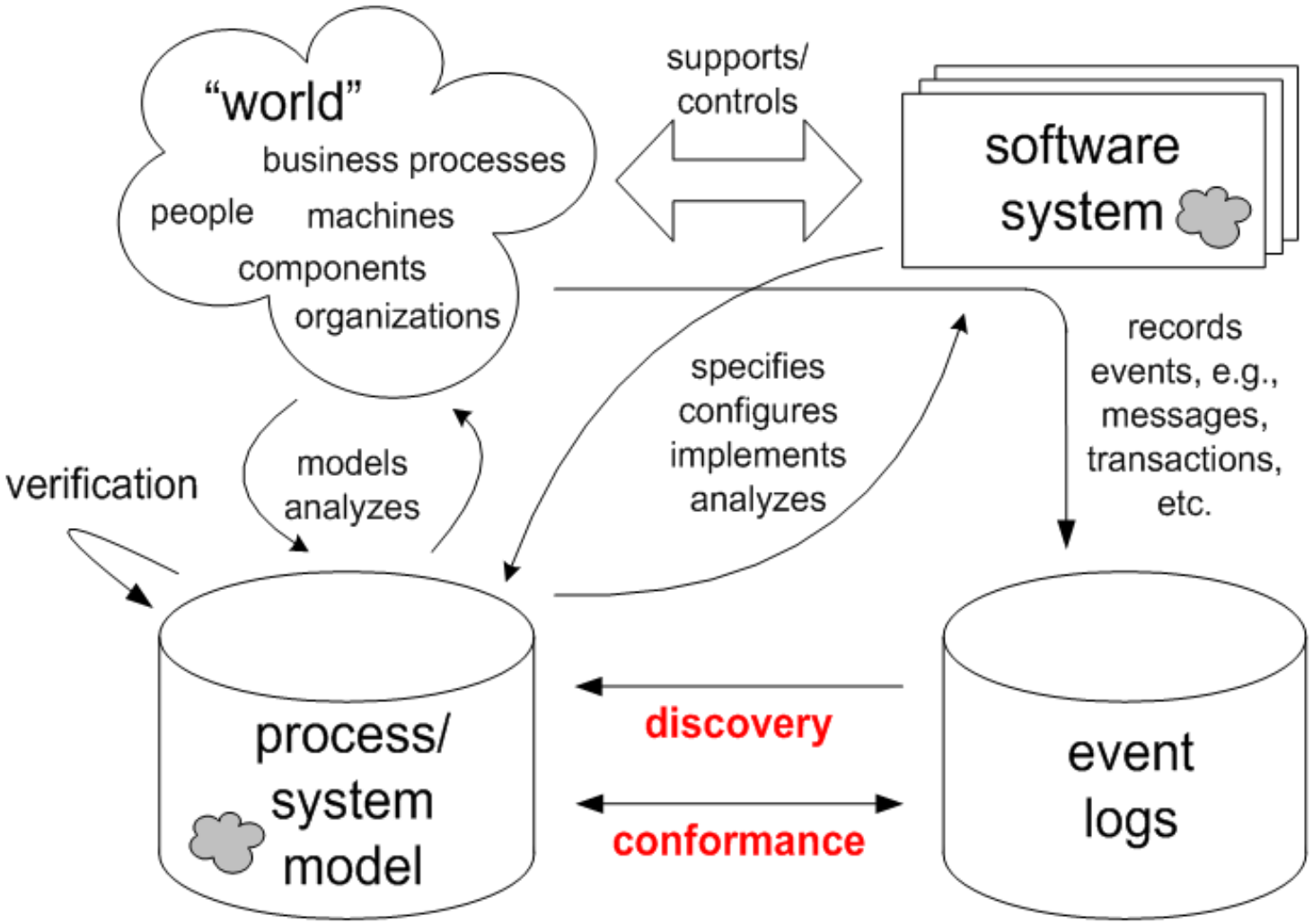
출처: Acatech, Industrie Maturity Index (2017)

원저: FIR e. V. at RWTH Aachen University

RWTH: Wil Van der Aalst

H-index:163, Citations:122,000
By Google Scholar

Process mining: Linking events to models

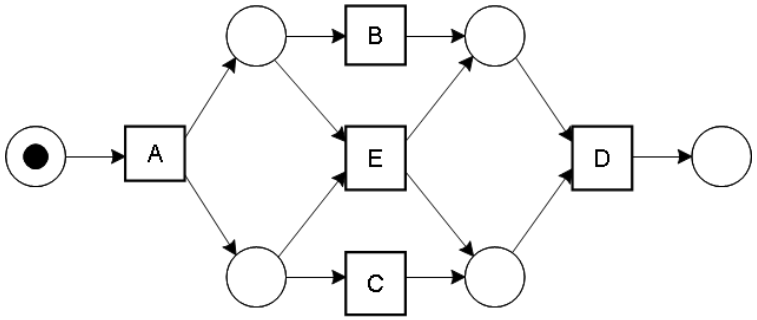


[Prof. van der Aalst]

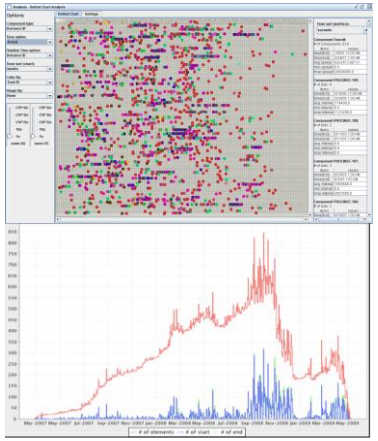
Discovery

Cases	Logs
1	(A,John,10:22:21),(B,Sue,10:25:20),(C,John,10:40:21),(D,Pete,10:45:25)
2	(A,John,10:24:27),(C,Carol,10:32:12),(B,Clare,10:44:23),(D,Pete,10:50:45)
3	(A,Carol,11:52:35),(E,Mike,13:23:56),(D,Sue,14:42:13)
4	(A,Pete,13:21:25),(C,Carol,14:23:21),(B,Clare,15:34:13) (D,Pete,16:21:13)
5	(A,Sue,14:22:34),(E,Pete,15:32:42),(D,Clare,16:13:15)

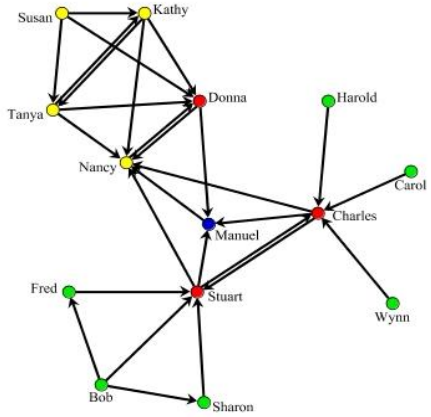
Process Model



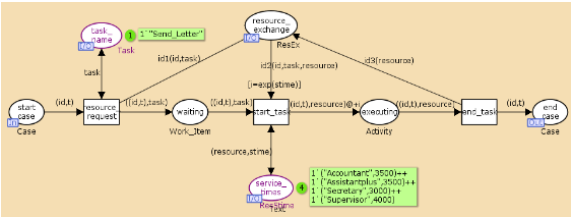
Performance Metrics



Social Network



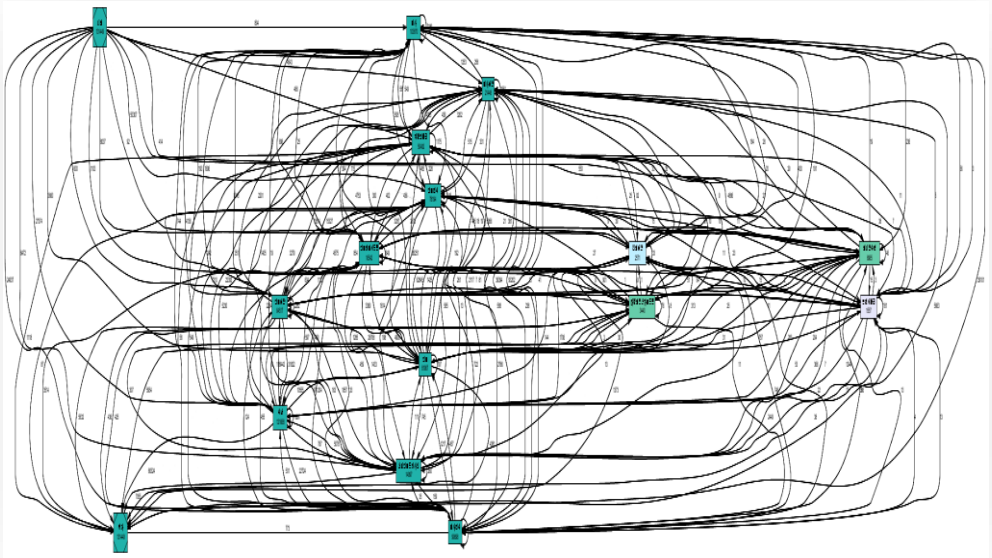
Simulation Models



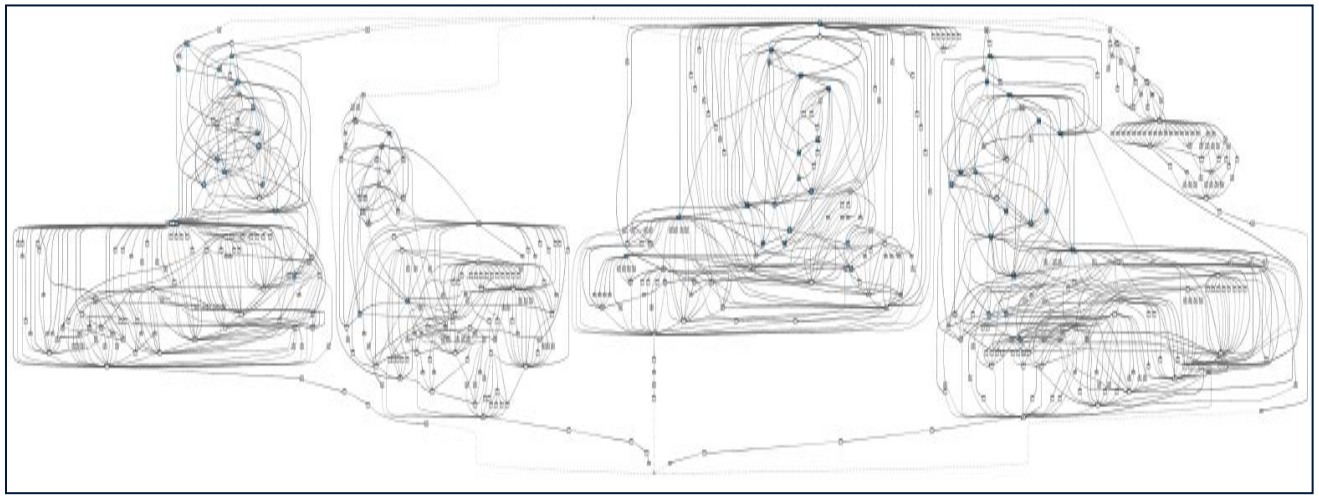

암병원 · 뇌신경병원

A manufacturing process in Samsung Electronics

Outpatient processes in SNUBH



A shipbuilding process in HHI



Trace clustering - examples

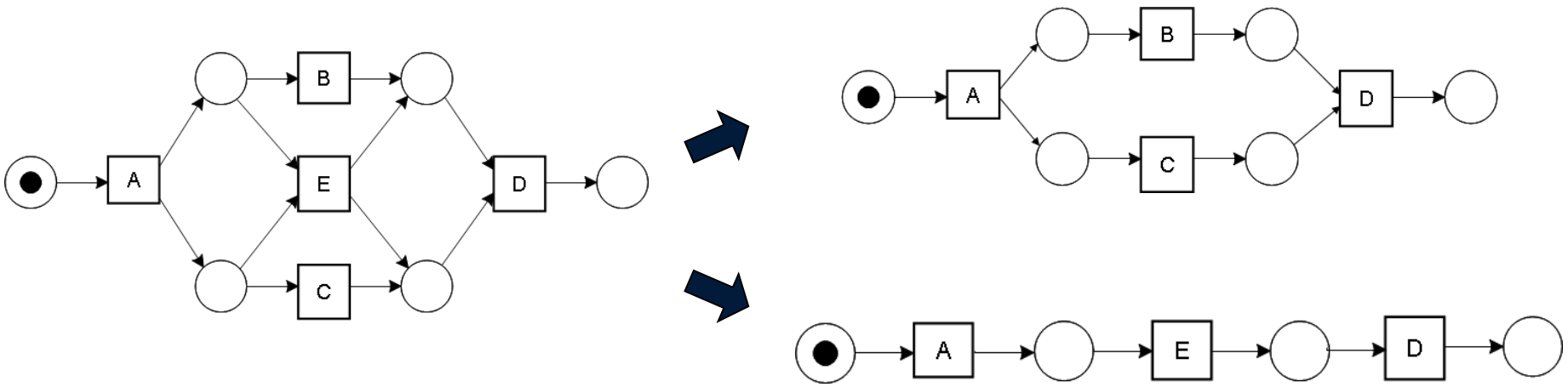
Cases	Logs
1	(A,John),(B,Sue),(C,John),(D,Pete)
2	(A,John),(C,Mike),(B,John),(D,Sue)
3	(A,Carol),(E,Mike),(D,Sue)
4	(A,Pete),(C,Carol),(B,Clare) (D,Pete)
5	(A,Sue),(E,Pete),(D,Clare)

Cases	Logs
1	(A,John),(B,Sue),(C,John),(D,Pete)
2	(A,John),(C,Mike),(B,John),(D,Sue)
4	(A,Pete),(C,Carol),(B,Clare) (D,Pete)

Cases	Logs
3	(A,Carol),(E,Mike),(D,Sue)
5	(A,Sue),(E,Pete),(D,Clare)

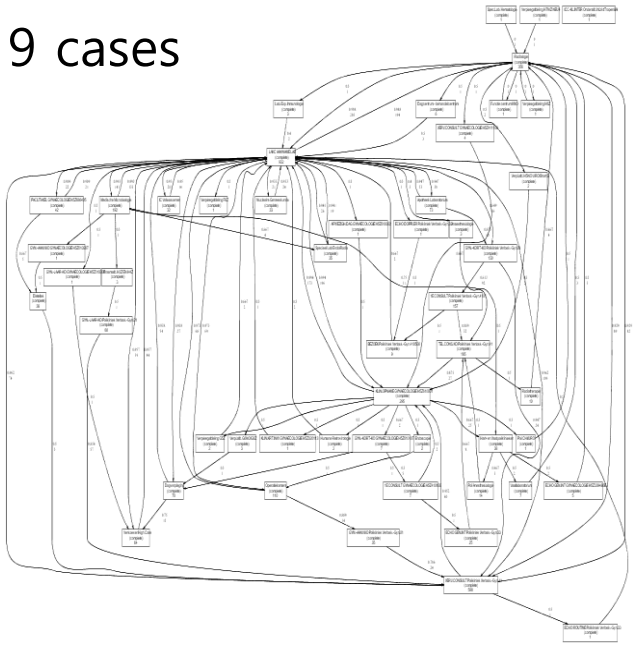
Process Log

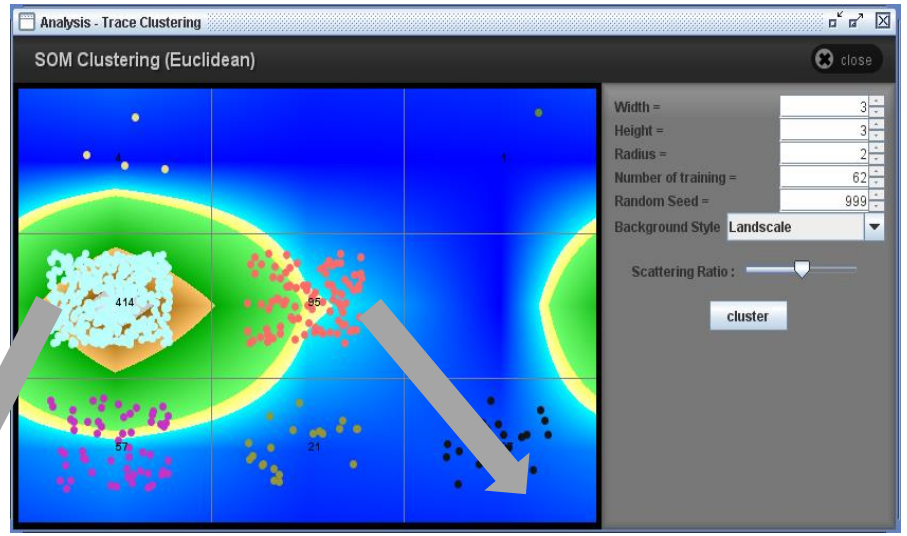
Mining result (process model)



Trace clustering

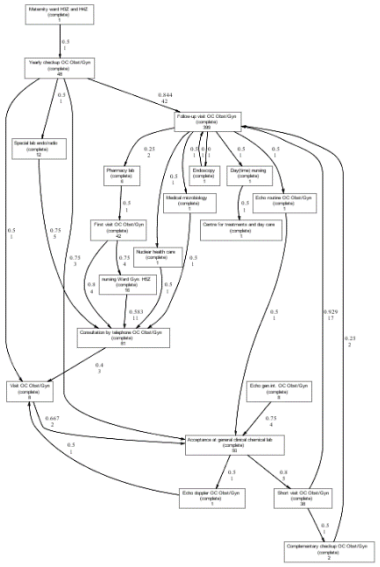
619 cases

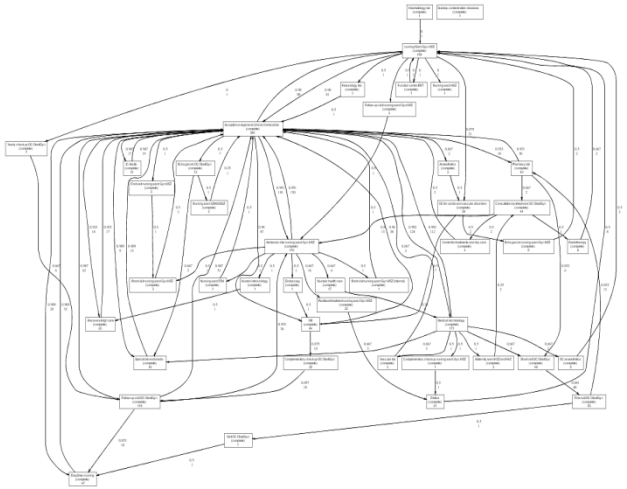




95 cases

414 cases





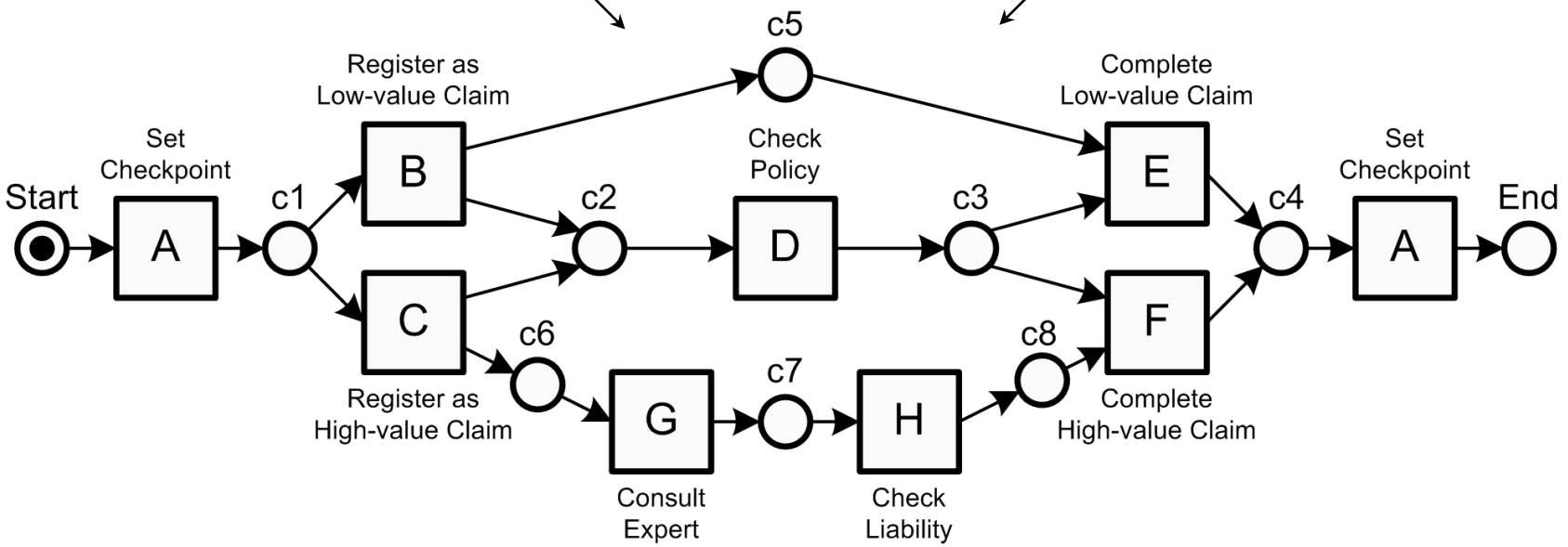
Conformance Checking: measuring fitness

No. of Instances	Log Traces
4070	ABDEA
245	ACDGHFA
56	ACGDHFA

No. of Instances	Log Traces
1207	ABDEA
145	ACDGHFA
56	ACGDHFA
23	ACHDFA
28	ACDHFA

No. of Instances	Log Traces
24	BDE
7	AABHF
15	CHF
6	ADBE
1	ACBGDFAA
8	ABEDA

f = 1.0 **f ≈ 0.955** **f ≈ 0.540**



[Prof. van der Aalst]

The Two Most Important Quotes In Business

Your #1 business mistake is that you're running your business blind!

"If you can't measure it, you can't improve it." - Peter Drucker -

Read more: http://www.growthink.com/content/two-most-important-quotes-business#ixzz4kHTfgjYu

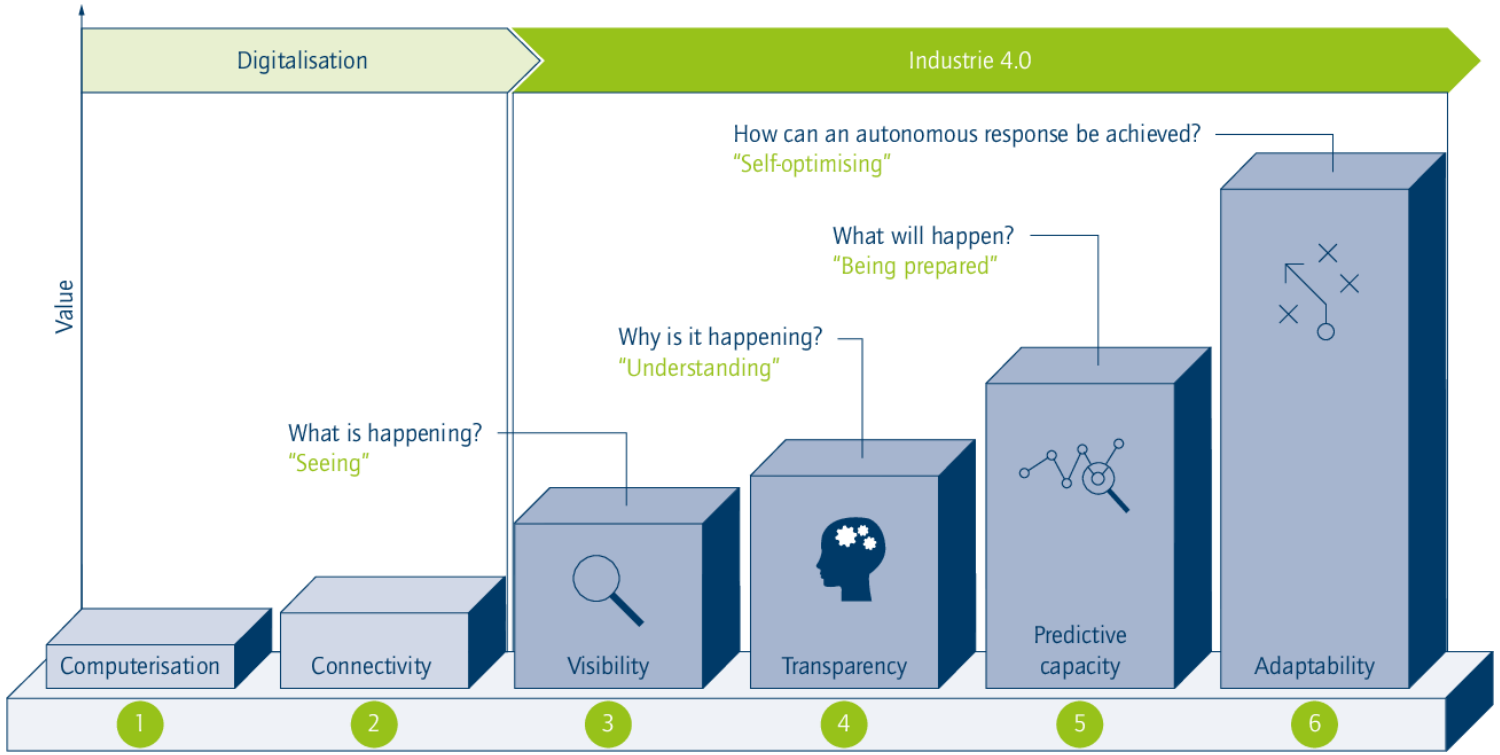
Recent works

Visibility
- **Model Discovery**

Transparency
- **Process Mining + Machine Learning**

Prediction
- **Process Mining + AI**

Adaptability
- **Process Mining + Optimization + Simulation + RPA**

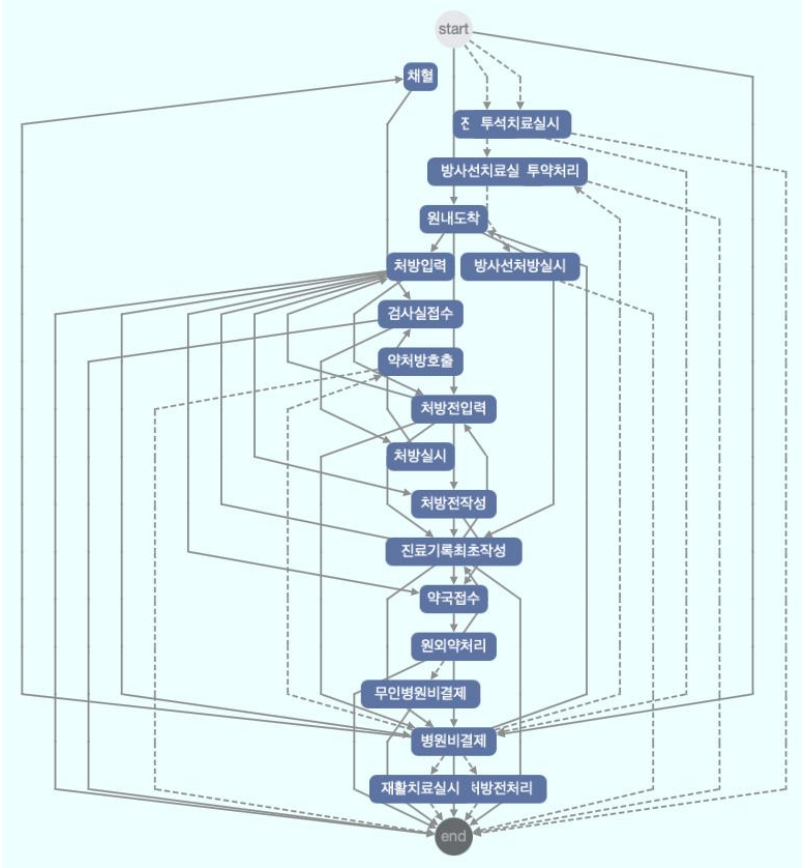


Visualization

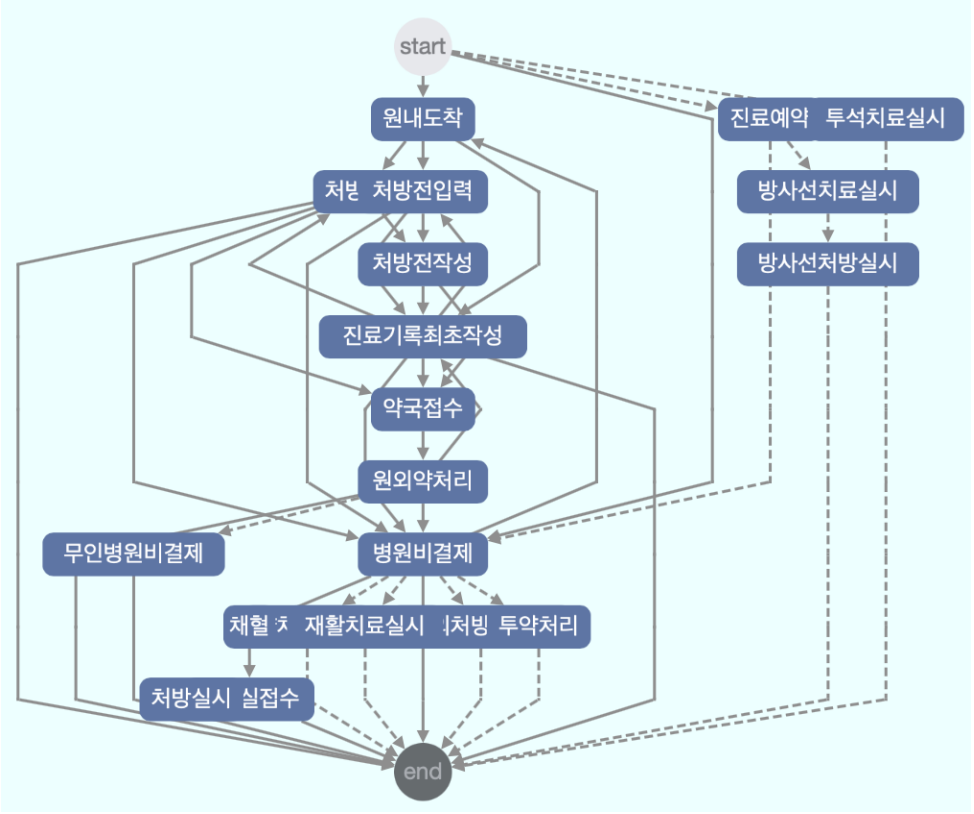
Understandable Process Model Discovery

Balance Component → Revise Rank → Minimize Cross → Spline drawing → Revise Order → Shrink Layout

기존 stable graph layout

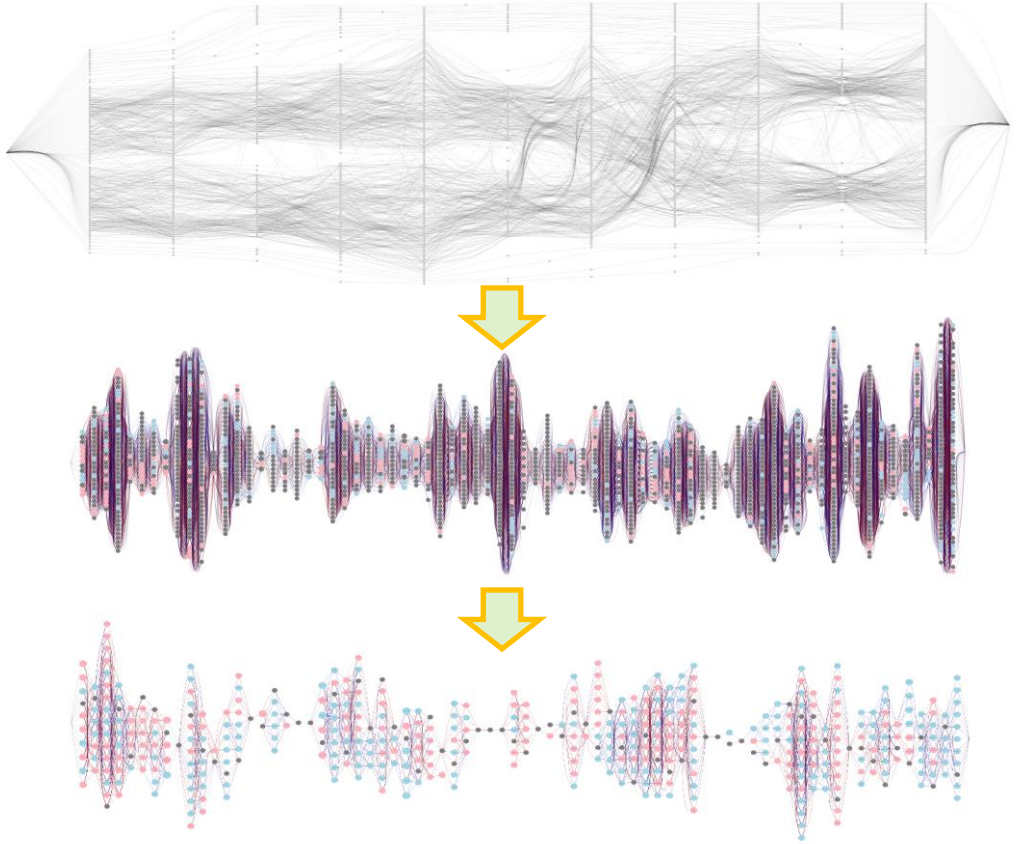


제시 알고리즘



Visualization

Understandable Process Model Discovery

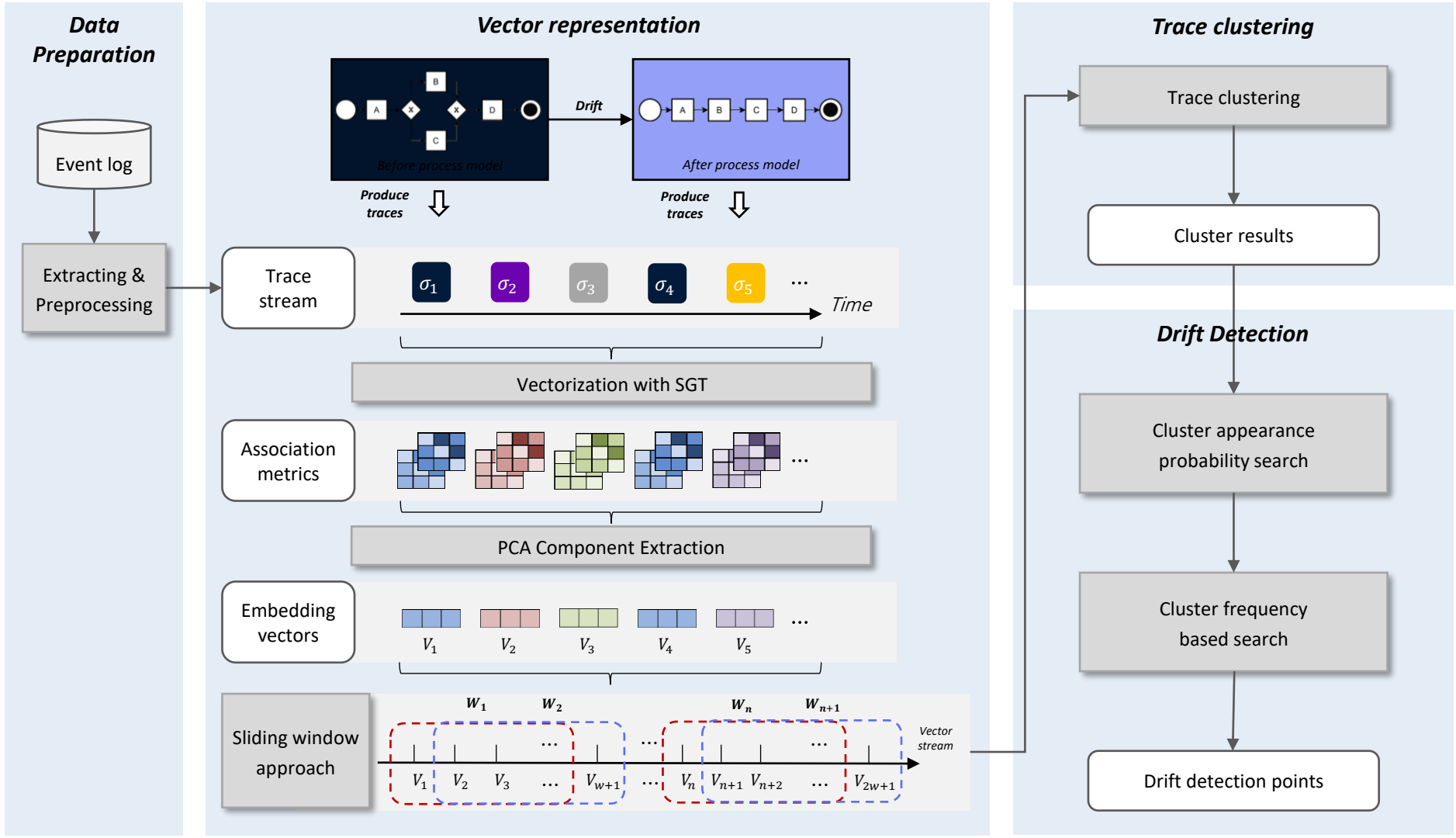


	단순화 전	단순화 후	비율
Node 수	1675	476	71.6% ↓
Arc 수	27462	2347	91.5% ↓

Cho, M., Park, G., Song, M., Lee, J., Lee, B., Kim, E., "Discovery of Resource-oriented Transition Systems for Yield Enhancement in Semiconductor Manufacturing." IEEE Transactions on Semiconductor Manufacturing, Vol. 34, No. 1, pp. 17-24, 2021.

Transparency

Finding Concept Drift



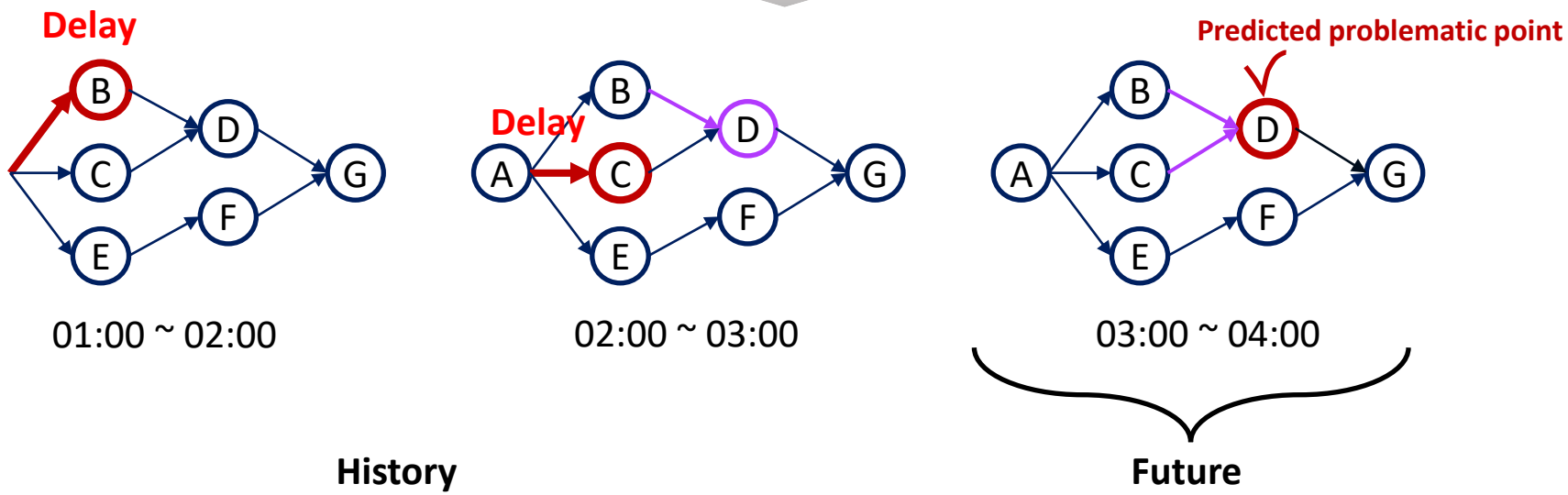
장영석

Prediction (PM +AI)

Process performance prediction

Next event prediction

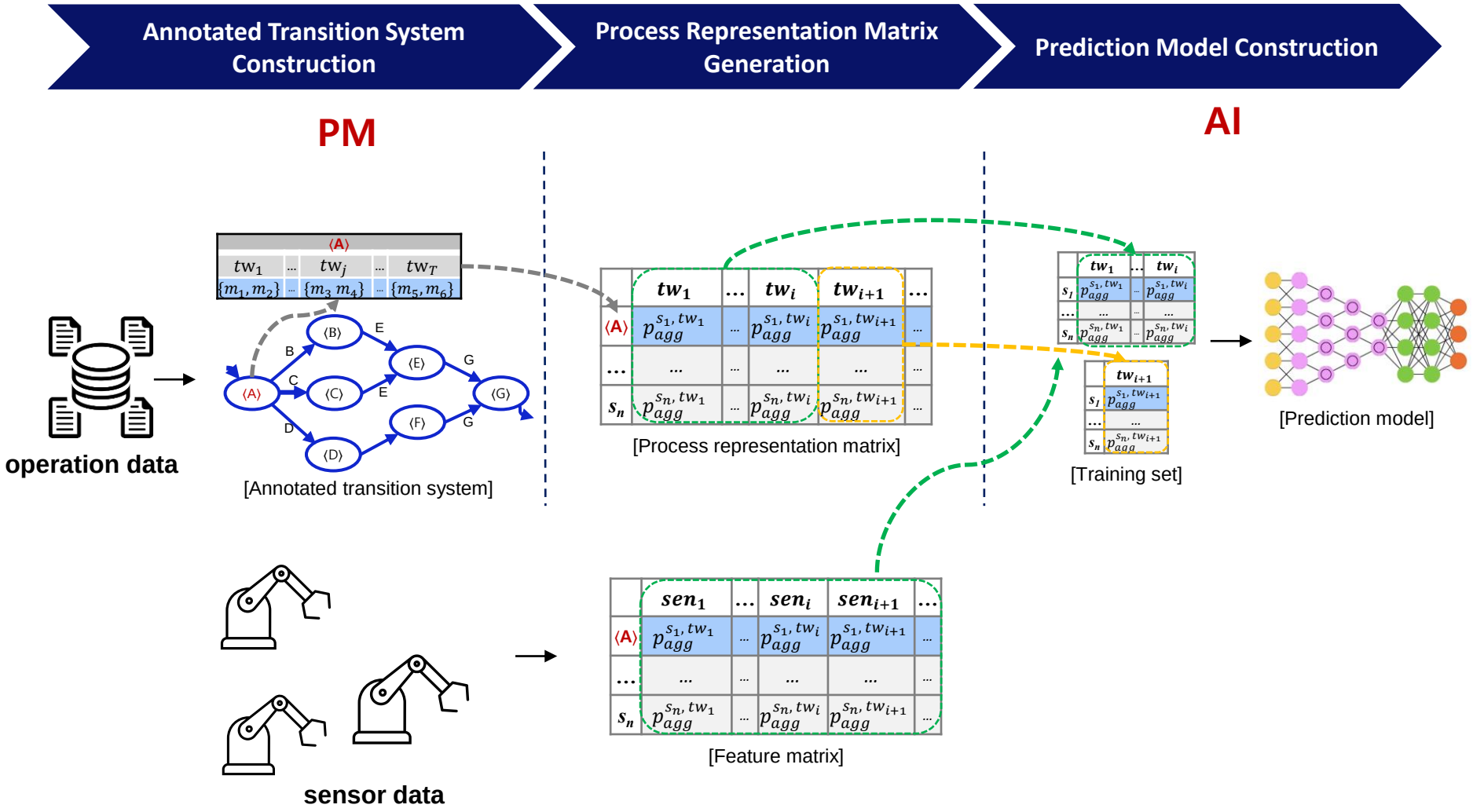
Pattern: Delay on **B** → Delay on **C** → Delay on **D**



Park. G. **Song, M.***, "Predicting Performances in Business processes using Deep Neural Networks" *Decision Support Systems*, Volume 129, 10.1016/j.dss.2019.113191, February 2020

Prediction (PM +AI)

Predicting Performances in Business Processes using Deep Neural Networks

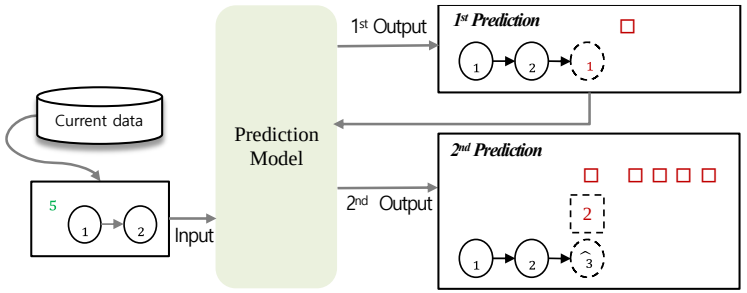


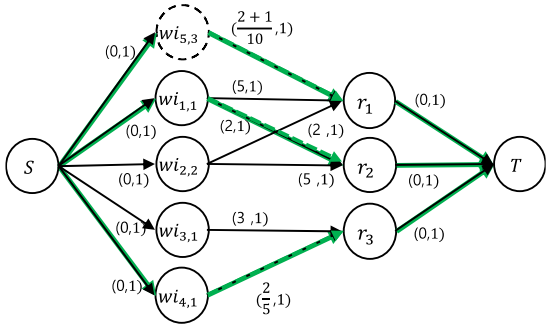
Park. G. **Song, M.***, "Predicting Performances in Business processes using Deep Neural Networks" *Decision Support Systems*, Volume 129, 10.1016/j.dss.2019.113191, February 2020

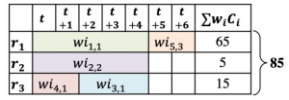
Adaptability(Process Mining + Optimization)

Phase 1: Offline prediction model construction

Phase 2: Online resource scheduling







improve

Here

	t	$t+1$	$t+2$	$t+3$	$t+4$	$\sum w_i C_i$
r_1		$wi_{5,3}$		$wi_{2,2}$		25
r_2	$wi_{1,1}$					2
r_3	$wi_{4,1}$	$wi_{3,1}$				15

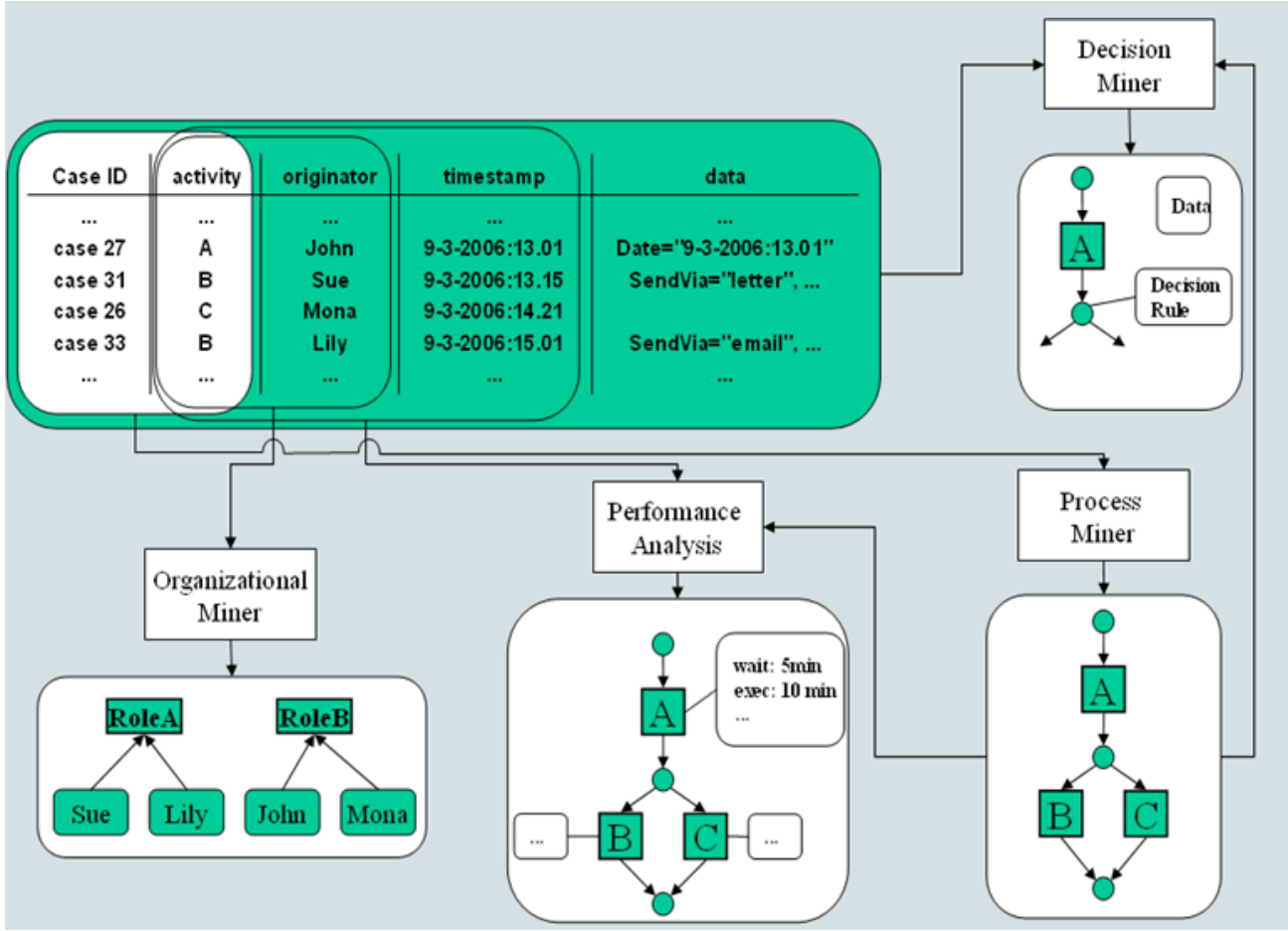
42

<Result of resource allocation>

Park, G., M., Song., "Prediction-based Resource Allocation using LSTM and maximum flow and minimum cost algorithm" In *International Conference on Process Mining (ICPM),* Aachen, Germany, June 24-26, 2019.

Adaptability(Process Mining + Simulation)

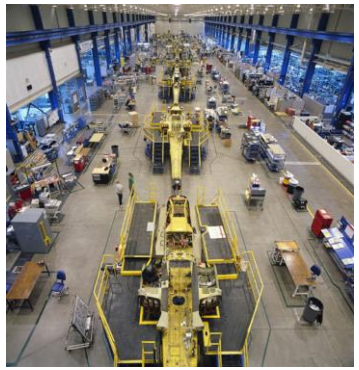
Simulation Model Generation



Rozinat, A., Mans, R. S., Song, M., van der Aalst, W. M. P., "Discovering simulation models." Information Systems, Vol. 34, No. 3, pp. 305-327, 2009.

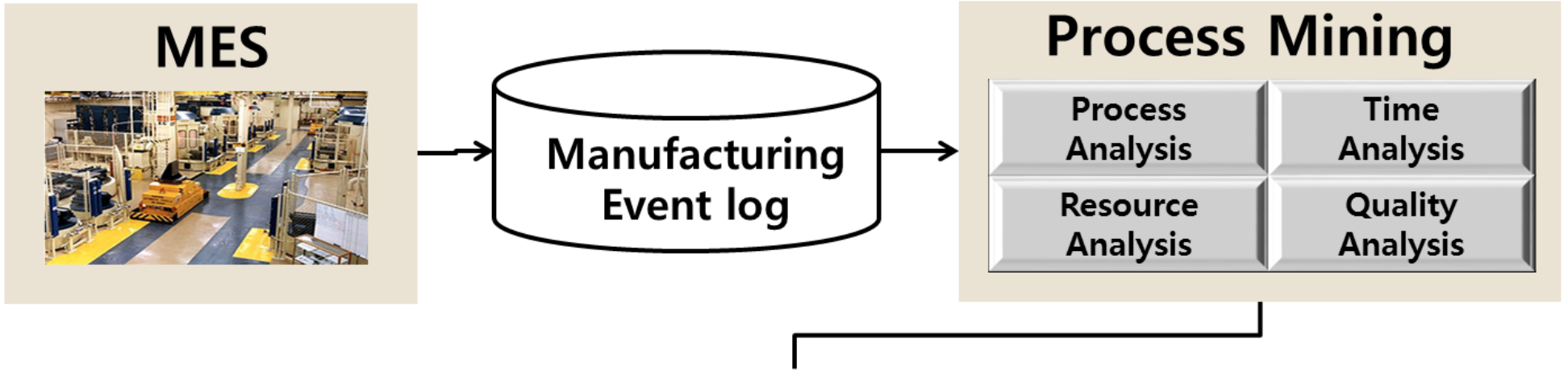
Applications in Korea

- Three major application areas
  - Manufacturing Industry: POSCO, Hyundai Heavy Industries, Samsung Heavy Industries, Samsung electronics, Samsung Electro-Mechanics, etc.
  - Healthcare Industry: SNU Hospital@Bundang, SNU Hospital@Boramae, Samsung Seoul Hospital, etc.
  - Finance Industry: KB



Manufacturing Process Analysis

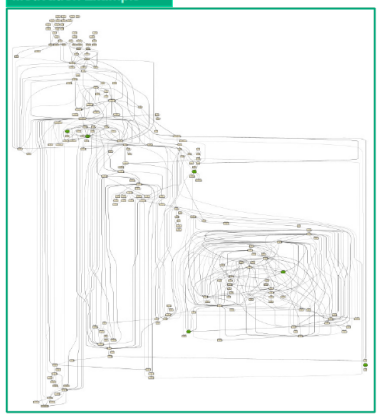


Process Analysis	Time Analysis	Resource Analysis	Passing Yield Analysis	Facility Standard Analysis
•Discovery Process Models •Conformance Checking •Bottleneck Analysis •Animation Analysis •Process Pattern Analysis	•Working, Waiting, L/T Performance Analysis •Performance Analysis for one task or machine •Dotted chart analysis for performance checking	•Time analysis of Working, Waiting, and L/T •Performance Operating Rate Analysis •Resource Network Analysis •Organizational Model •Task by Matrix •Machine analysis for product family	•Passing Yield Analysis for One lot •Passing Yield Analysis for One task •Passing Yield Analysis for One machine •Change graph of passing yield	•Facility Standard Analysis for passing yield •Facility Standard Analysis for Lead Time •Facility Standard Analysis simulation

MES 데이터 분석

Proposed Method – Motivation

Motivation Example



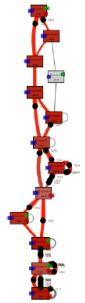
- We extracted a process model from process event logs with ProM.
- Unfortunately, the model is too complicated, so hard to understand.
- To find bottlenecks, we simulated the model with process logs but couldn't get any insight due to model complexity.

Process Model & Bottlenecks

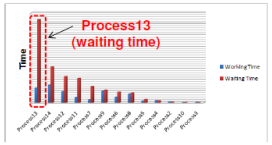
Case Study
- Process model and bottleneck
- Model conformance
- Process visualization

- Step5. (Optional) Repeat Step3-4 to find a narrower bottleneck within each process boundary.

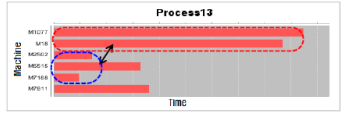
Process Model within Process Boundary2



Process Flow Simulation



Bottleneck Analysis within Process Boundary2

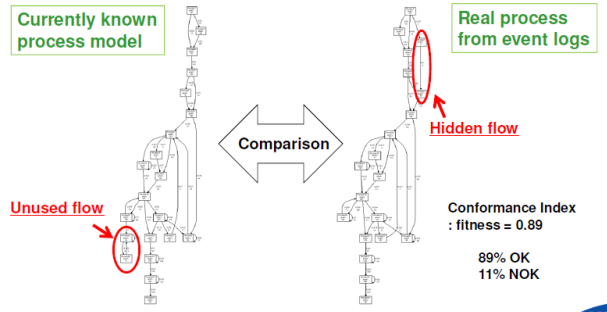


Waiting Time Distribution of Process13

Background

Process Mining Framework

- Phase II: Conformance Test
  - Find the difference between the currently known process model and the real event logs.
  - From this analysis, (1) unused flow and (2) hidden flow are found.

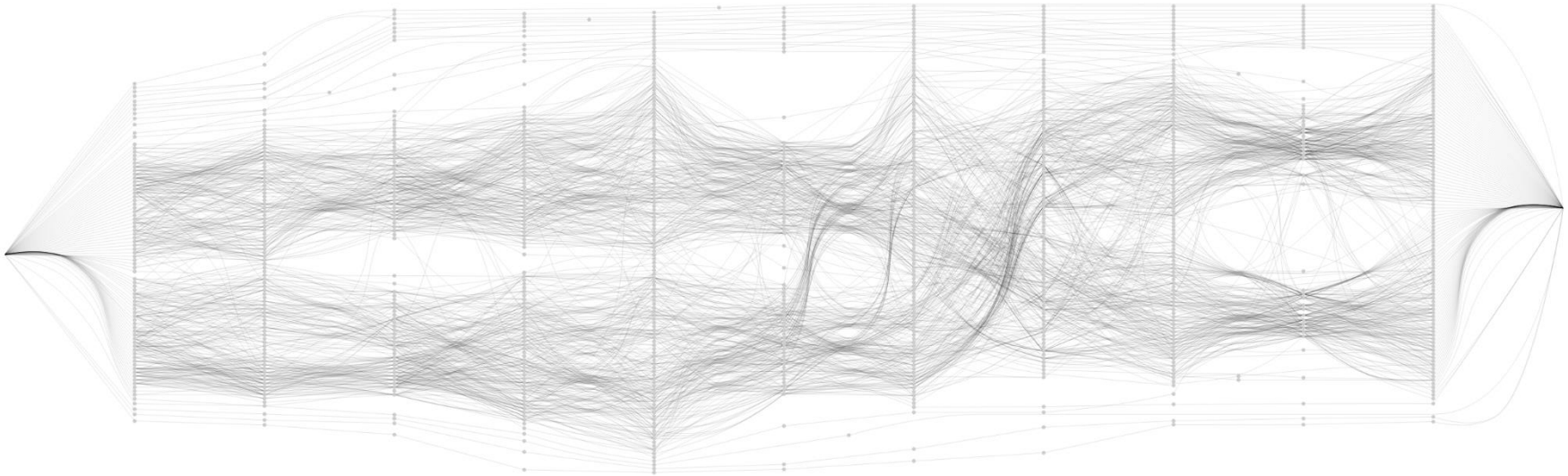


삼성전자 정일교 박사

BOB/WOW: 수율 기반 최적 설비 경로 도출 방법론

Transition System 모델 도출

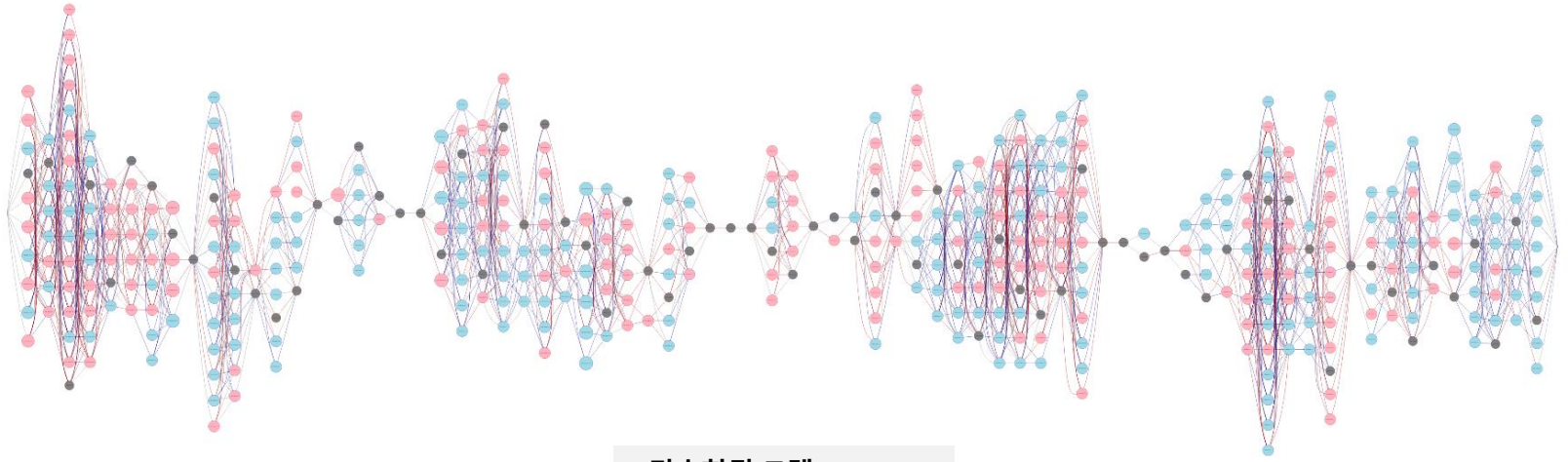
- 실제 공정 로그에서 생성된 FSM 모델은 **일반적으로 매우 복잡하여 중요 설비를 고려한 모델의 단순화 필요**
- 아래 예시는 전체 **공정 중 11개의 공정**에 대한 모델 도출 결과임



<실제 공정 로그를 활용한 FSM Model 도출 결과>

BOB/WOW: 수율 기반 최적 설비 경로 도출 방법론

유의/더미 설비 분석 기발 설비 프로세스 모델 단순화

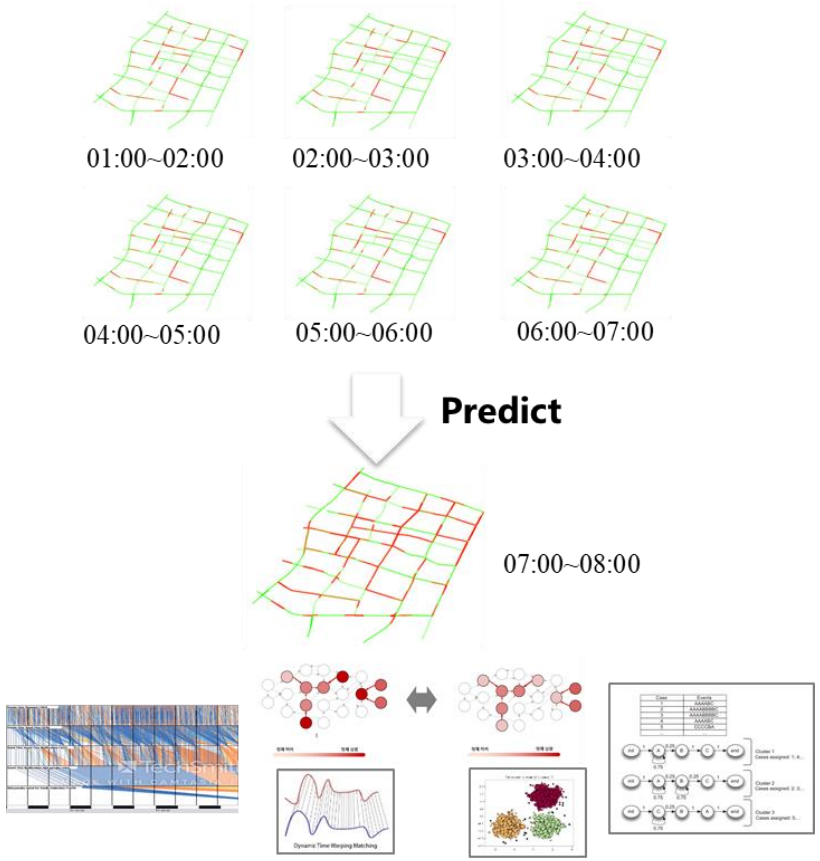


단순화된 모델 (Type 1)

	단순화 전	단순화 후	비율
Node 수	1675	476	71.6% ↓
Arc 수	27462	2347	91.5% ↓

Congestion analysis in FAB

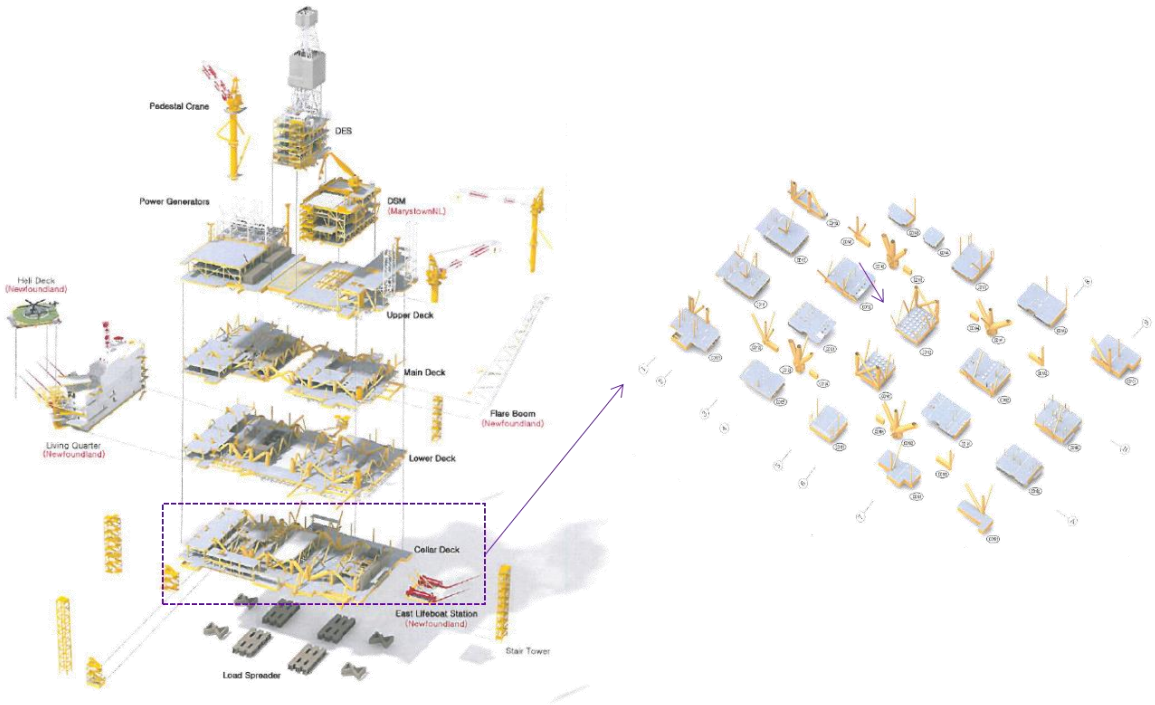
반도체 물류 내 비효율을 효과적으로 감지하고 이러한 비효율의 원인을 분석하여 개선을 위한 인사이트를 제공하는 실용적인 방법 개발



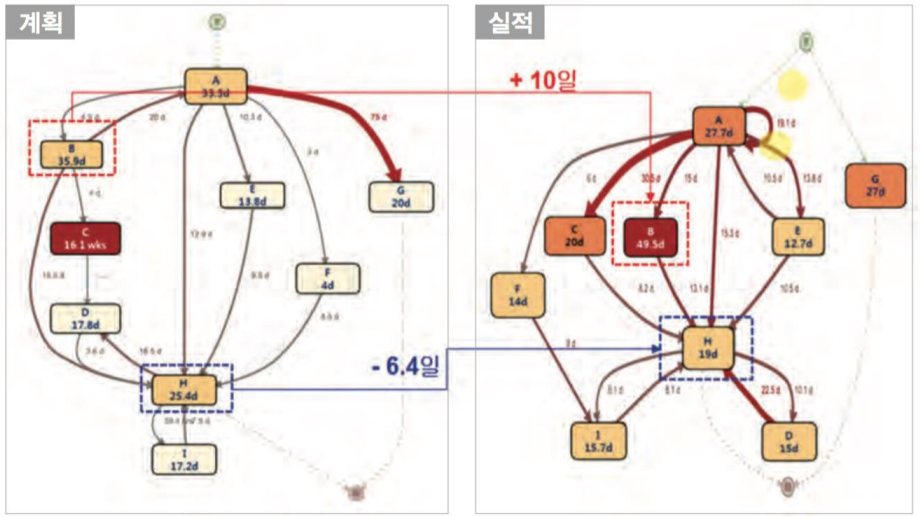
[Congestion analysis & prediction]

[복잡한 물류 흐름 예시]

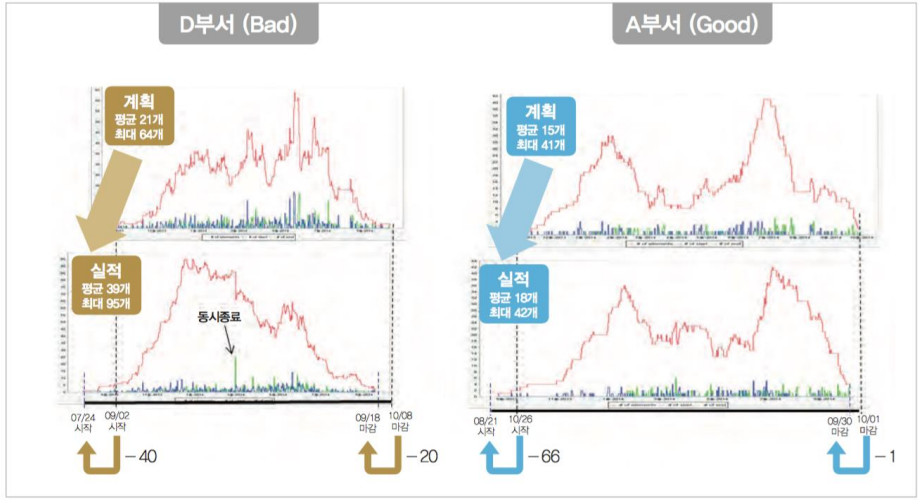
Bottleneck Analysis



[그림] A 중공업 계획 실적 프로세스 모델 비교

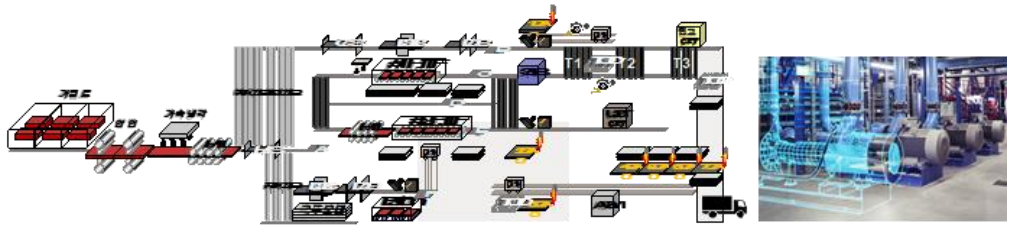


[그림] 부서별 부하 비교 분석



손숙영, 박민정

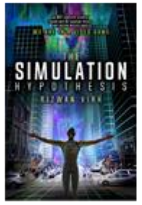
Process Mining & Digital Twin



3D Model + MR

Digital Twin

IoT

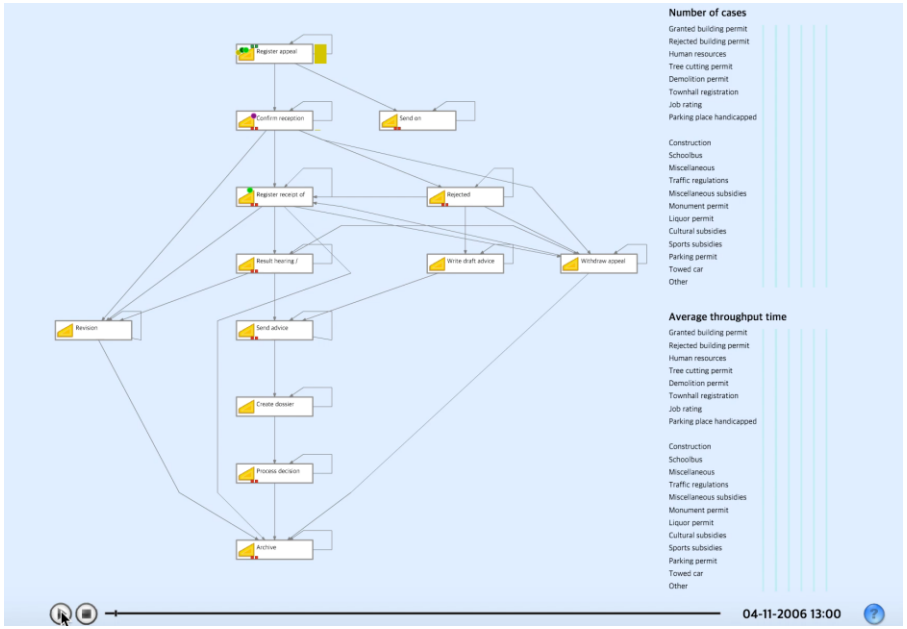


Simulation

AI+ML

Optimization

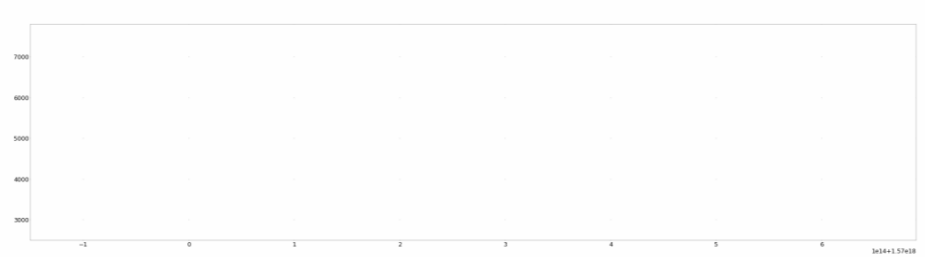
Process Mining & Digital Twin



Futura

Visualization (Process Discovery + Animation)

Digitalization (IoT)

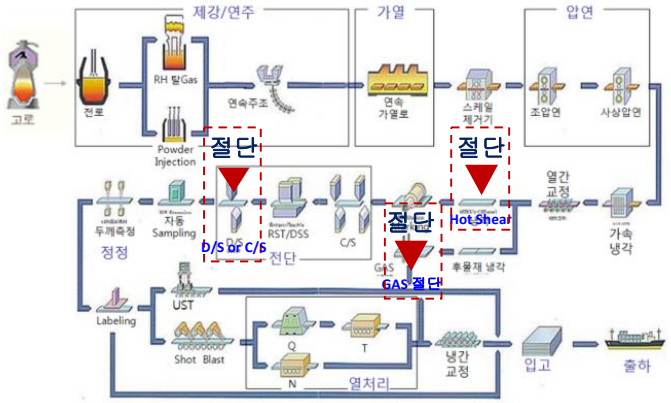


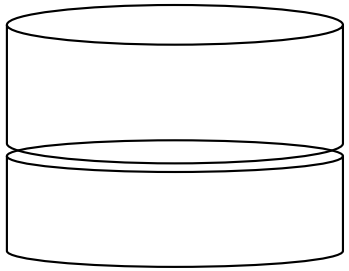
Prediction + Optimization + Simulation

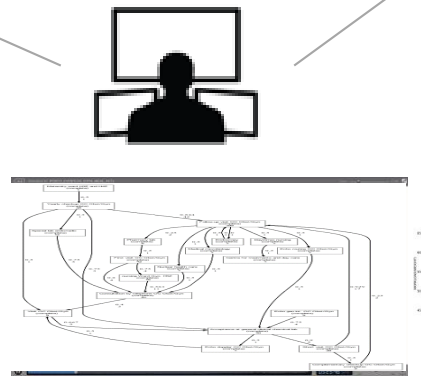
Process Mining & Digital Twin

Adaptability - Self-Optimizing

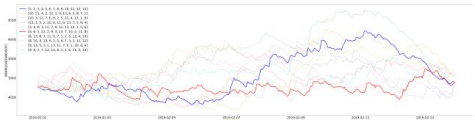
압연 일자(일)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
원 편성안	1	2	3	4	5	6	7	8	9	10	11	12	13	14
최적 편성안 (예시)	12	11	13	10	14	9	7	6	2	4	3	1	8	5







디지털 트윈 Platform



편성안 검증

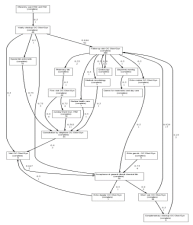
Process Mining & Digital Twin

Adaptability - Self-Optimizing

일자(일)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
원 스케줄	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Random 스케줄	10	11	4	2	12	3	9	13	6	5	8	14	7	1
LP 스케줄	1	11	4	5	8	2	6	12	3	7	13	9	10	14
AI 스케줄	5	14	6	1	12	2	9	3	13	7	10	4	11	8

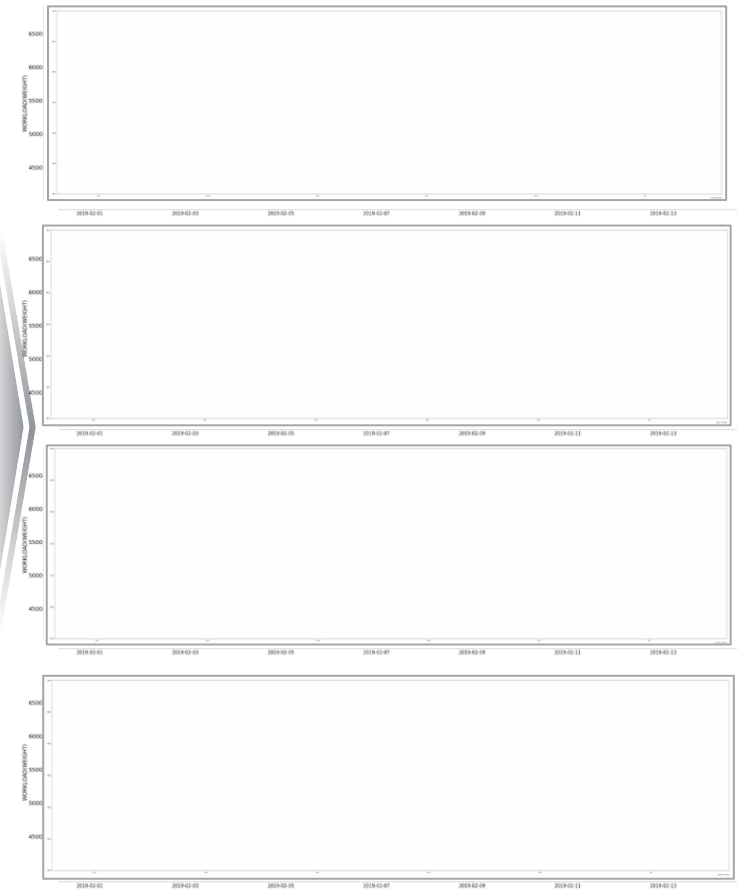
N : Roll 편성(1 turn)

Digital Twin



예측 공정 부하량

2019-02-01~2019-02-14



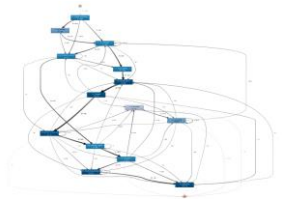
Process Mining & Digital Twin

Simulation model generation framework

Process Mining & Machine Learning

Process discovery

[Direct-Follows Graph]

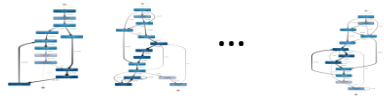


Trace clustering

Complex business process
→ Cluster cases with similar control-flow

[Complex business process]

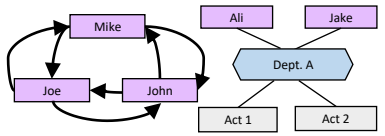
[cluster1] [cluster2] ... [clusterN]



Organizational mining

Relationship among resources in process
→ Social Network Analysis, Role discovery

[Social Network] [Role Discovery]



Queue discipline discovery

Discover queue discipline
→ Correlation analysis

Correlation of arrival-execution

[First In First Out]

$\rho_{x,y} \approx 1$

[Last In First Out]

$\rho_{x,y} \approx -1$

[Randomly]

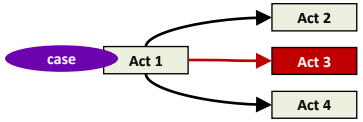
$\rho_{x,y} \approx 0$

Cluster assignment

Assign new cases to cluster
→ Classification model

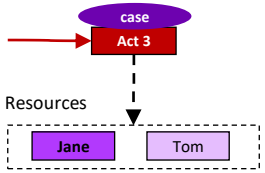
Decision point analysis

Predict next activity at each decision point
→ Classification model



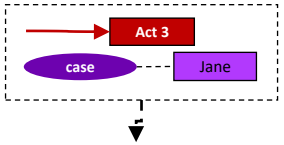
Resource allocation

Predict what resource should work for this case
→ Classification model



Activity duration prediction

Predict activity duration
→ Regression model



- Execution time
- Sojourn time=waiting time + execution time

Business Process Simulation

Simulation

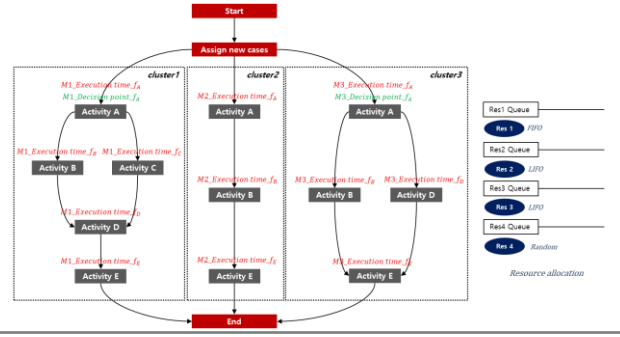
[Control-flow]
Process discovery, Trace clustering, Cluster assignment, Decision point analysis*

[Activity]
Activity duration prediction*

[Resource]
Resource allocation*, Queue discipline discovery

*Organizational mining based feature selection method

[Predictive model annotated DFG-based simulation model]



서정우 & 박신념

Process Mining & Digital Twin

Simulation model generation framework

대기열 정책 발견 알고리즘(Queue Discipline Discovery)

[First In First Out]

$Arrival\ order(x)$ 1 2 3 4 5

$Execution\ order(x)$ 1 2 3 4 5

$r_{x,y} \approx 1$

Strongly positive correlated

[Last In First Out]

$Arrival\ order(x)$ 1 2 3 4 5

$Execution\ order(x)$ 5 4 3 2 1

$r_{x,y} \approx -1$

Strongly negative correlated

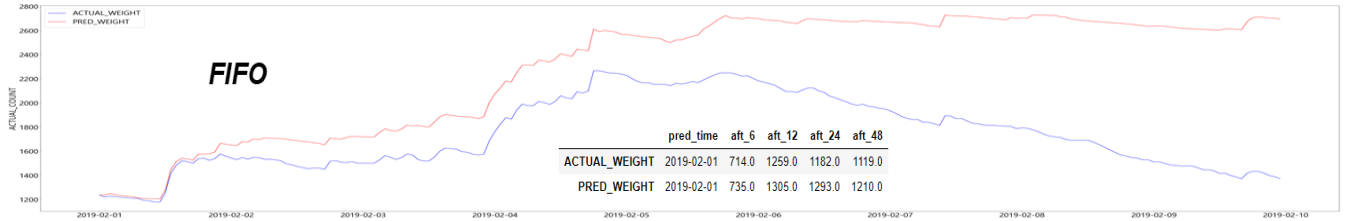
[Randomly]

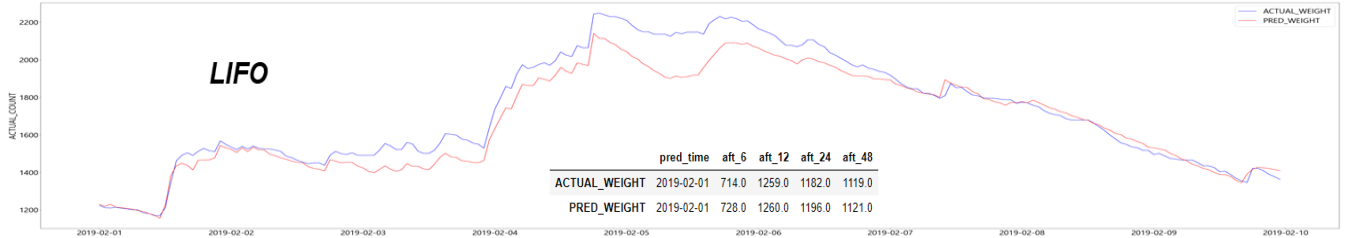
$Arrival\ order(x)$ 1 2 3 4 5

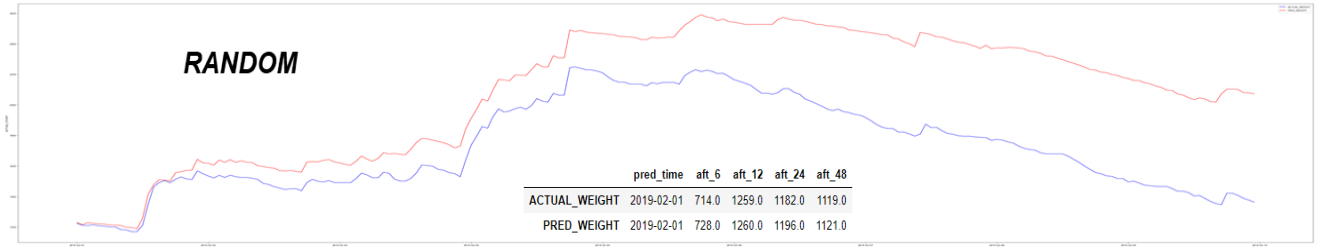
$Execution\ order(x)$ 2 4 1 5 3

$r_{x,y} \approx 0$

Uncorrelated



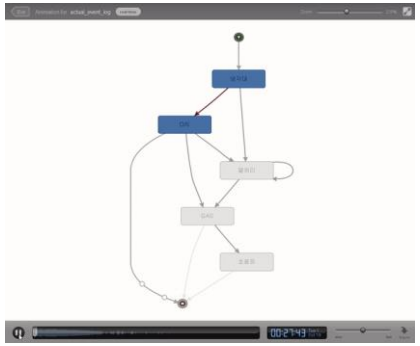


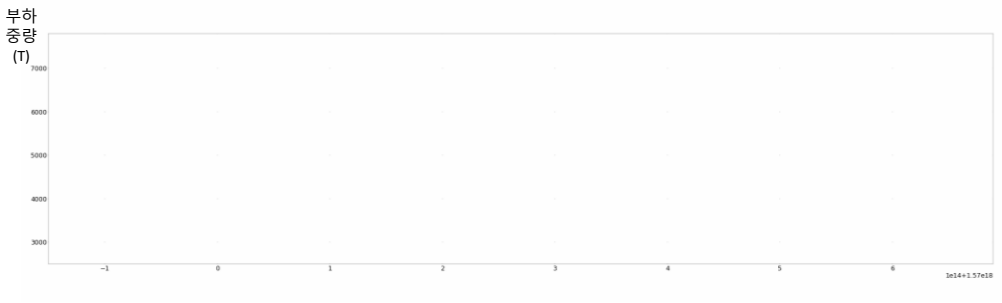


서정우 & 박신념

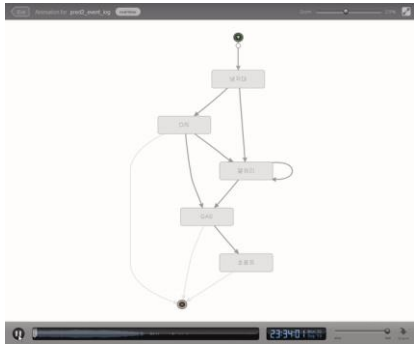
Process Mining & Digital Twin

실제로그

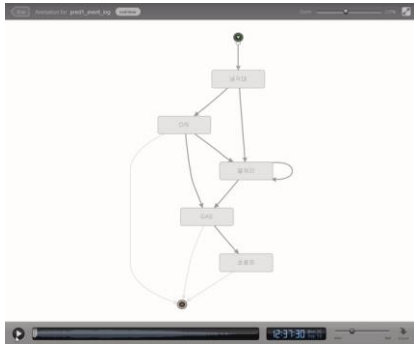




프로세스 마이닝
기반 예측
(초기 모델)

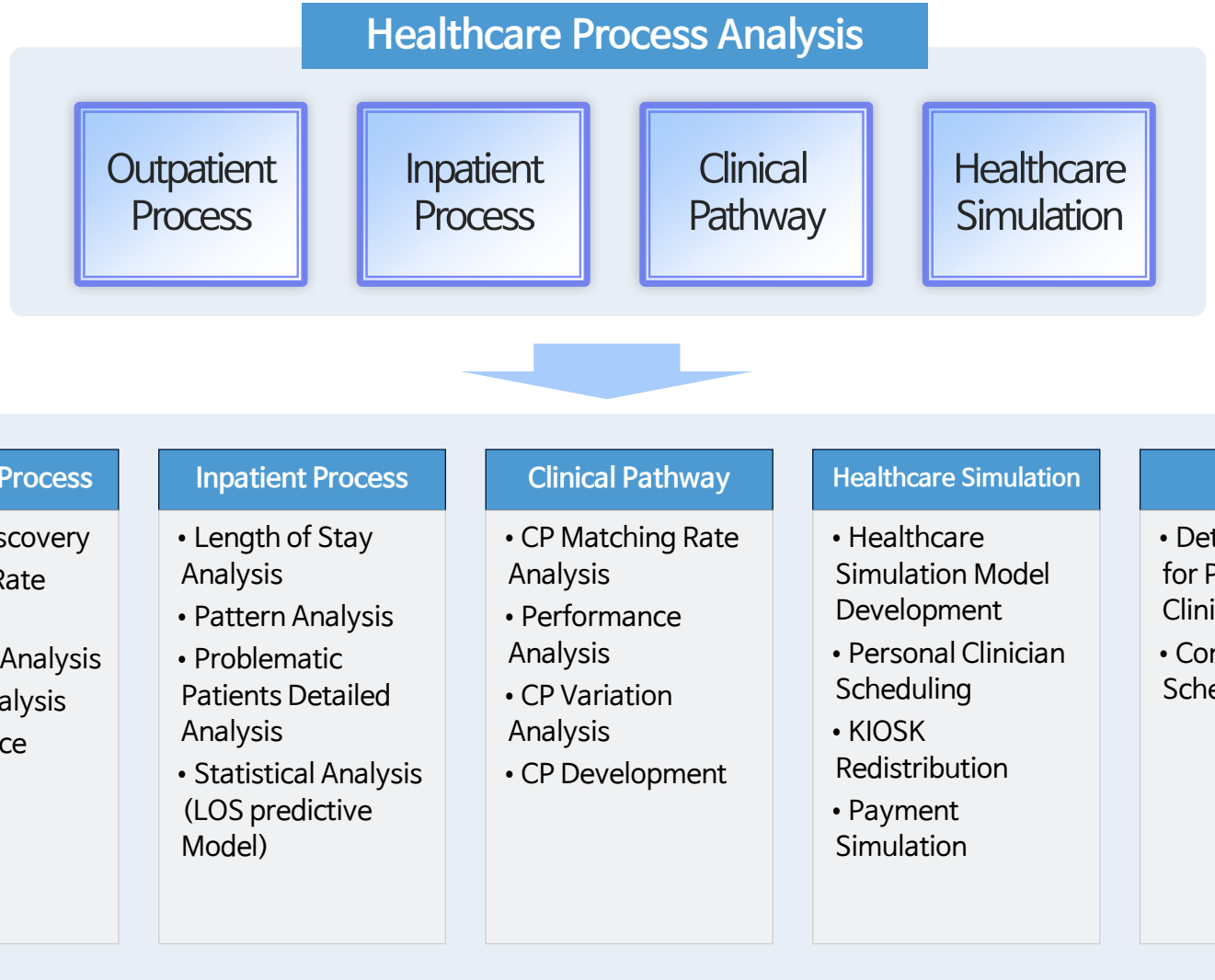


프로세스 마이닝
기반 예측
(개선된모델)



서정우 & 박신념

Healthcare Process Analysis



의료 프로세스 분석

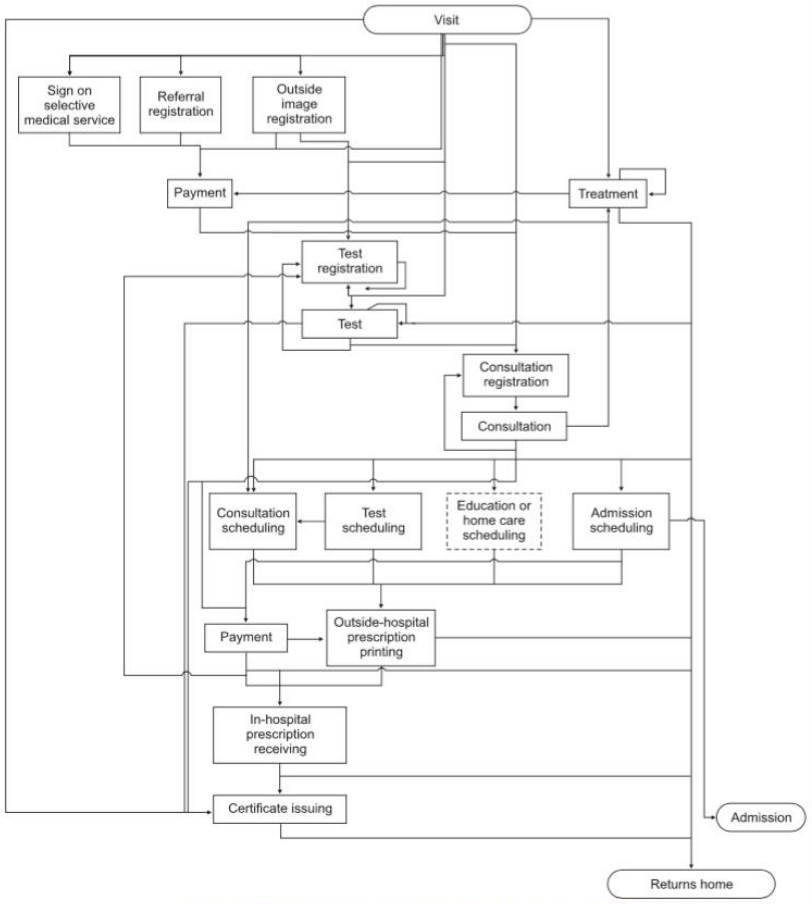
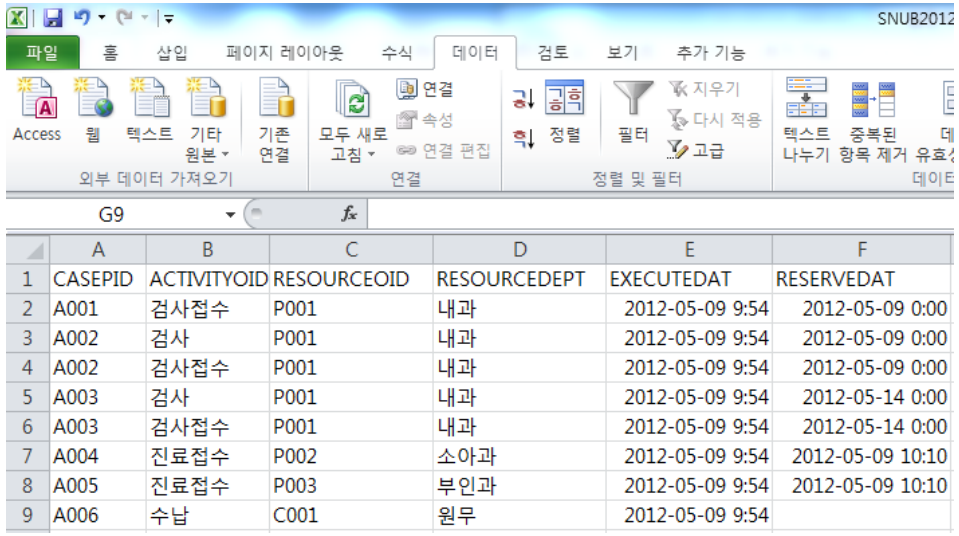


Figure 1. Outpatient care mega-process model derived from domain experts.



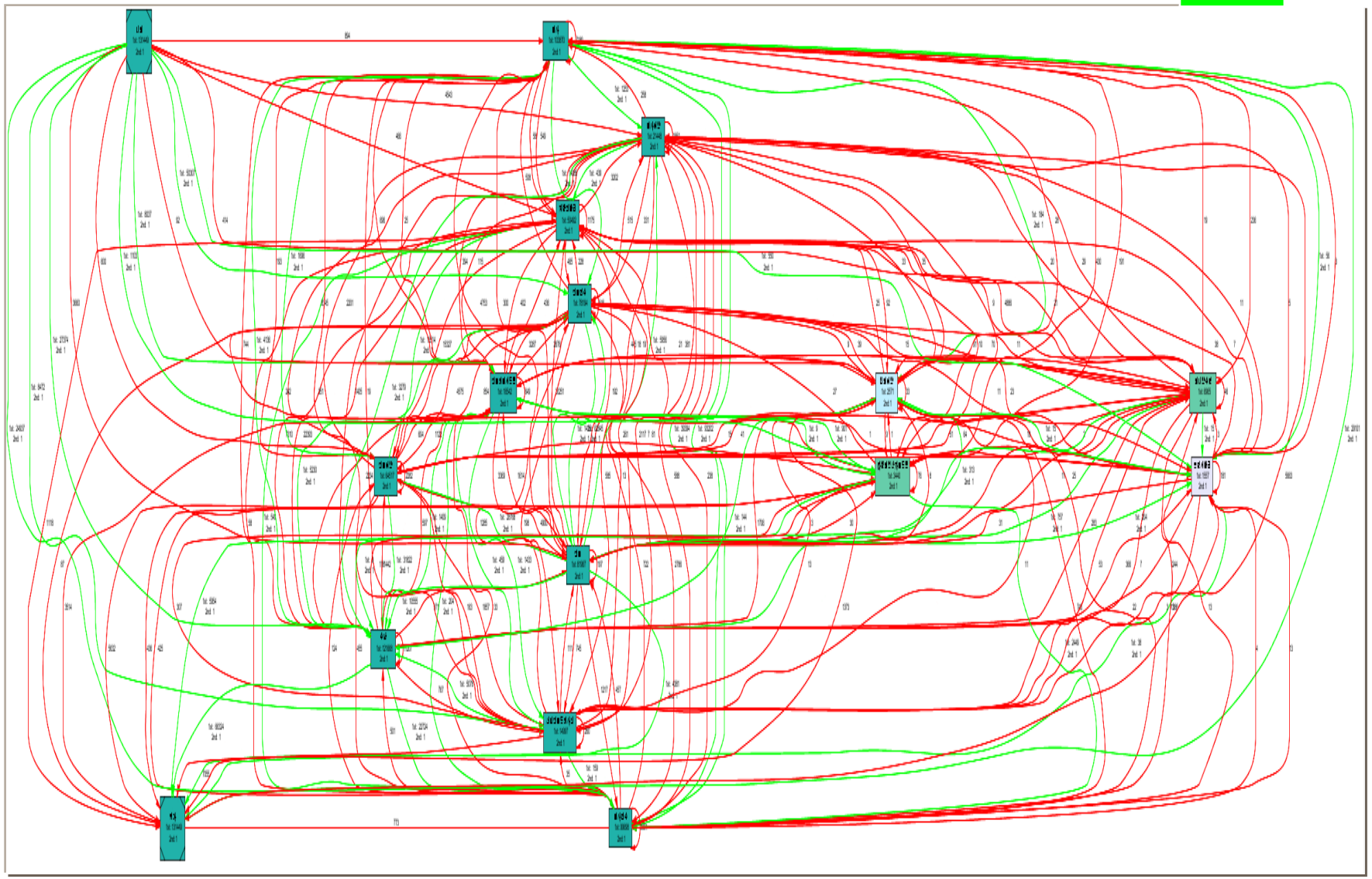
G9

	A	B	C	D	E	F
1	CASEPID	ACTIVITYOID	RESOURCEOID	RESOURCEDEPT	EXECUTEDAT	RESERVEDAT
2	A001	검사접수	P001	내과	2012-05-09 9:54	2012-05-09 0:00
3	A002	검사	P001	내과	2012-05-09 9:54	2012-05-09 0:00
4	A002	검사접수	P001	내과	2012-05-09 9:54	2012-05-09 0:00
5	A003	검사	P001	내과	2012-05-09 9:54	2012-05-14 0:00
6	A003	검사접수	P001	내과	2012-05-09 9:54	2012-05-14 0:00
7	A004	진료접수	P002	소아과	2012-05-09 9:54	2012-05-09 10:10
8	A005	진료접수	P003	부인과	2012-05-09 9:54	2012-05-09 10:10
9	A006	수납	C001	원무	2012-05-09 9:54	

Kim, E., Kim, S., Song, M., Kim, S., Yoo, D., Hwang, H., Yoo, S. “Discovery of outpatient care process of a tertiary university hospital using process mining.” Healthcare informatics research, Vol. 19, No. 1, pp. 42-49, 2013.

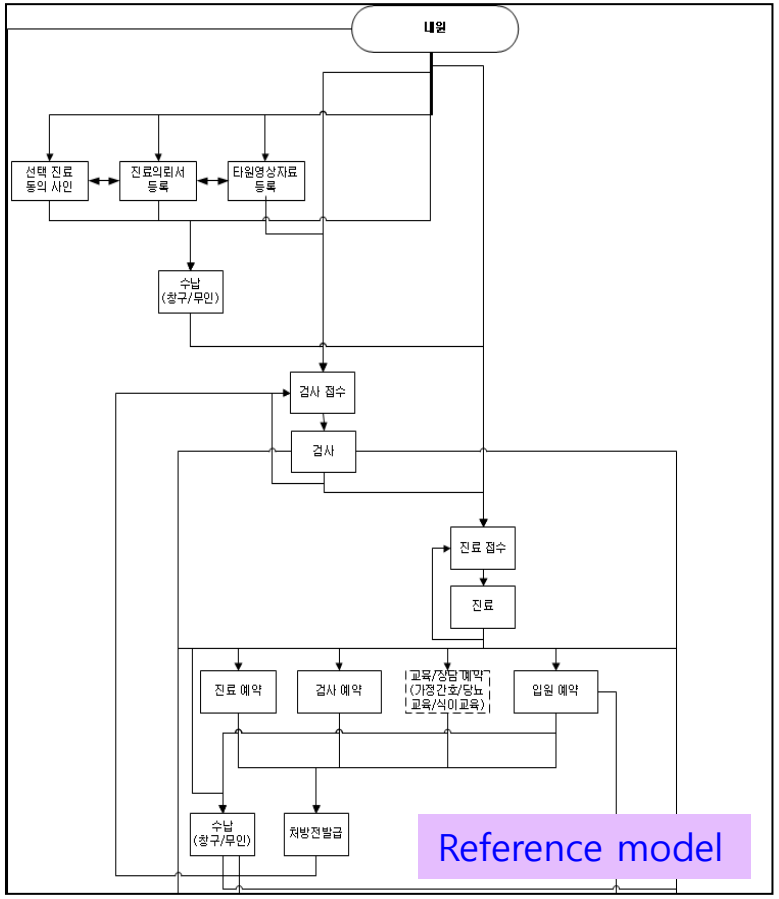
의료 프로세스 분석 – 모델 비교

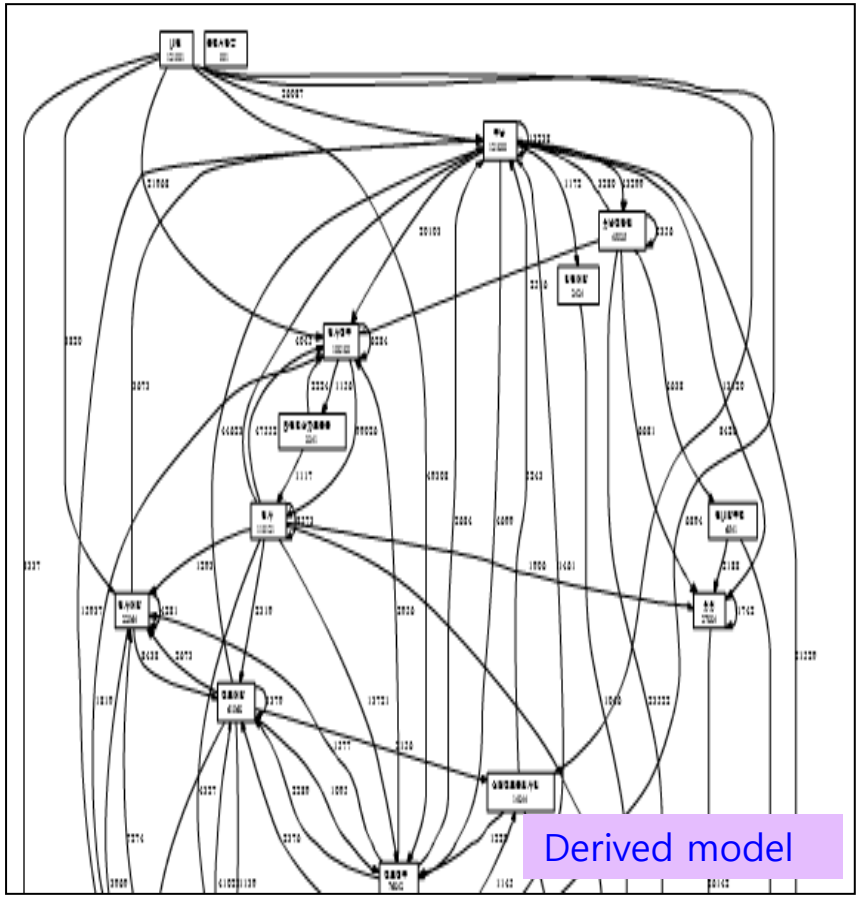
Original
Mined
Both



표준 의료 프로세스 정합도 측정

matching rate = 89.01%





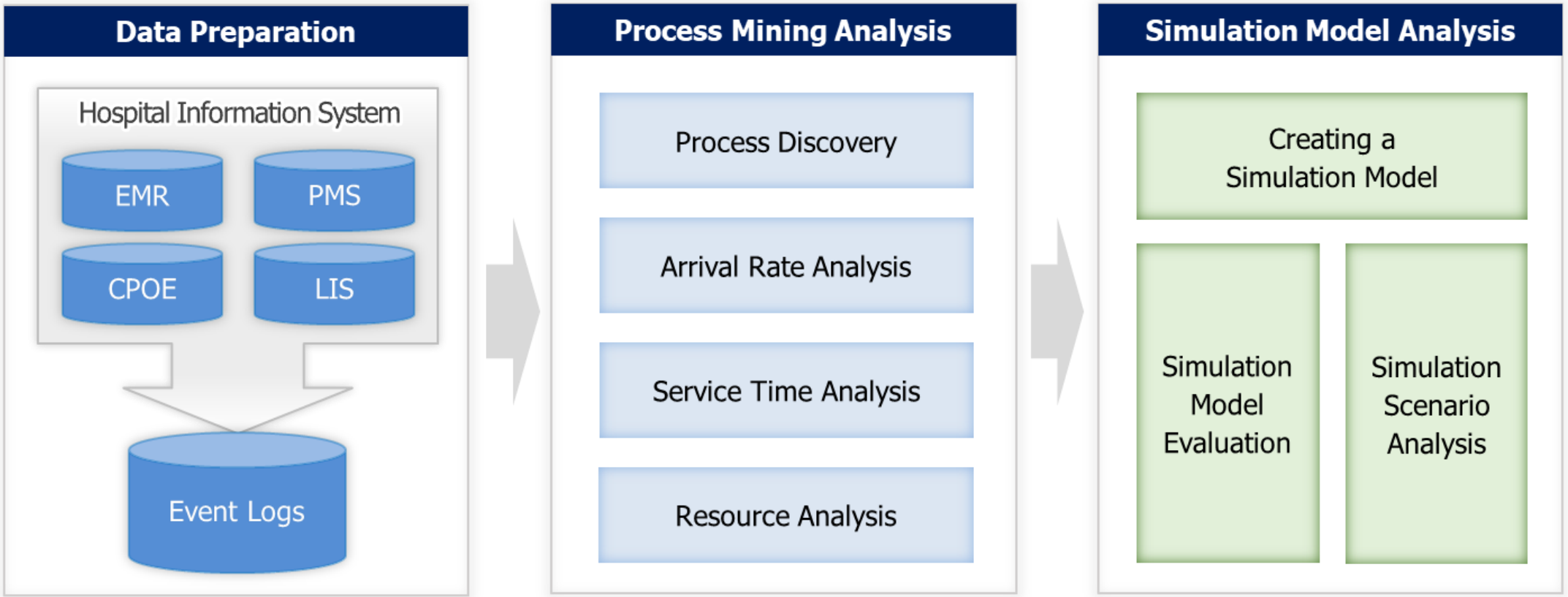
Cho, M., Song, M.*, Yoo, S. “A systematic methodology for outpatient process analysis based on process mining.” International Journal of Industrial Engineering, Vol. 22, No. 4, pp. 480–493, 2015.

미수납 패턴

	Performance Sequence Analysis	Frequency	Time (Min)
p0	**Consulting room assignments → Consultation**	**99**	**135**
p1	**Registration of an outside referral document → Registration of an outside referral document**	**16**	**38**
p2	**Consulting room assignments → Consultation → Issuance of prescription → Reservation for visit → Payment**	**16**	**71**
p3	**Preparation for test → Test → Payment → Test**	**13**	**679**
p4	**Consulting room assignments → Consultation → Payment**	**10**	**267**
p5	**Consultation → Consulting room assignments → Preparation for test → Test → Reservation for visit → Payment**	**10**	**63**
p6	**Consulting room assignments → Consultation → Reservation for visit → Payment**	**9**	**93**

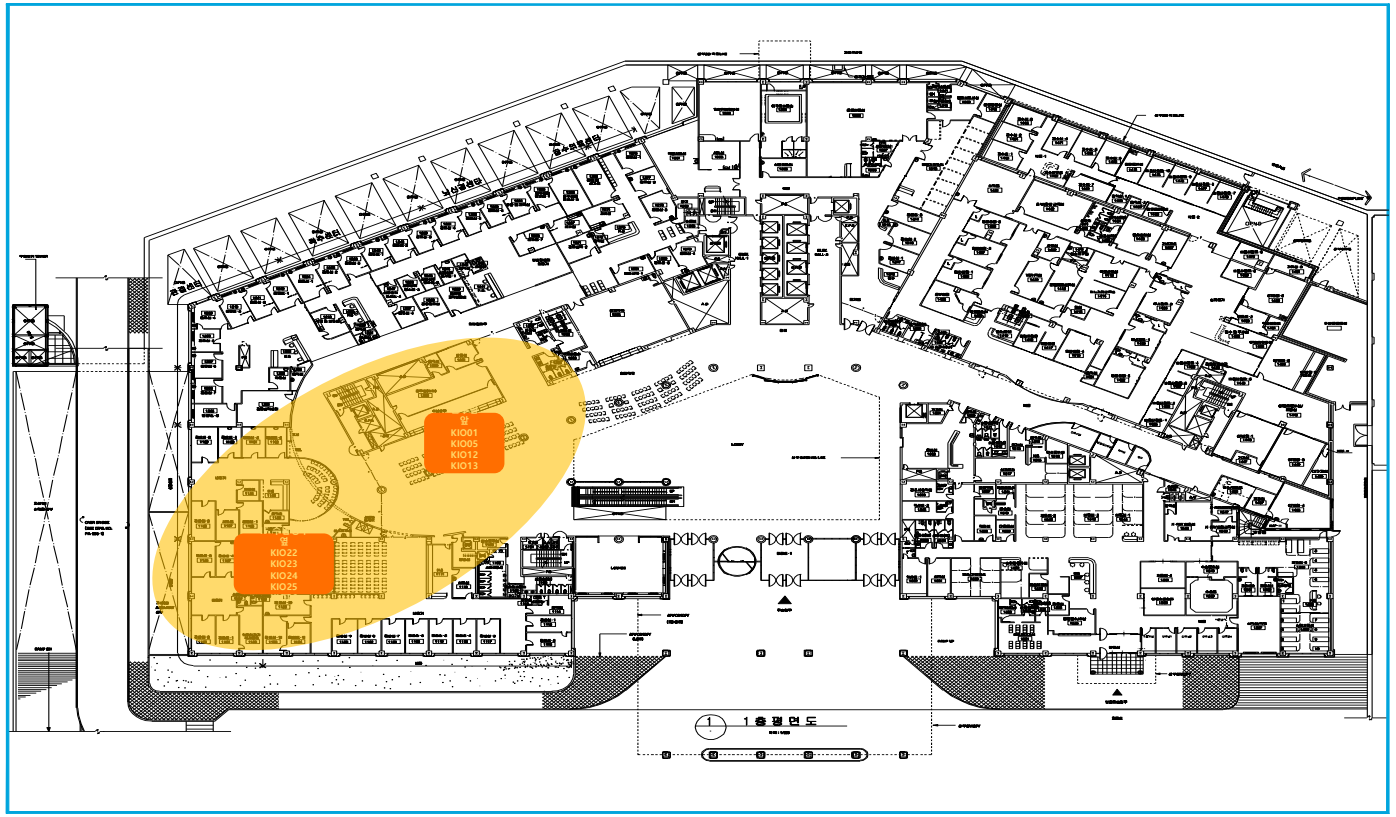
Healthcare Process Simulation:

Process Simulation Methodology



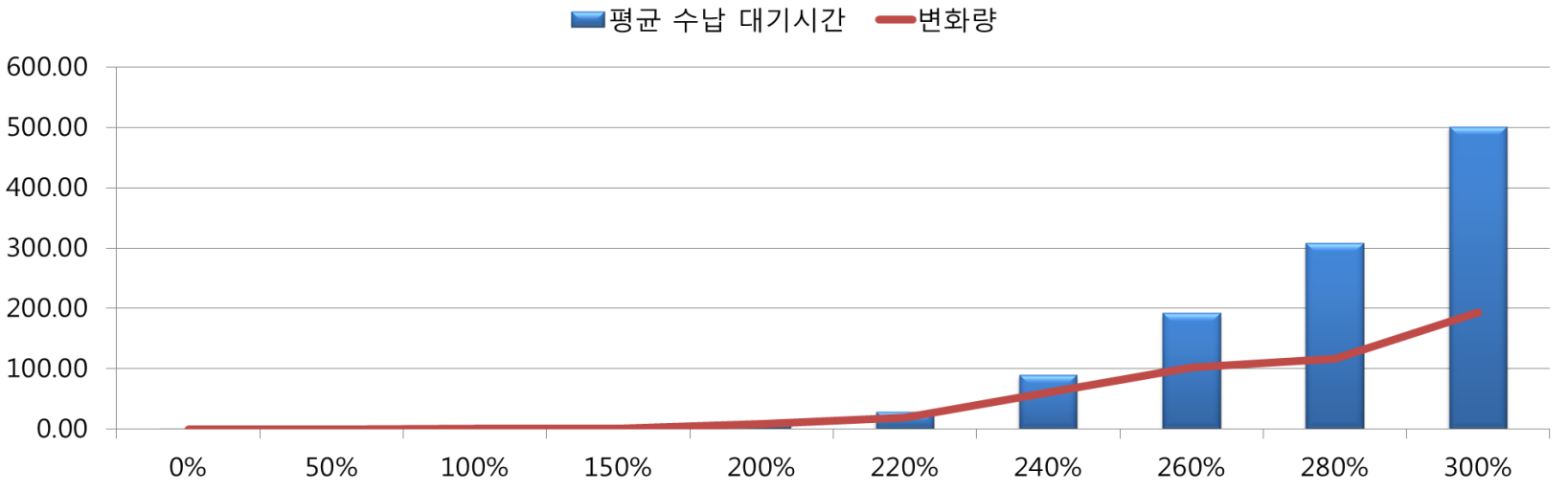
<Process Simulation Analysis Framework>

Simulation Analysis - KIOSK



Kim, E., Kimg, S., Cho, M., Song, M., Yoo, S. “Simulation of optimal number of outpatient payment KIOSK estimation using process mining.”, *Proceedings of the 2013 Korean Society of Medical Informatics Spring Conference,* Asan Hospital, Korea, June 13-14, 2013.

Simulation Analysis - KIOSK

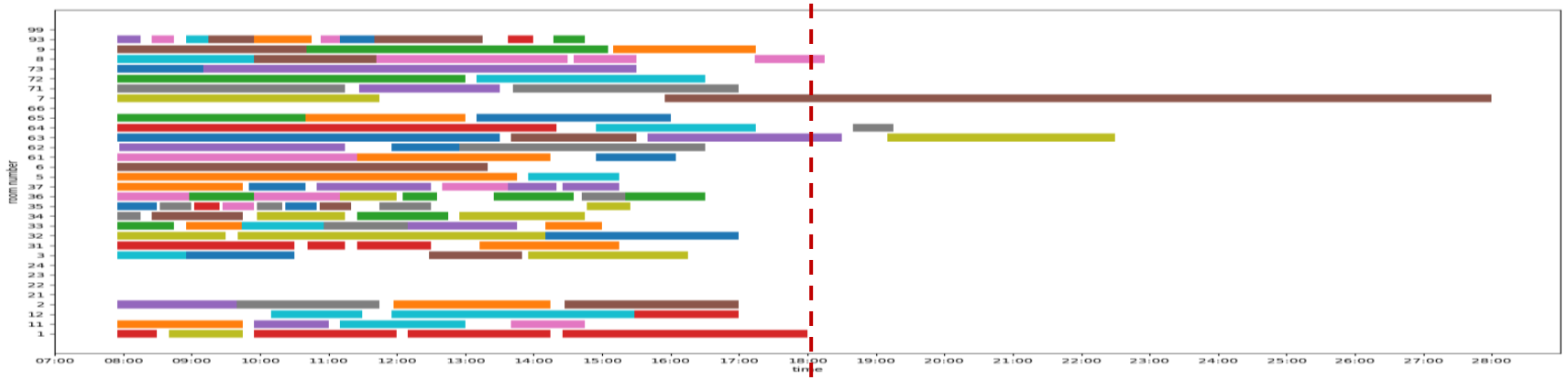


Increasing ratio	0%	50%	100%	150%	200%	**220%**	240%	260%	280%	300%
# payment	1265.7	1894.8	2529.3	3167.5	3801.4	**4030.1**	5293.4	4542.6	4801.7	5067.3
Total time	10.17	10.17	10.18	10.21	10.34	**10.57**	11.27	12.59	14.80	18.51
Waiting time (s)	0.00	0.03	0.24	1.46	9.40	**27.98**	89.01	191.70	307.89	500.61

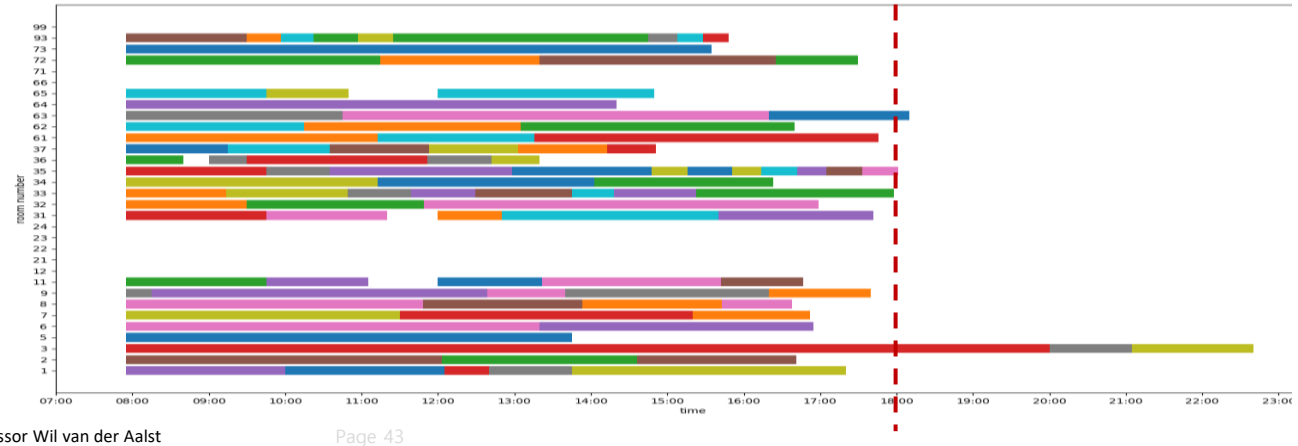
Kim, E., Kimg, S., Cho, M., Song, M., Yoo, S. “Simulation of optimal number of outpatient payment KIOSK estimation using process mining.”, *Proceedings of the 2013 Korean Society of Medical Informatics Spring Conference,* Asan Hospital, Korea, June 13-14, 2013.

Process Mining + Optimization + Scheduling

- 실제 수술실행 현황 (2018.11.13)
  - 26개의 수술실 109개 수술 할당, 오버타임 16시간 발생



- 스케줄러에서 계획한 수술일정 (2018.11.13) – **실제 수술에 걸린 시간으로 스케줄링**
  - 24개의 수술실 109개 수술 할당, 오버타임 5시간 46분 발생



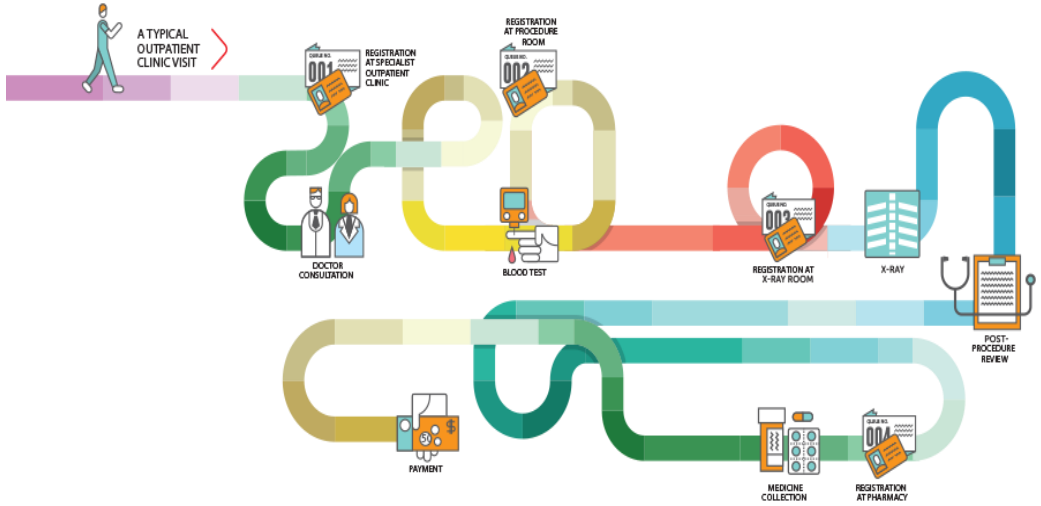
Using OPERA (OPERAting room optimizing scheduler)
By 김병인 교수 (logistics.postech.ac.kr)

Clinical Pathway

CP(Clinical Pathway): 질병에 따라 정해진 표준 진료 지침

CP의 목적

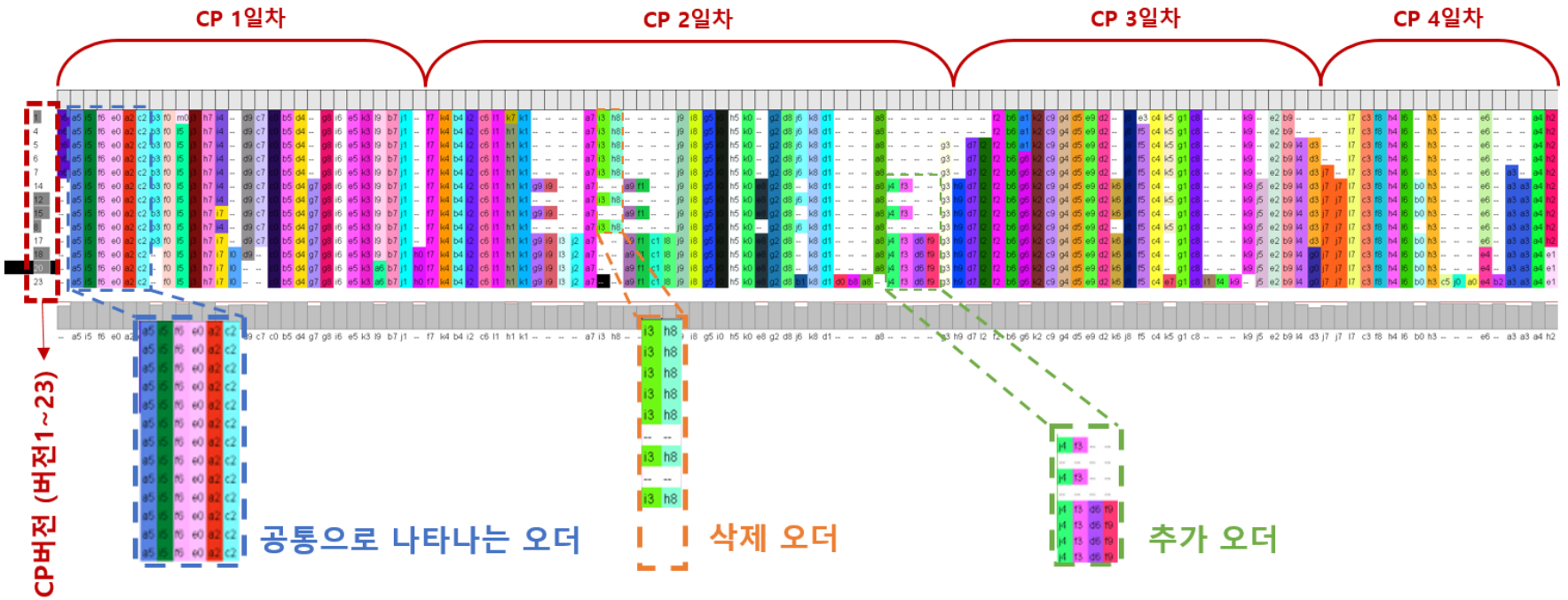
- 선진 지료 과정을 선택하여 일관적인 진료 시도
- 입원기간, 진단과정, 치료에 대한 표준을 설정
- 진료 과정 중에 가장 힘든 난관을 극복할 수 있는 방안 발견
- 모든 의료인에게 공통적인 진료계획을 제시, 자신의 역할 인지
- 의무기록 간소화
- 진료계획에 대한 교육을 통해 환자 만족



기존 CP 이해 및 평가 (Conformance) – Reference model 분석

CP Master 변화 분석

- Trace alignment
  - Trace들을 순서를 맞춰 최적으로 줄지어 배열하는 Process mining 기법
  - Trace들에서 공통으로 나타나는 이벤트와 차이가 나는 이벤트를 시각적으로 표현
- Trace alignment를 활용한 Reference model의 변화 시각화



Cho, M., Kim, K., Lim, J., Baek, H., Kim, S., Hwang, H., Song, M., Yoo, S., "Developing data-driven clinical pathways using electronic health records: The cases of total laparoscopic hysterectomy and rotator cuff tears." International Journal of Medical Informatics, Vol. 133, 104015, 2020.

기존 CP 이해 및 평가 (Conformance)
– Reference model vs. 환자 로그 비교

CP 활용도 평가: CP Master와 실제 환자의 오더 기록의 유사도 분석

- 정합률
  - Fitness 계산 기법을 활용한 지표로 CP Master와 실제 환자의 오더 기록의 유사도 수치화

$$\textbf{\textit{Matchrate}}\ (\text{정합률}) = \frac{1}{2}\left(1 - \frac{M_{CP}}{N_{CP}}\right) + \frac{1}{2}\left(1 - \frac{R_{Log}}{N_{Log}}\right)$$

- N_{CP} : 표준 CP에 포함되어 있는 오더 코드 수
- M_{CP} : 표준 CP에는 포함되어 있지만, 이벤트 로그에 나타나지 않는 오더 코드 수
- N_{Log} : 처방 데이터에 포함되어 있는 오더 코드 수
- R_{Log} : 처방 데이터에는 포함되어 있지만, 표준 CP에는 포함되어 있지 않은 오더 코드

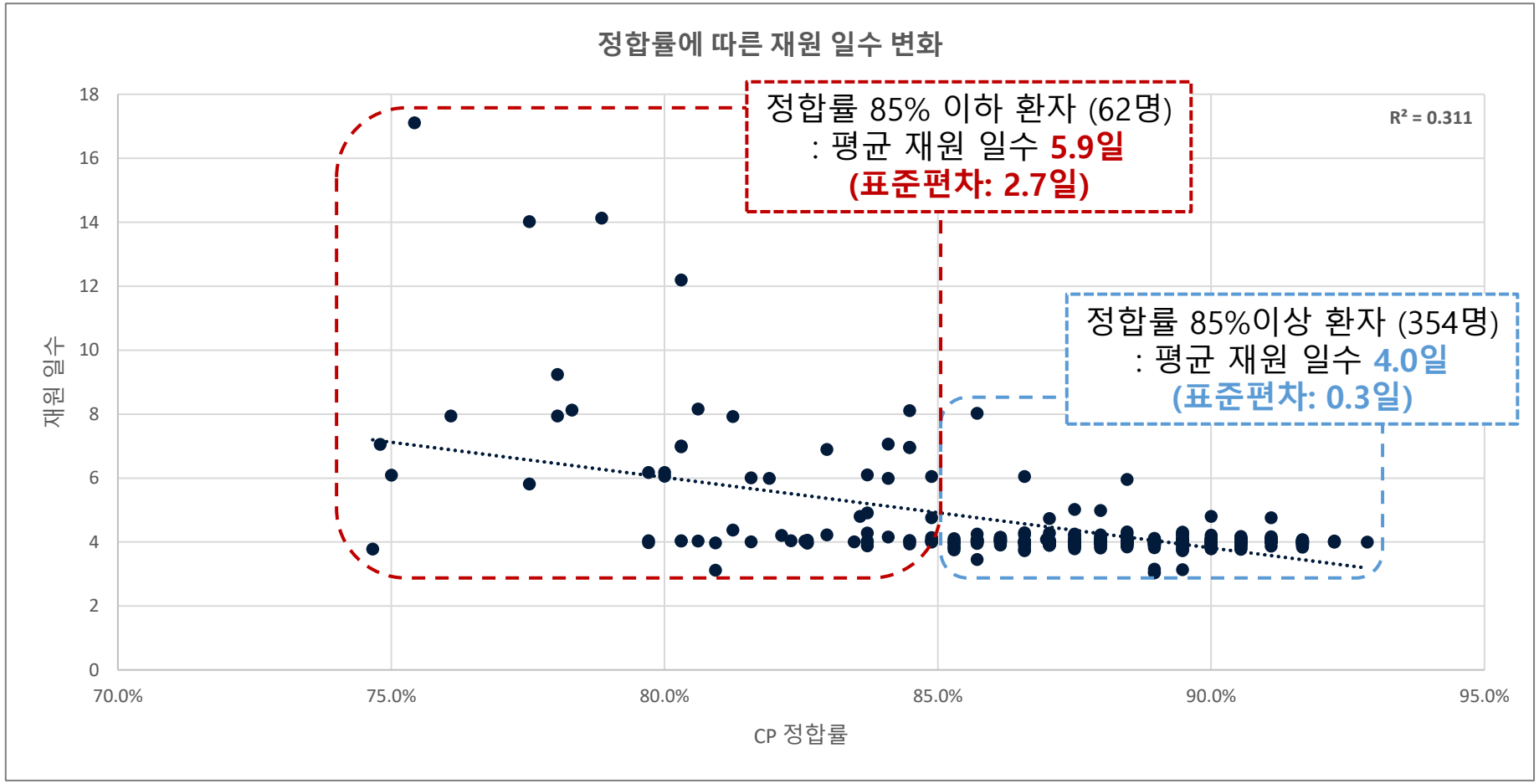
<표준 CP, 오더 로그의 매칭 예시>

CP와 로그에 모두 나타남 / CP에만 나타남 / 로그에만 나타남

작업	처치				검사			투약			식이					매칭결과				정합률
표준 CP	T1	T2	T3	–	Te1	Te2	Te3	M1	M2	M3	I1	I2	I3	–	–	N_{CP}	M_{CP}	N_{Log}	R_{Log}	
환자1	T1	T2	T3	–	Te1	Te2	Te3	M1	M2	M3	I1	I2	I3	–	–	12	0	12	0	1
환자2	T1	T2	T3	–	Te1	Te2	–	M1	M2	M3	I1	–	–	–	–	12	3	9	0	0.875
환자3	T1	T2	T3	T4	Te1	Te2	Te3	M1	M2	M3	I1	I2	I3	I4	I5	12	0	15	3	0.9
환자4	T1	–	T3	T4	Te1	Te2	–	M1	–	M3	I1	I2	–	I4	–	12	4	10	2	0.733

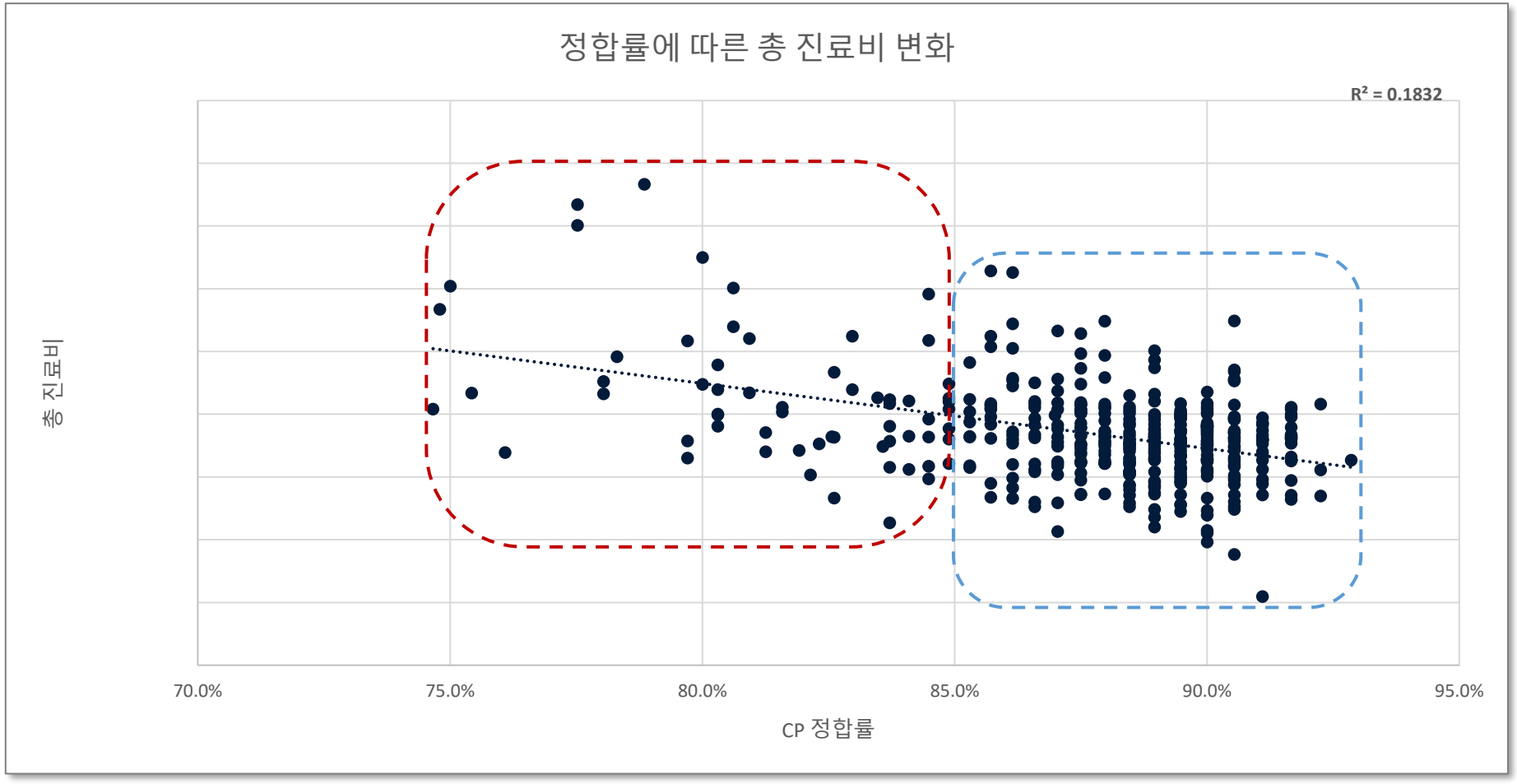
기존 CP 이해 및 평가 (Conformance)
– CP 효과 평가

CP와 재원일수의 연관성 분석



기존 CP 이해 및 평가 (Conformance)
– CP 효과 평가

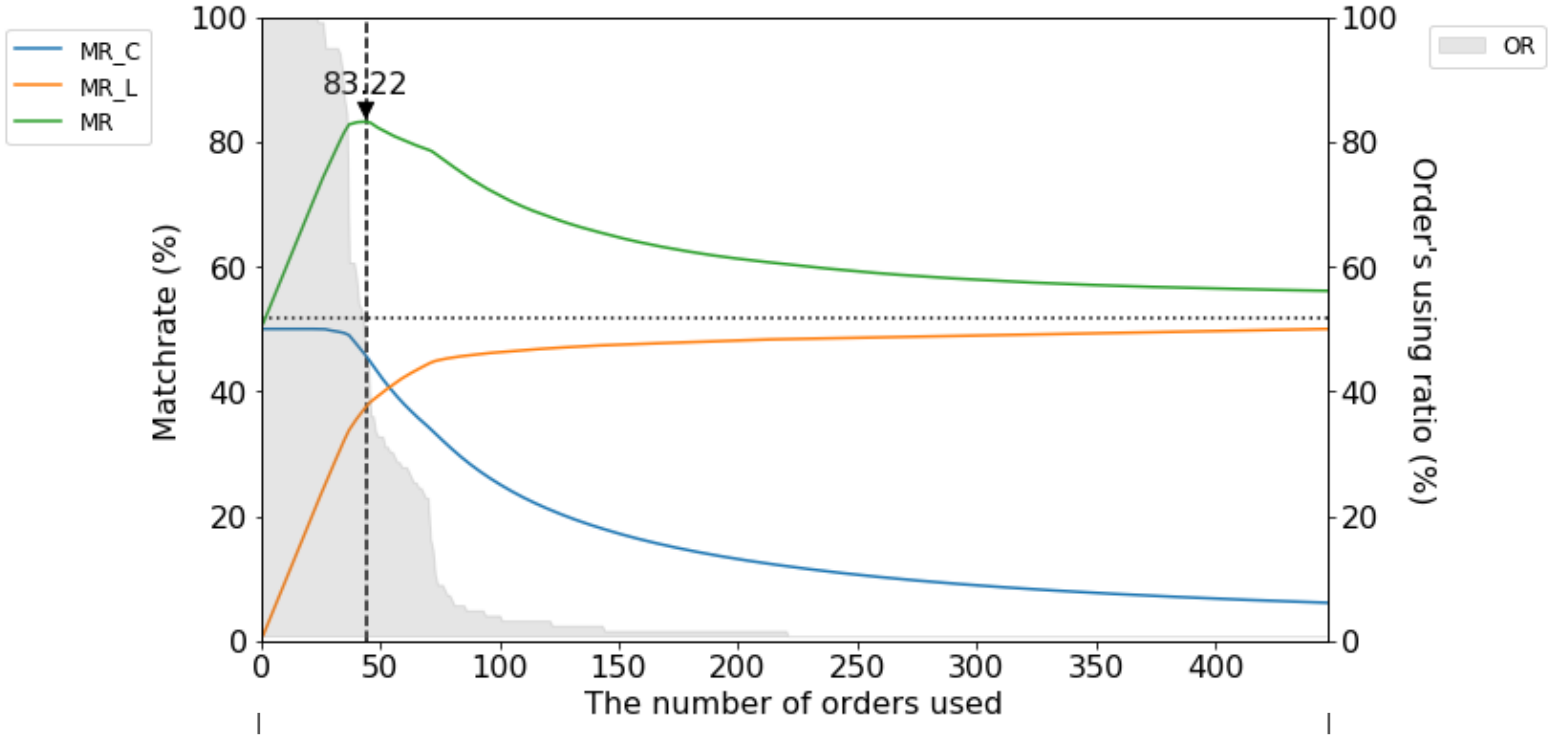
CP와 진료비의 연관성 분석



데이터 기반 CP 개발 (Discovery)
– 데이터 기반 CP 개발 방법론

오더 실적용률 & 정합률 기반 CP 개발

- 실적용률이 51.64% 이상인 오더들로 CP Master를 구성할 때 환자들의 오더 로그와 CP Master의 유사성이 가장 높음



실적용률이 가장 높은
오더만 CP Master에 포함

CP Master에 실적용률이 높은 오더 하나씩 추가

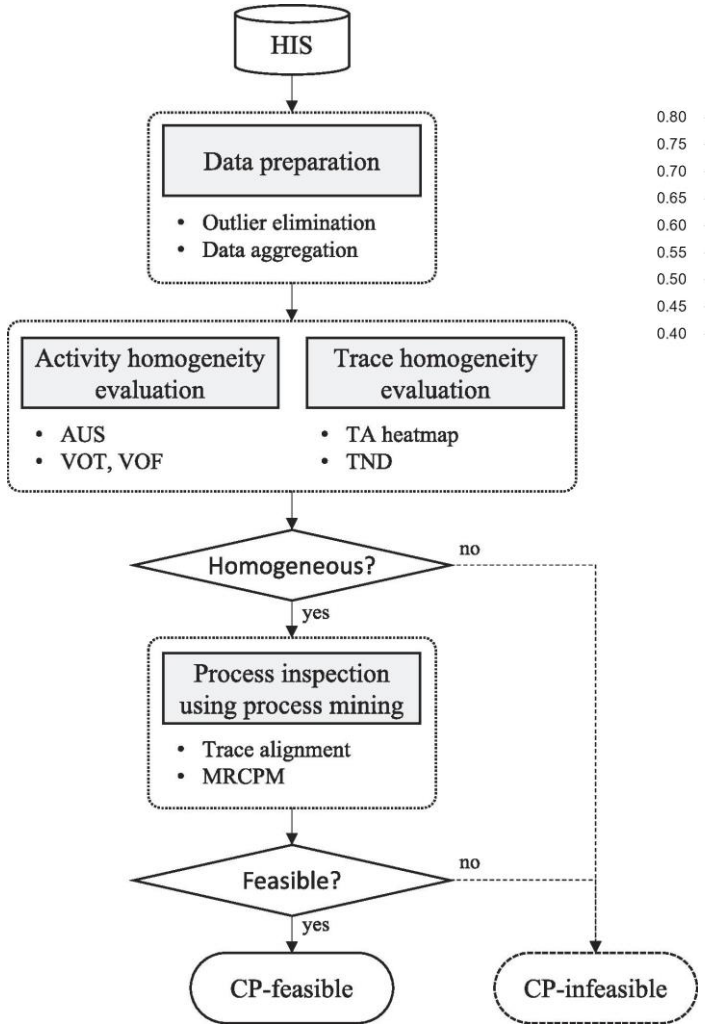
CP Master에
모든 오더 포함

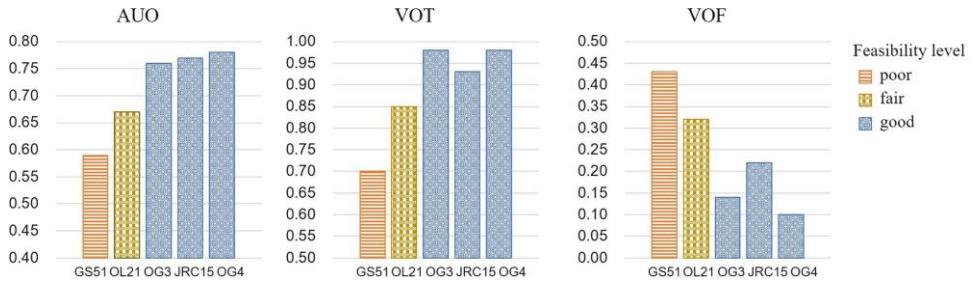
수술 1일 전		수술일		수술 1일 후		수술 2일 후		수술 3일 후	
Original	New	Original	New	Original	New	Original	New	Original	New
D11AX	D11AX	A02BA03	A02BA03	A02BA03	A02BA03	A02BA03	A02BA03	A04AA01	A04AA01
M01AH01	M01AH01	A04AA	A04AA	A04AA	A04AA	A04AA01	A04AA01	B05XA03	B05XA03
N01BB02	N01BB02	A04AA01	A04AA01	A04AA01	A04AA01	B05XA03	B05XA03	L2017	L2017
N02AA05	N02AA05	B05BB01	B05BB01	B05XA03	B05XA03	N02AA01	N02AA01	L3001	L3001
N02BE01	N02BE01	B05XA03	B05XA03	N02AA01	N02AA01	R05CB02	R05CB02	L3092	L3092
RG9045	RG9045	J01DB04	J01DB04	R05CB02	R05CB02	J01DB04	J01DB04	N02AA01	N02AA01
		N02AA01	N02AA01	J01DB04	J01DB04	L2017	L2017	L3046	L3046
		R05CB02	R05CB02	L2017	L2017	L2201	L2201		J01DB01
		B05BB02	B05BB02	L2201	L2201	A02BX		RG6061R_pre	RG6061R
		M01AH01		A02BX		L3001		RG6062R_pre	RG6062R
		N02AB03		D03AX		L3046		RG6063R_pre	RG6063R
		N02AX02		L3001		L3092		A02BX	A02BX
		B05XA03_pre		L3046		M01AH01		M01AH01	
				L3092		N02AB03		M03BX	
				M01AH01		N02AX02		N02AX02	
				N02AB03		N02AX52		N02AX52	
				N02AX02		RG6061L_pre		RG6061L_pre	
				N02AX52		RG6061R_pre		RG6062L_pre	
				RG6061L_pre		RG6062L_pre		RG6063L_pre	
				RG6061R_pre		RG6062R_pre		A02BA02_pre	
				RG6062L_pre		RG6063L_pre			
				RG6062R_pre		RG6063R_pre			
				RG6063L_pre					
				RG6063R_pre					

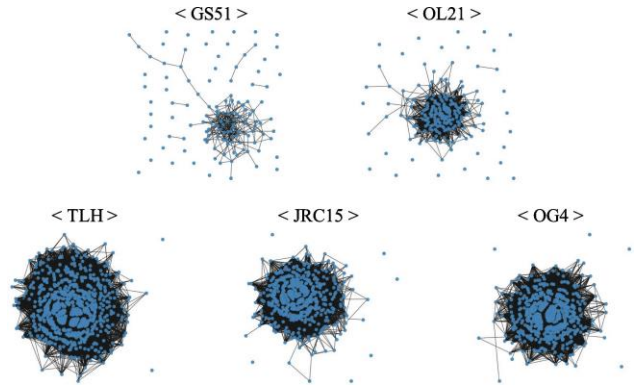
Original & New CP Master의 공통 오더
CP Master에 포함될 필요가 없는 오더
기존 CP Master에서 제거되어야 할 오더
기존 CP Master에 추가되어야 할 오더

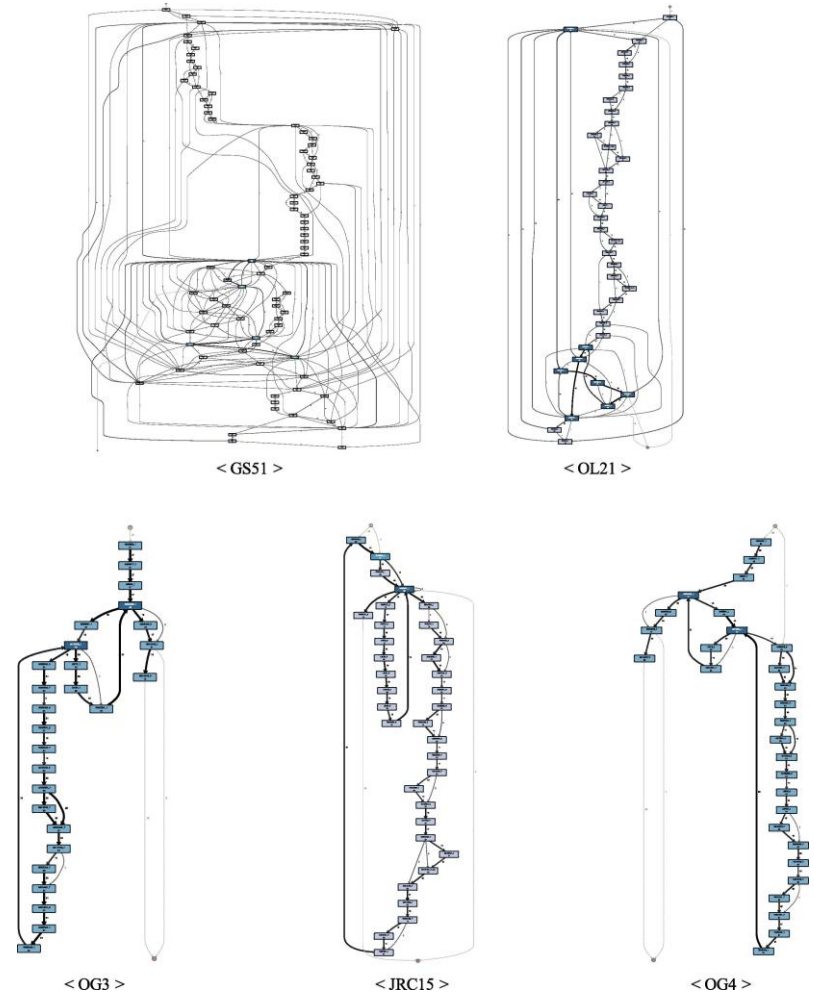
데이터 기반 CP 개발 (Discovery)

– 표준화 가능성 평가



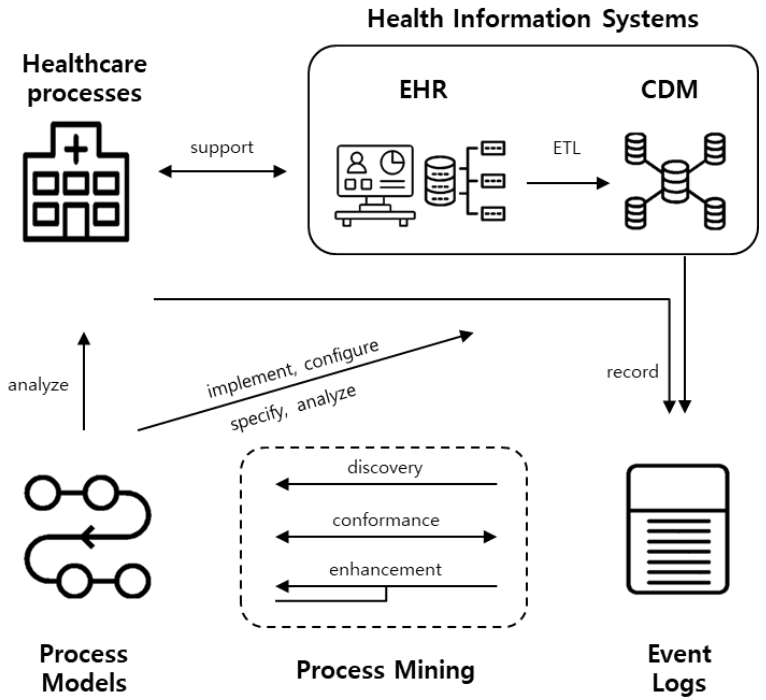


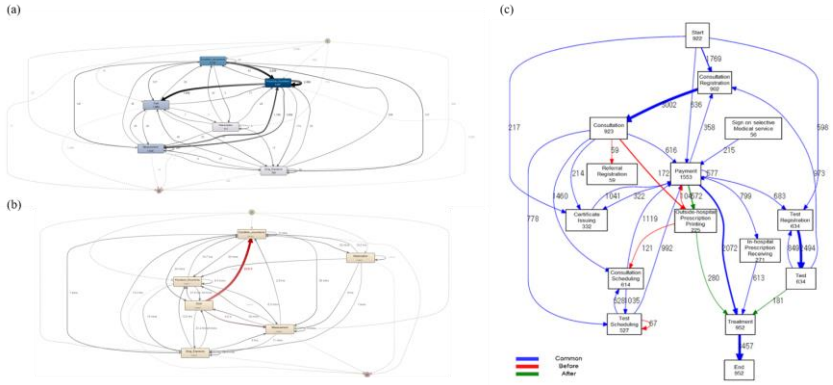




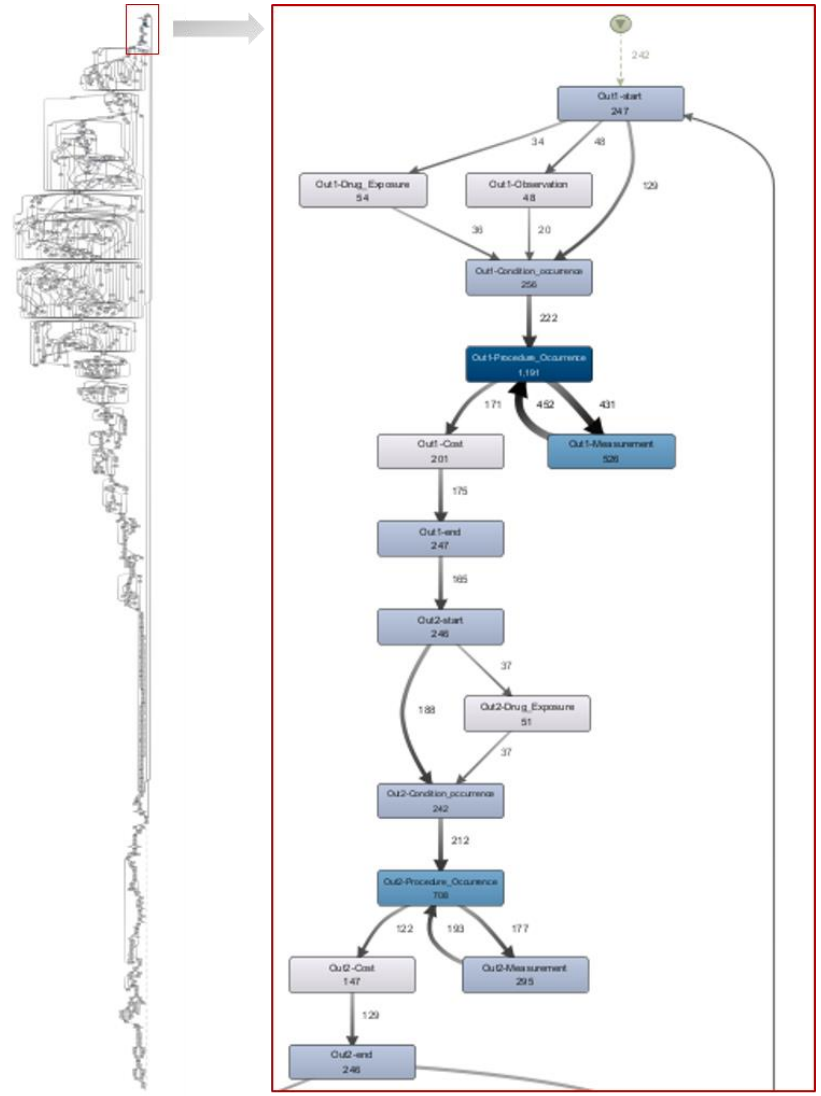
Lim, J., Kim, K., Song, M., Yoo, S., Baek, H., Kim, S., Park, S., Jeong, W., "Assessment of the feasibility of developing a clinical pathway using a clinical order log", Journal of Biomedical Informatics, Vol. 128, 104038, 2022.

OMOP CDM + Process Mining





Outpatient Process Analysis



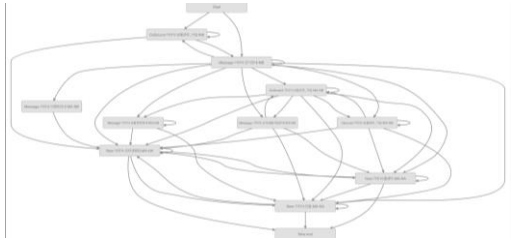
Patient journey

박강아 & 조민수

Finance Case: CJ Analysis

Cases	Logs
1	(A,John),(B,Sue),(C,John),(D,Carol)
2	(A,John),(C,Mike),(B,John),(D,Sue)
3	(A,Carol),(E,Mike),(D,Sue)
4	(A,Pete),(C,Carol),(B,Clare) (D,Pete)
5	(A,John),(E,Carol),(D,Clare)

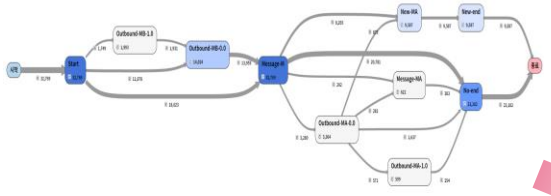
Process Mining



AS-IS CJ

ML (prediction)

Who? When?



How? (MSG)

Text Analysis

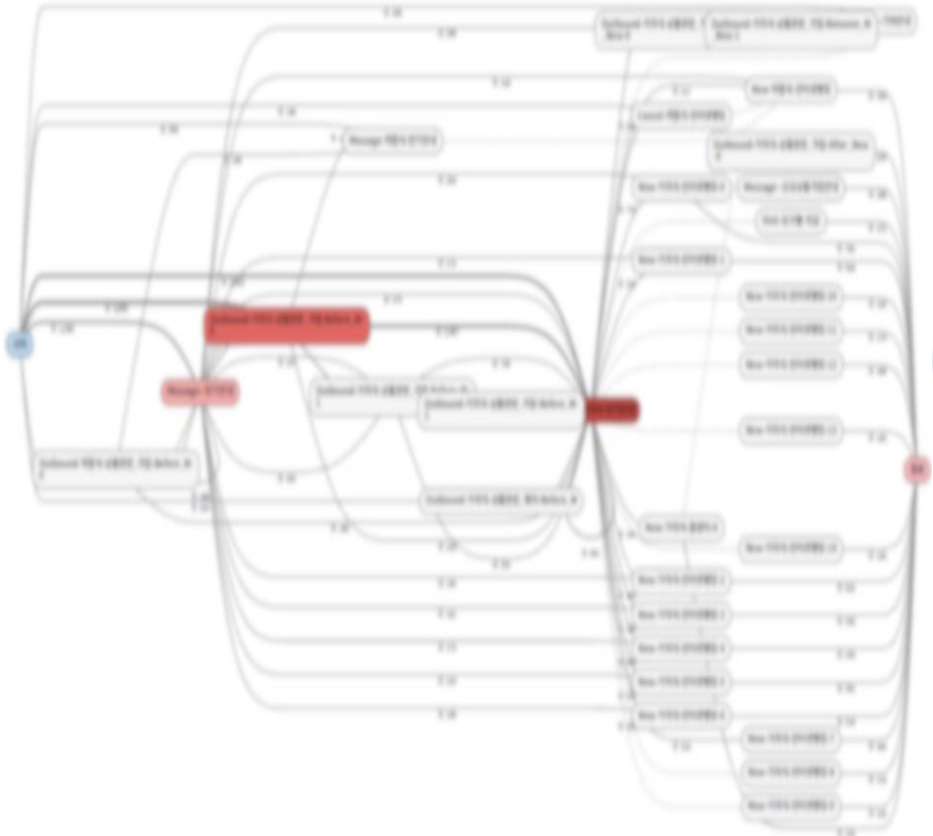
TO-BE CJ

박강아, 장윤희, 정승민 & 조민수

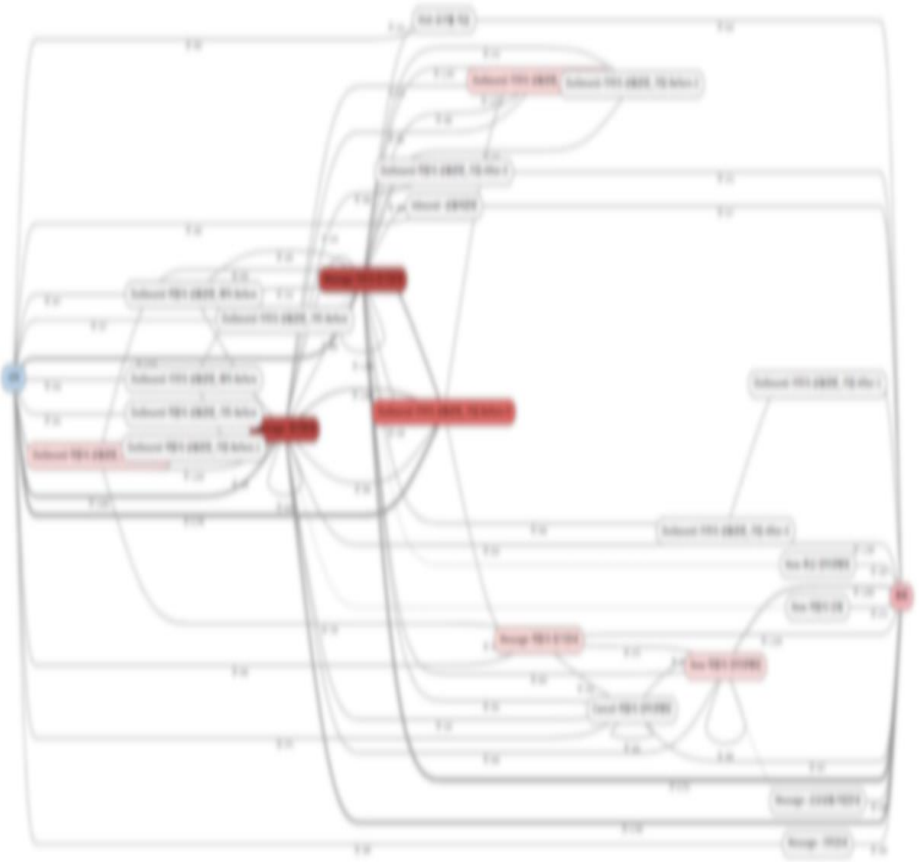
As-is CJ 도출

가입과 미가입 케이스의 CJ가 다름을 확인

가입 Process

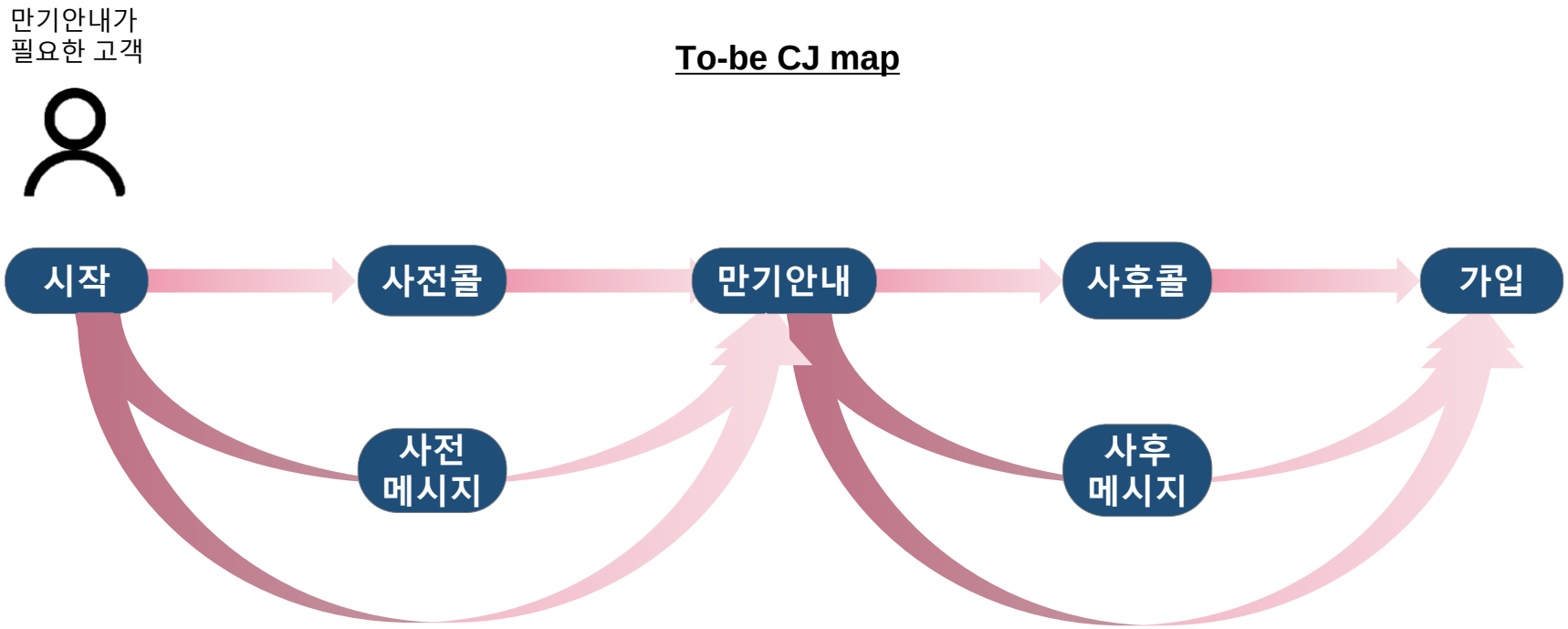


미가입 Process



To-be CJ 도출

만기안내 전 사전콜/사전메시지, 만기안내 후 사후콜/사후메시지



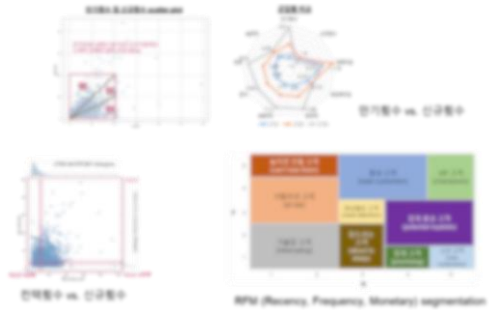
누구에게 **언제** 사전콜/사후콜을 해야 하는가? ➔ **AI 예측**
사전/사후 **메시지의 내용**은 무엇인가? ➔ **Text Analysis**

AI 기반 예측 모델링: Who? When?

EDA (Exploratory Data Analysis)

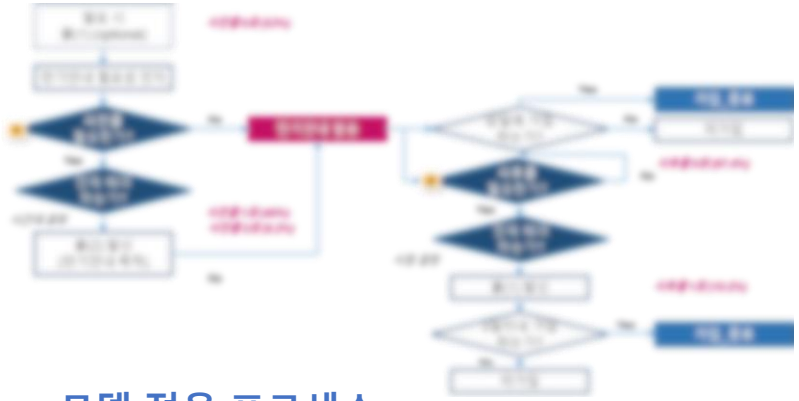
Who? 콜 효과가 큰 profile

When? 콜 시간대

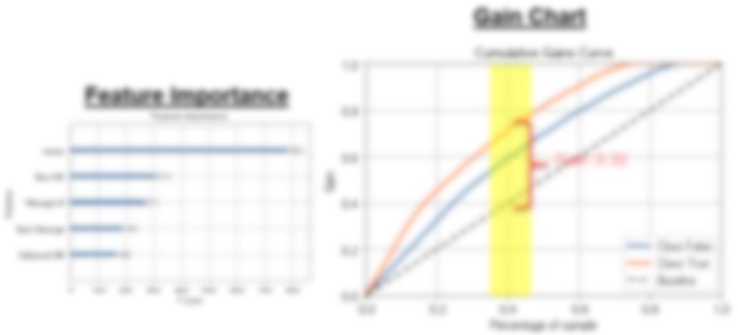


다양한 고객 군집 정보 활용

AI 기반 예측 모델링



모델 적용 프로세스



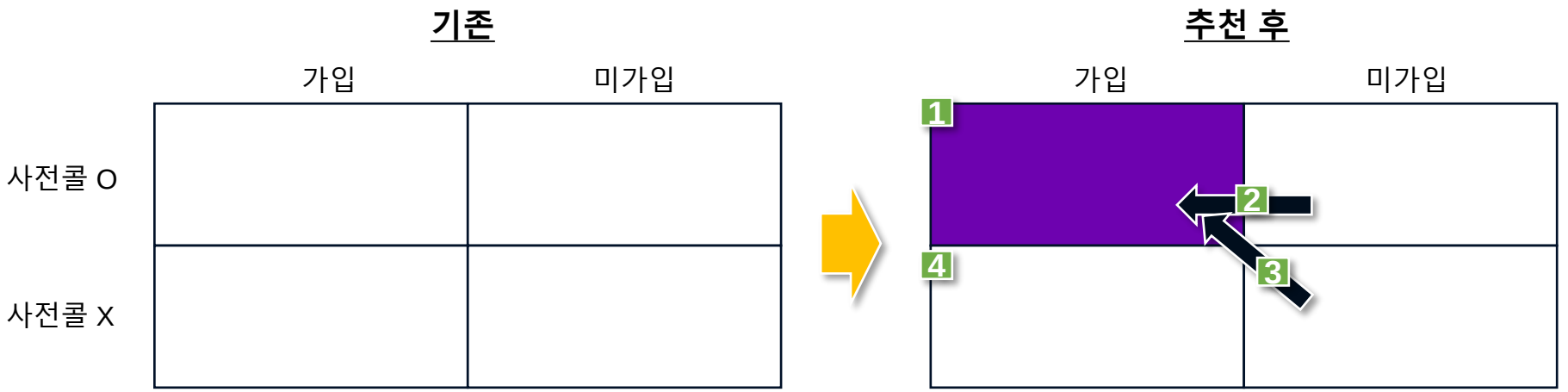
XGboost 기반 모델링

AI 기반 예측 모델링: 기대 효과

가입률 증가: 2배

사전콜 수행비중 증가: 2배

최빈시간대 변경: 월요일 ➔ 금요일



1. **사전콜 O → O, 가입 유지**: 가입확률을 더 높이는 시간대 추천
2. **사전콜 O → O, 미가입 → 가입**: 가입확률을 높이는 시간대로 변경 추천
3. **사전콜 X → O, 미가입 → 가입**: 콜 수행 추천, 시간대는 새로 추천
4. **사전콜 X → X, 가입 → 가입**: no action (현상유지)

우수 직원 vs. 일반 직원

신규 실적이 많은 직원은 고객 向, 일반 직원은 은행 向 키워드가 많은 경향

Conclusion: Process Management

- **Process Discovery: PM (discovery)**
- **Process Monitoring:**

  PM (discovery + conformance checking) + Real Time/Big DATA
- **Process Prediction: PM + ML + AI**
- **Process Optimization: PM + OR**
- **Process Improvement: PM + AI + SIMULATION**

Conclusion: Digital Twin

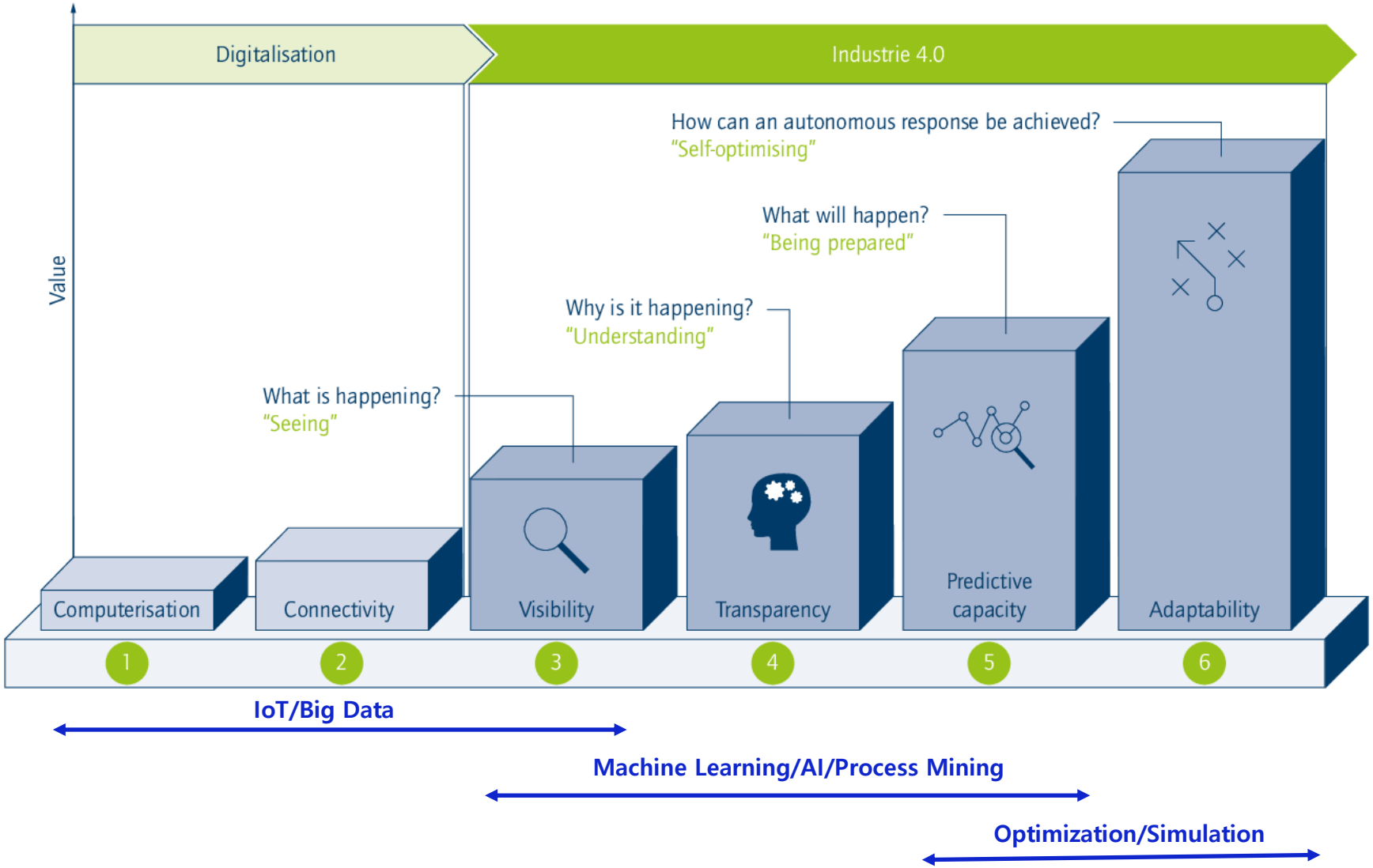
Data Driven Rapid Model Generation

- Process Model* Discovery: PM
- Rules/Prediction Model Discovery: PM + ML + AI

DT Monitoring & Improvement

- Process Monitoring: PM (Discovery + Conformance)
- Process Optimization: PM + OR
- Process Improvement: PM + AI + SIMULATION

Conclusion: Stages in the Industrie 4.0 development path



출처: Acatech, Industrie Maturity Index (2017)

원저: FIR e. V. at RWTH Aachen University

Agenda

Keynote

Prof. van der Aalst: Object-Centric Process Mining: Moving from 2D to 3D process analytics

제조

삼성전자: 반도체 FAB 공정의 프로세스 마이닝 적용 사례
LG CNS: 제조업에서의 프로세스 마이닝을 통한 제조 업무 프로세스 혁신 및 개선 모델 탐색
KAI/IMP: Digital 시대의 경영, Data를 활용하여 기업행동을 재설계하라

서비스

신한은행: 프로세스 마이닝 기법을 활용한 고객 경험 개선 사례
한림대학교 성심병원: 병원은 왜 프로세스 마이닝을 필요로 하는가?
SK텔레콤: 고객접점 MOT로부터의 프로세스 및 IT자원 최적화

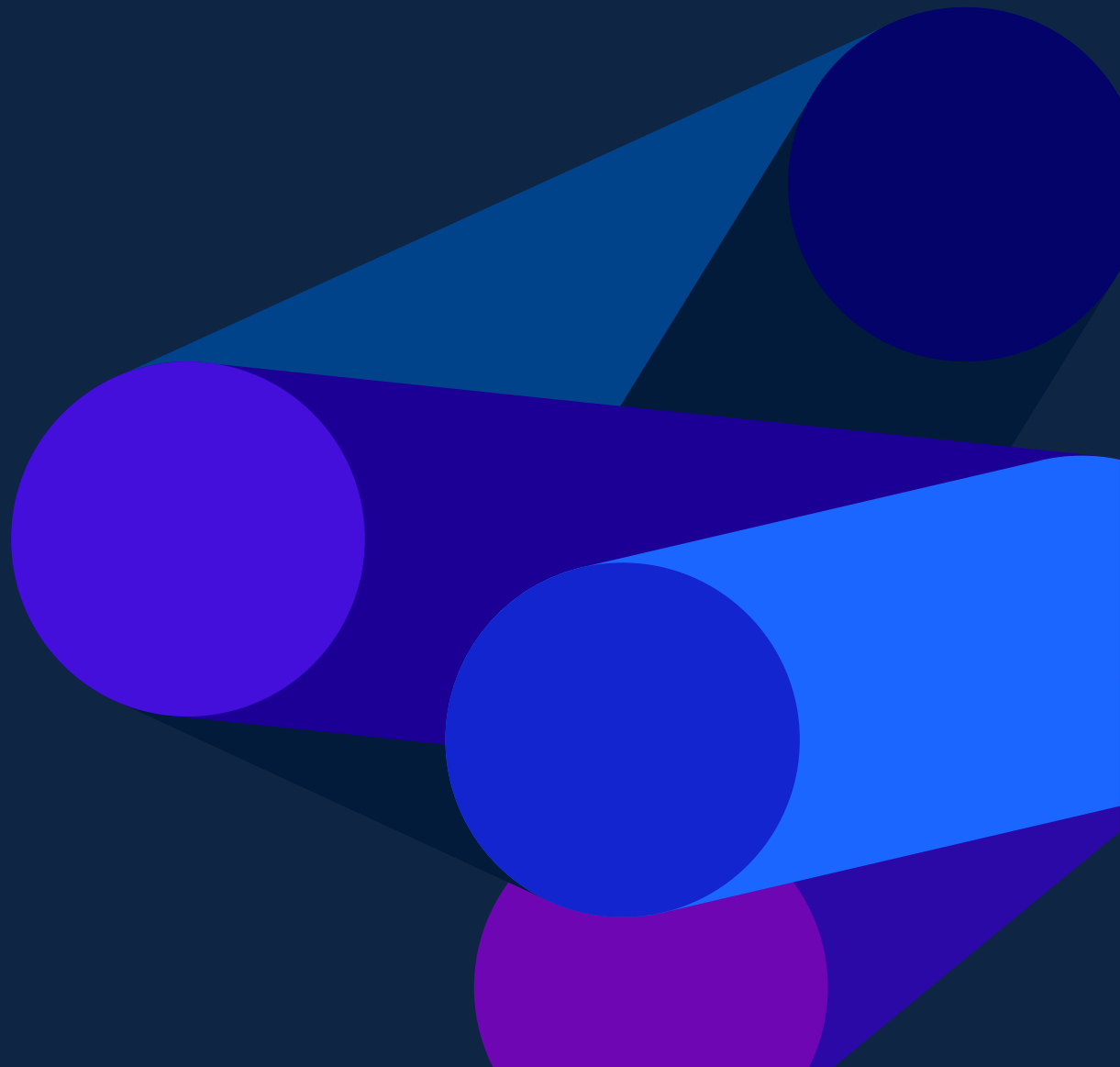
솔루션

퍼즐데이터:프로세스 마이닝으로 하는 모니터링, 분석, 최적화, 검증! 프로세스 인텔리전스 플랫폼

Thank you

프로세스 마이닝 창시자 윌 반 데르 알스트(Wil van der Aalst) 교수 초청

'프로세스 마이닝 워크샵'



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