Industrial AI:
concept and its applications

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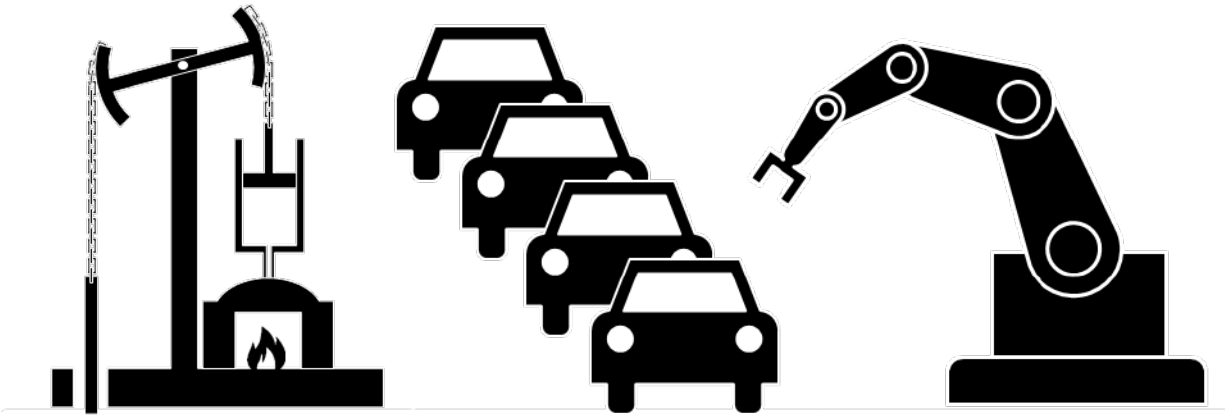
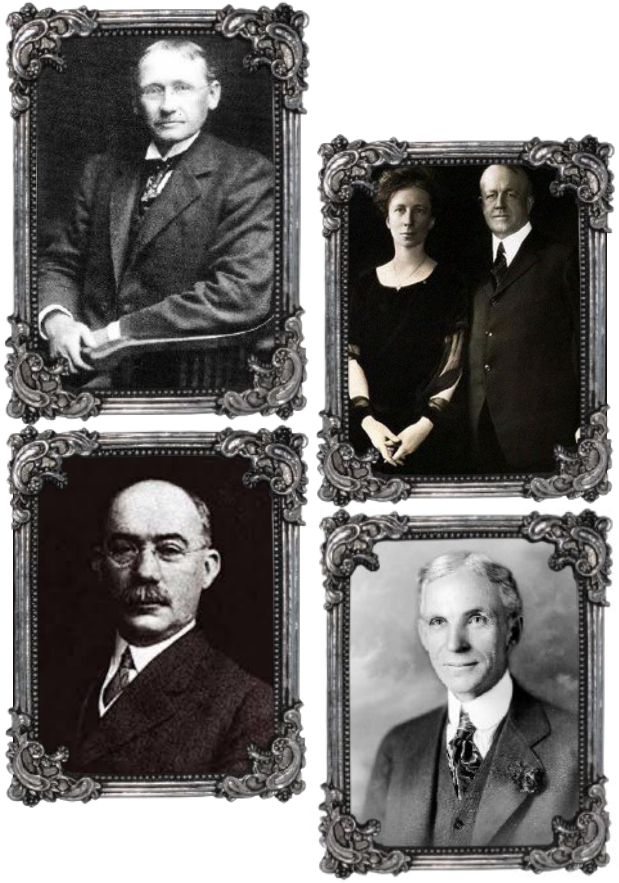
산업경영공학의 역사: '산업 혁명'



1st	2nd	3rd
Mechanization, water power, steam power	Mass production, assembly line, electricity	Computer and automation
End of 18th Century	Beginning of 20th Century	1970's ~ 20th Century

Pioneers of IME



Source: Google Images

Time Study & ‘Taylorism’

Frederick Taylor
(1856-1915)

Tabor Company

Image Source: Google Images

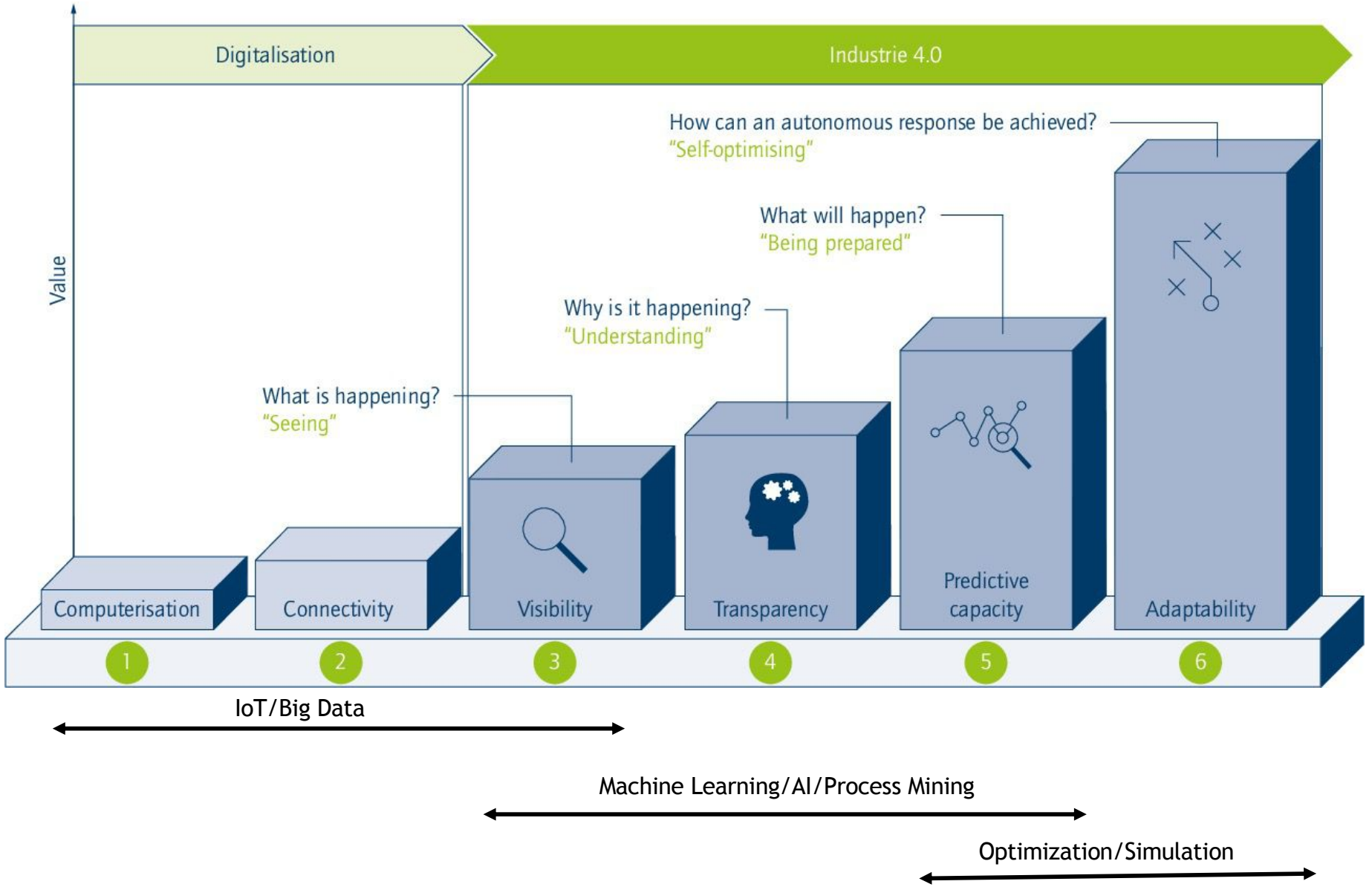
Motion Study & ‘Therblig’

Motion Study by Gilbreth

Lilian Gilbreth (1878-1972) Frank Gilbreth (1868-1924)

Image Source: Google Images

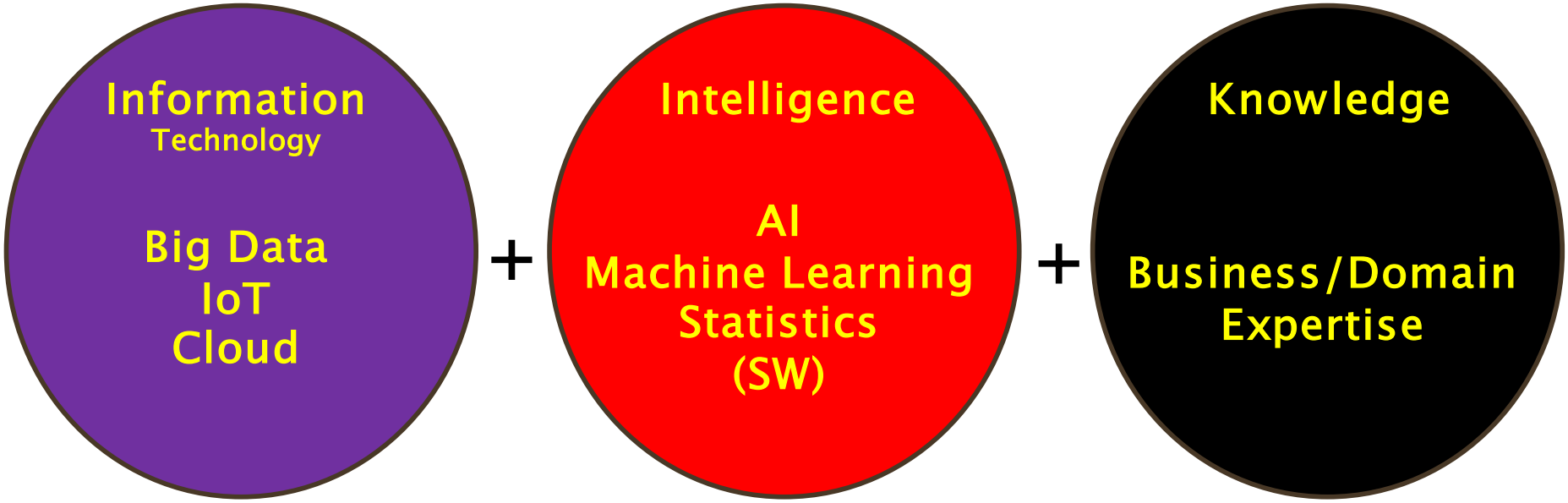
Stages in the Industrie 4.0 development path



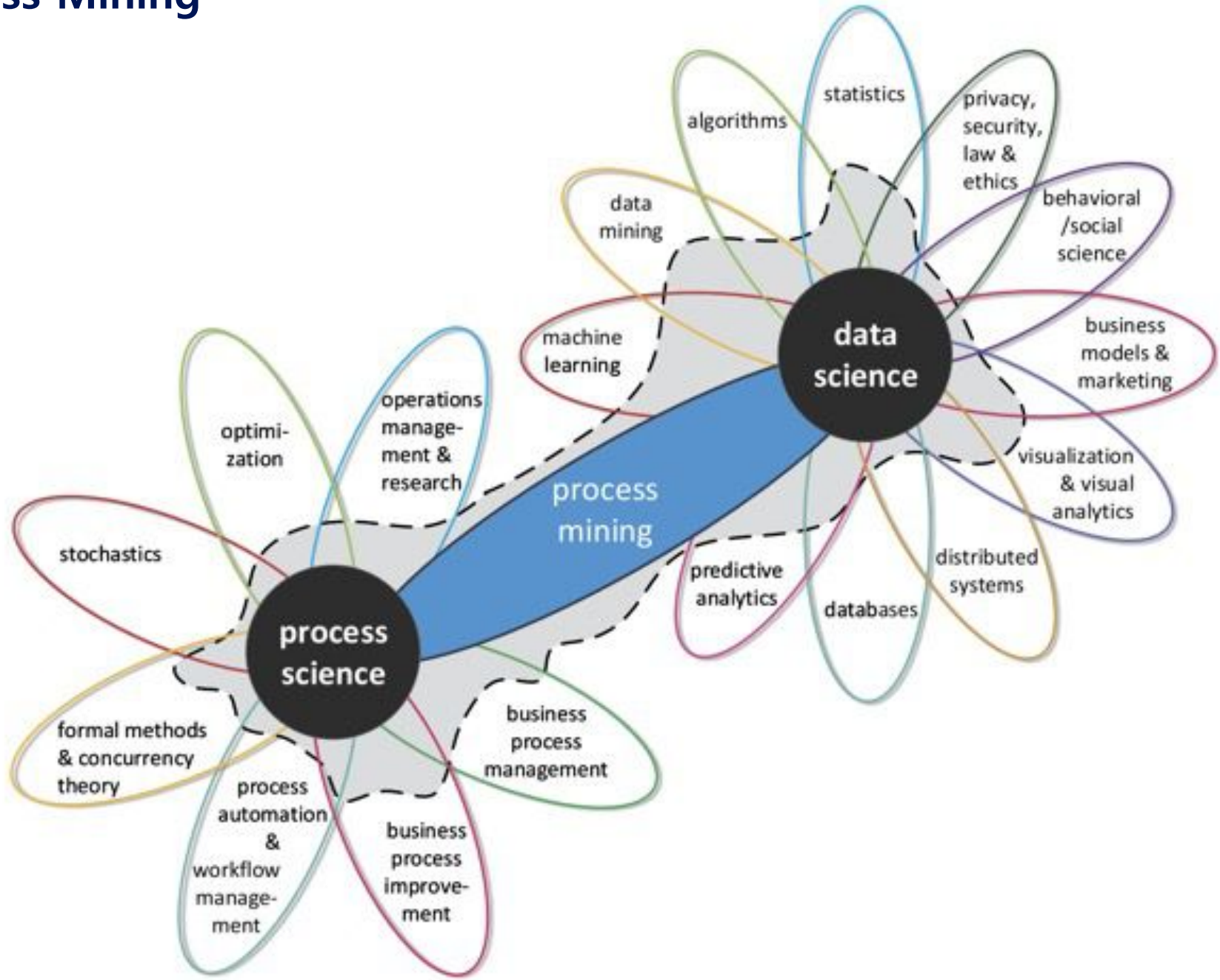
출처: Acatech, Industrie Maturity Index (2017)

원저: FIR e. V. at RWTH Aachen University

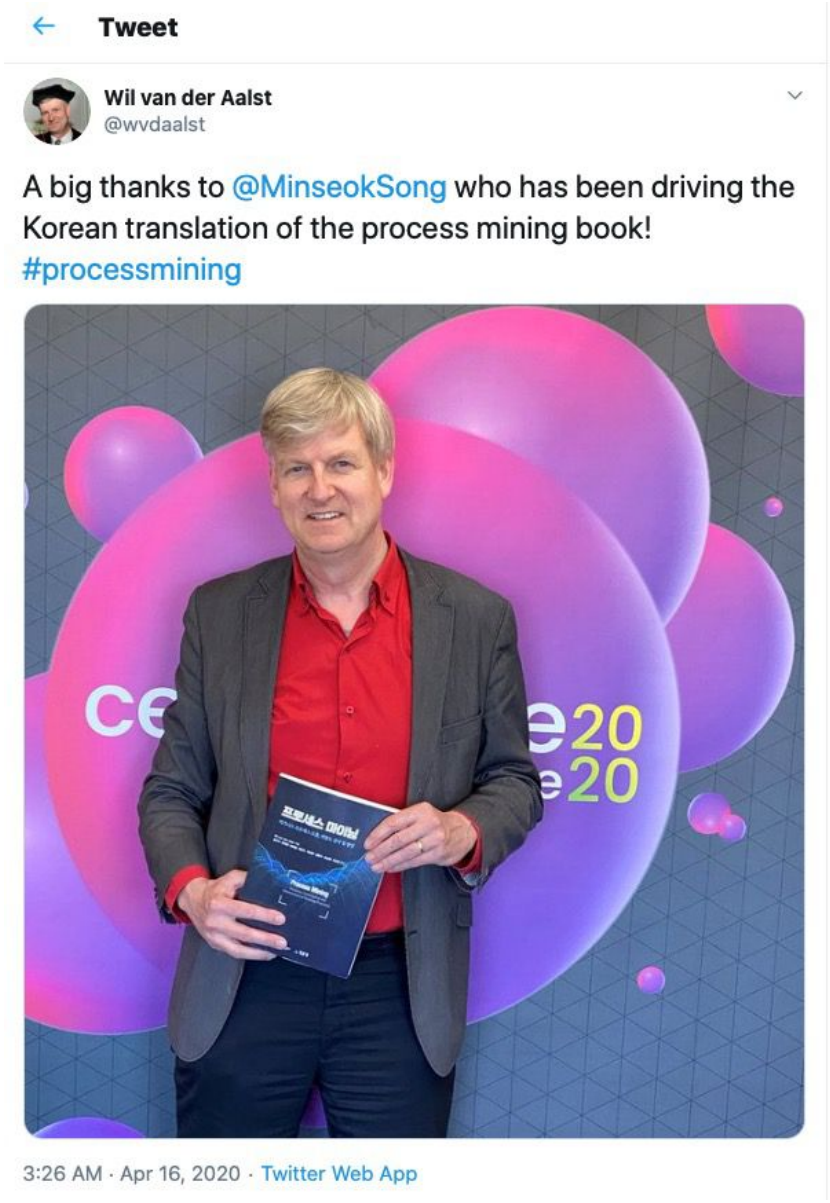
Industrial AI



Process Mining



RWTH: Wil Van der Aalst



Citation indices	All	Since 2016
Citations	117981	44748
h-index	159	95
i10-index	824	589

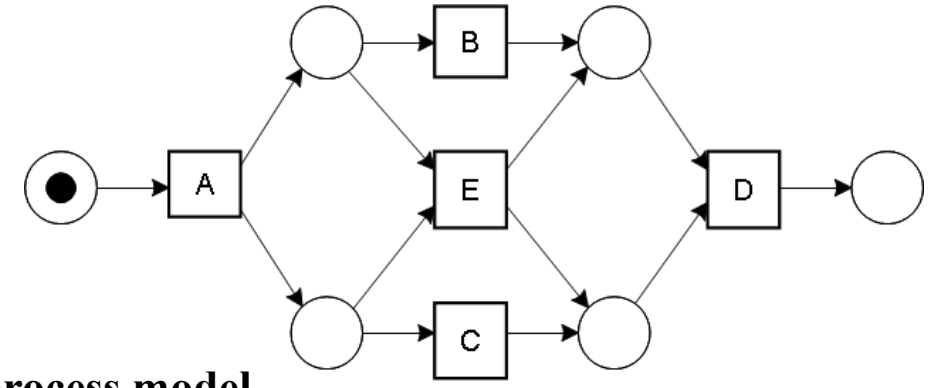
Example

Event Log

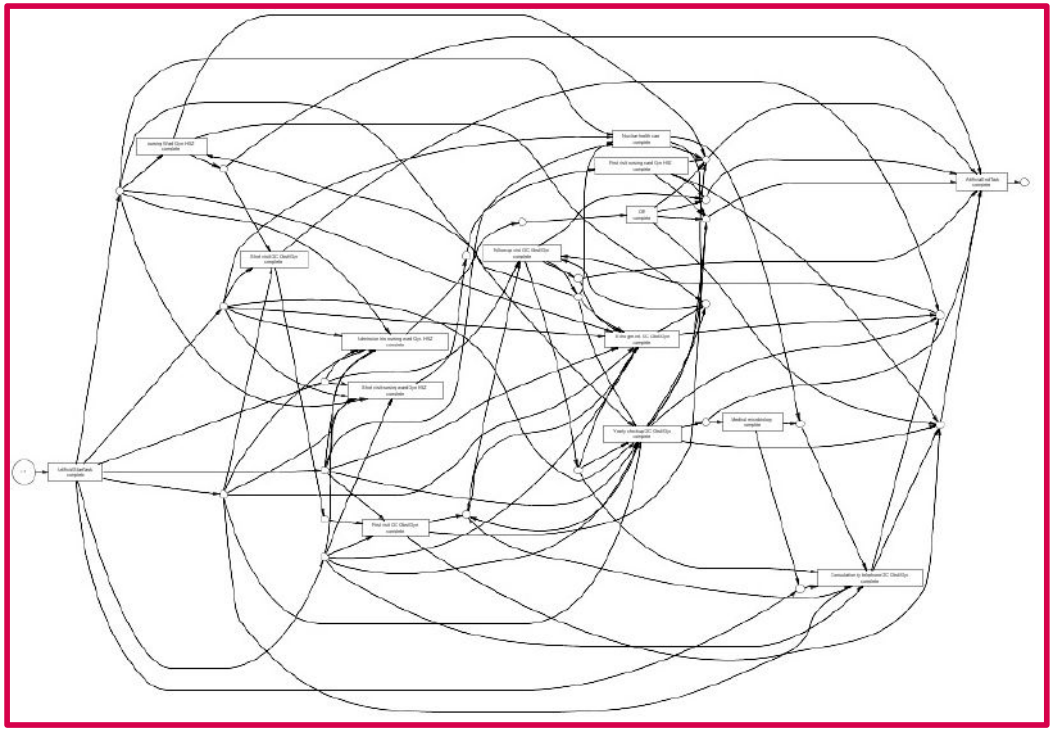
Cases	Logs
1	(A,John),(B,Sue),(C,John),(D,Carol)
2	(A,John),(C,Mike),(B,John),(D,Sue)
3	(A,Carol),(E,Mike),(D,Sue)
4	(A,Pete),(C,Carol),(B,Clare) (D,Pete)
5	(A,John),(E,Carol),(D,Clare)

```
..
<AuditTrailEntry>
  <WorkflowModelElement>A. Register
Claim</WorkflowModelElement>
  <EventType>start</EventType>
  <Timestamp>2007-04-08T09:52:00.000+01:00</Timestamp>
  <Originator>Mona</Originator>
 <Data>
  <Attribute name="Amount">50</Attribute>
  <Attribute name="CustomerID">C493823084</Attribute>
  </Data>
</AuditTrailEntry>
..
```

Mining result

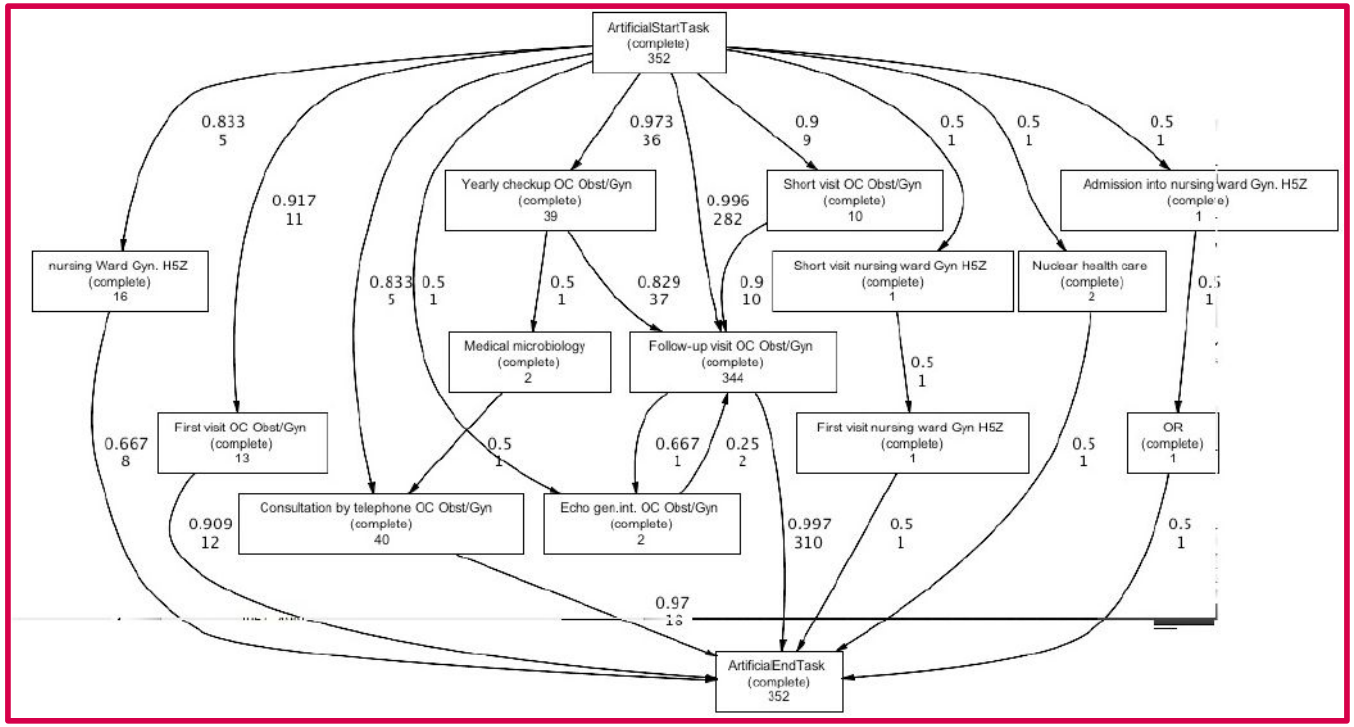


process model



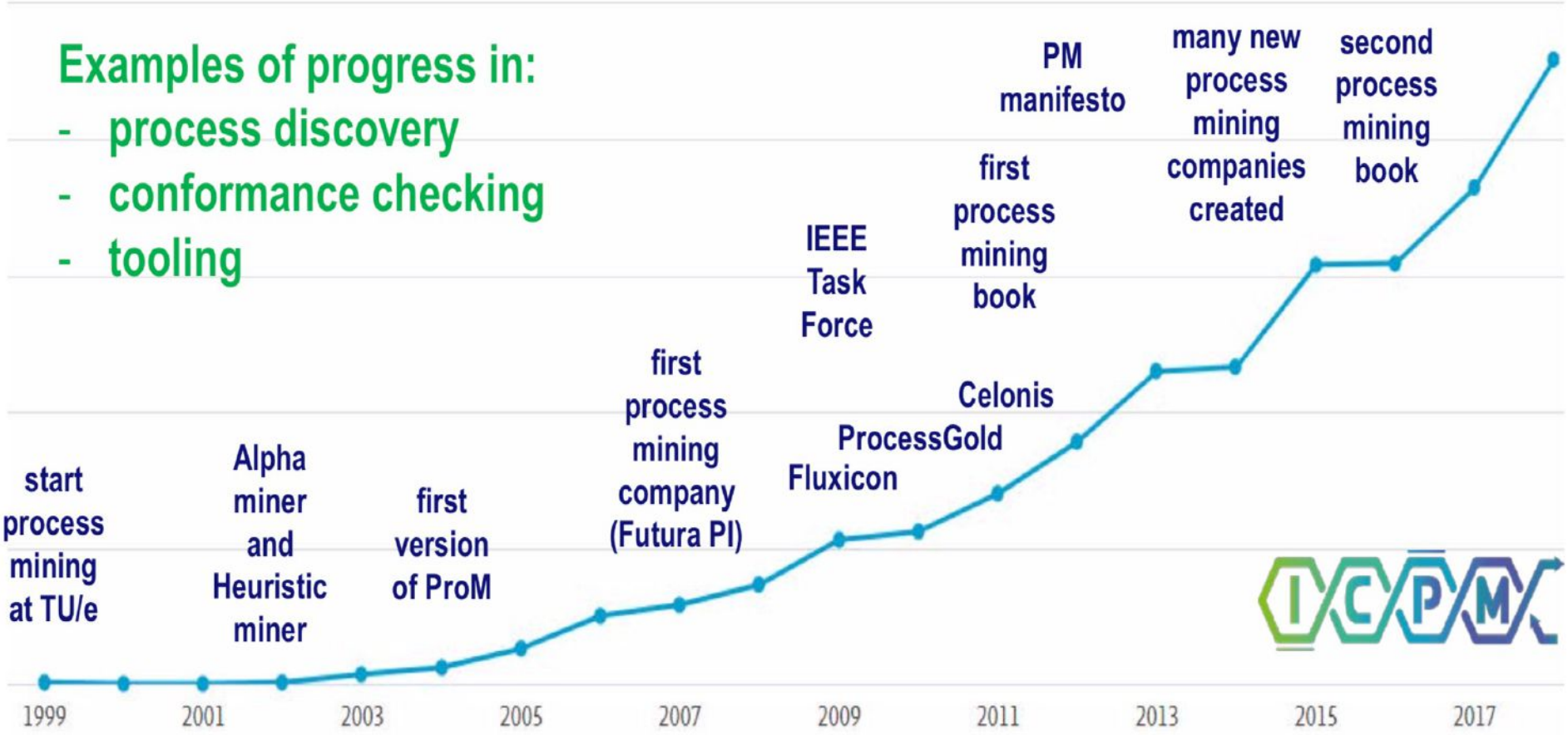
α-algorithm

Heuristic algorithm



Scientific publications on process mining

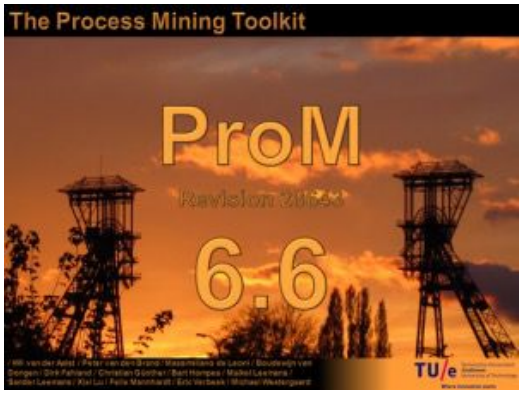
(Scopus, June 2019)



[Prof. Wil van der Aalst, 2019]

Process Mining Tool

celonis



fluxicon Process mining for professionals.

myinvenio

ICARO TECH

PROCESSGOLD

QPR

KOFAX

LANA LABS

minit

paf now

PUZZLE DATA

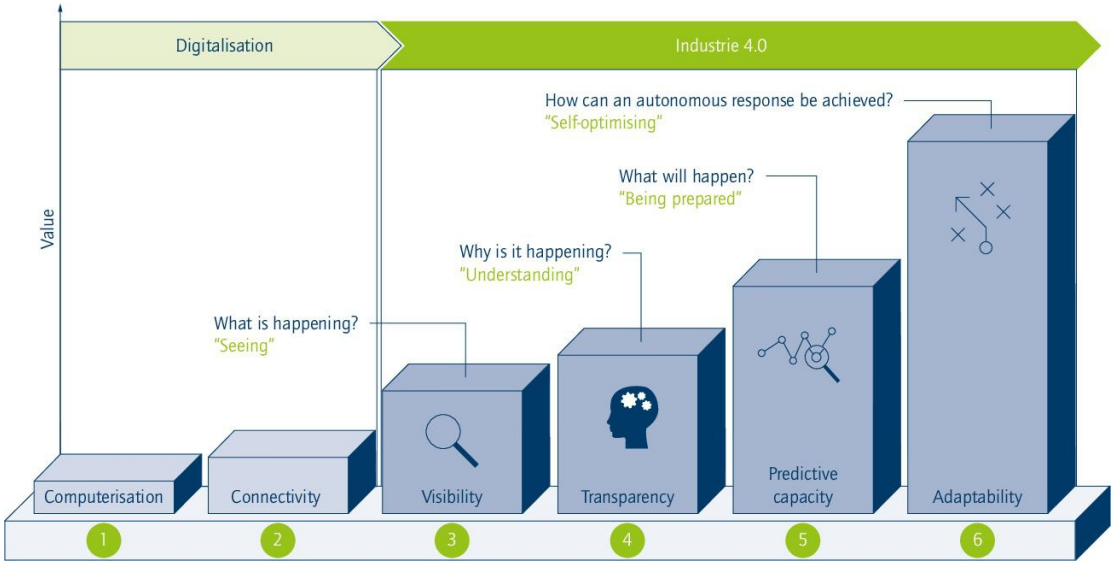
SIGNAVIO

software AG

stereologic Intelligent Operations

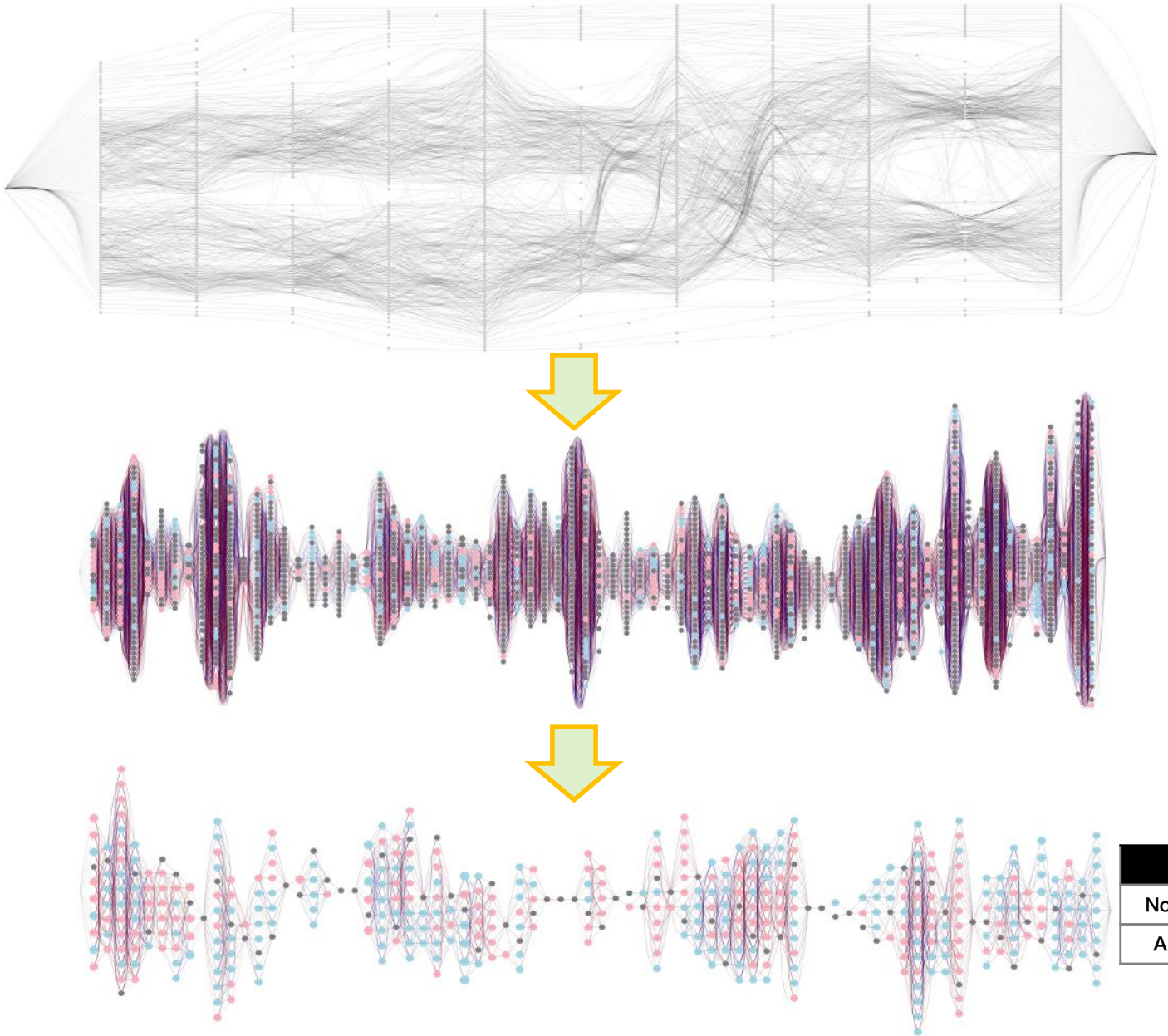
Puzzle Data: ProDiscovery

Recent Works



- Visibility
  - Model Discovery
  - Comparative Analysis
  - Conformance Checking
- Transparency
  - Process Mining + Machine Learning
- Prediction
  - Process Mining + AI
- Adaptability
  - **Process Mining + Optimization + Simulation + RPA**

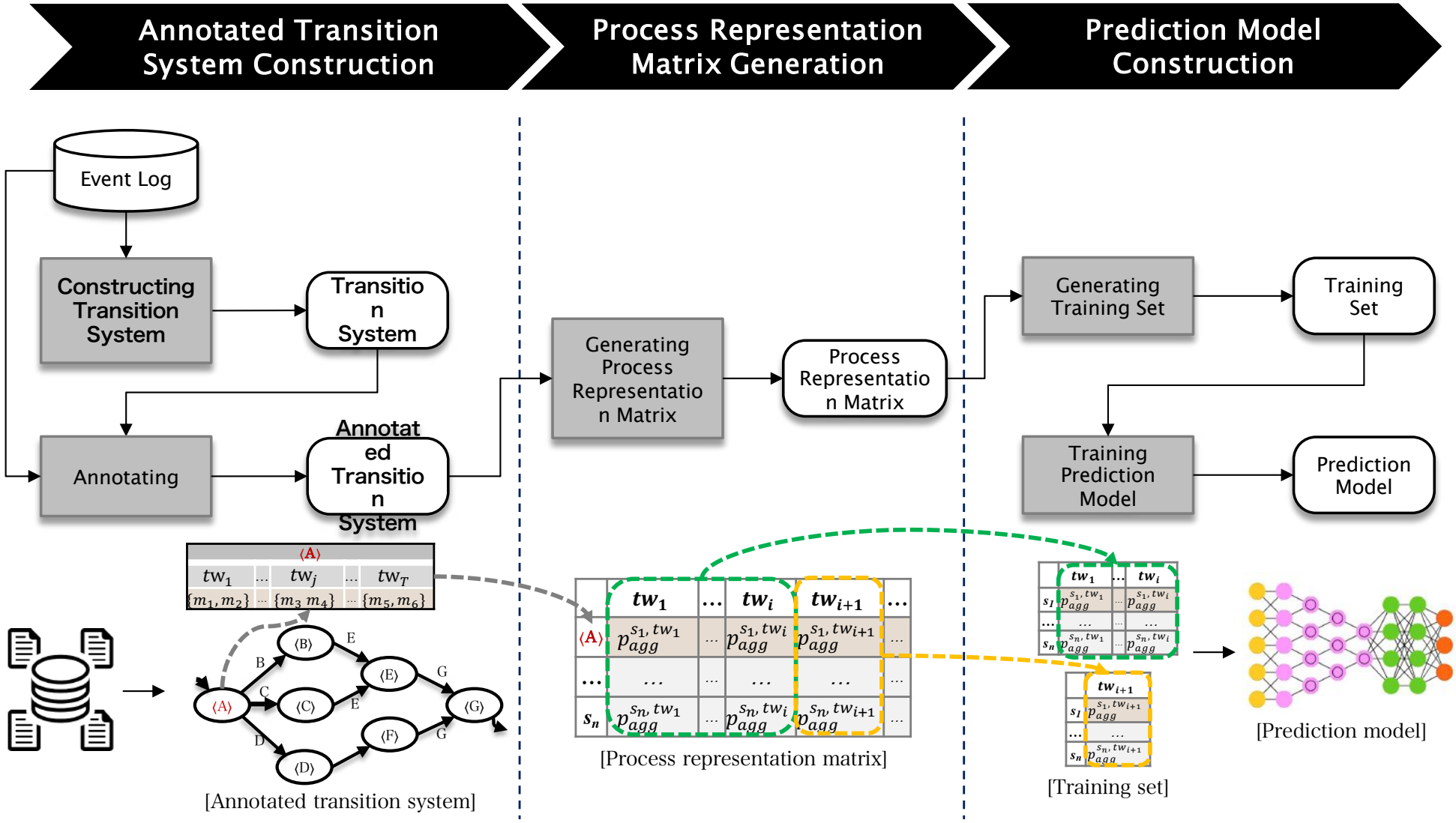
수율 기반 최적 설비 경로 도출 방법론



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

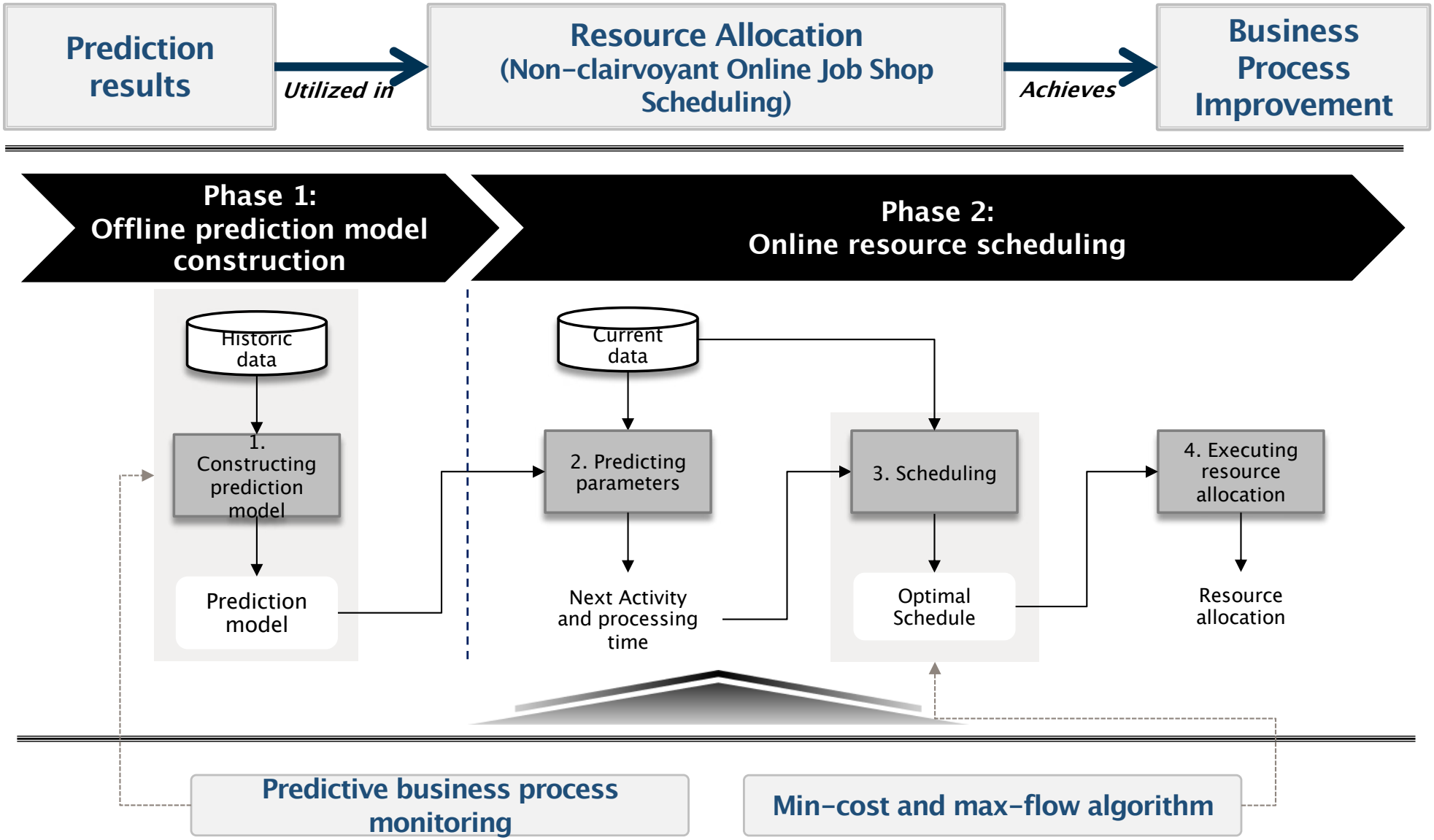
Cho, M., Park, G., Song, M., Lee, J., Lee, B., Kim, E., "Discovery of Resource-oriented Transition Systems for Yield Enhancement in Semiconductor Manufacturing." IEEE Transactions on Semiconductor Manufacturing, Vol. 34, No. 1, pp. 17-24, 2021.

Predicting Performances in Business Processes using Deep Neural Networks



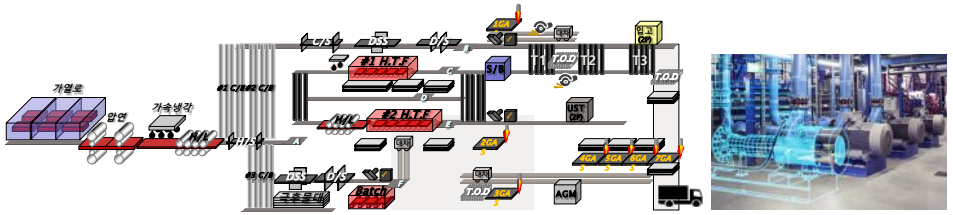
[Park. G. **Song, M.***, "Predicting Performances in Business processes using Deep Neural Networks" *Decision Support Systems*, Volume 129, 10.1016/j.dss.2019.113191, February 2020]

Process Mining + Optimization



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.

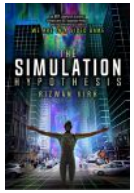
Digital Twin



3D Model + MR

Digital Twin

IoT

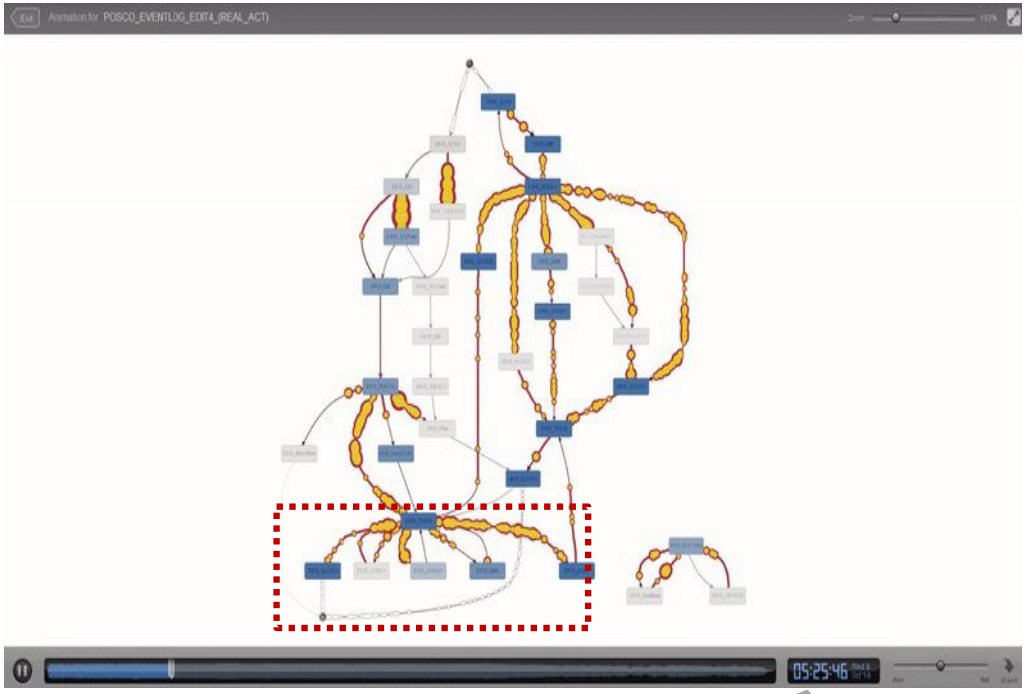


Simulation

AI+ML

Optimization

Process Mining & Digital Twin



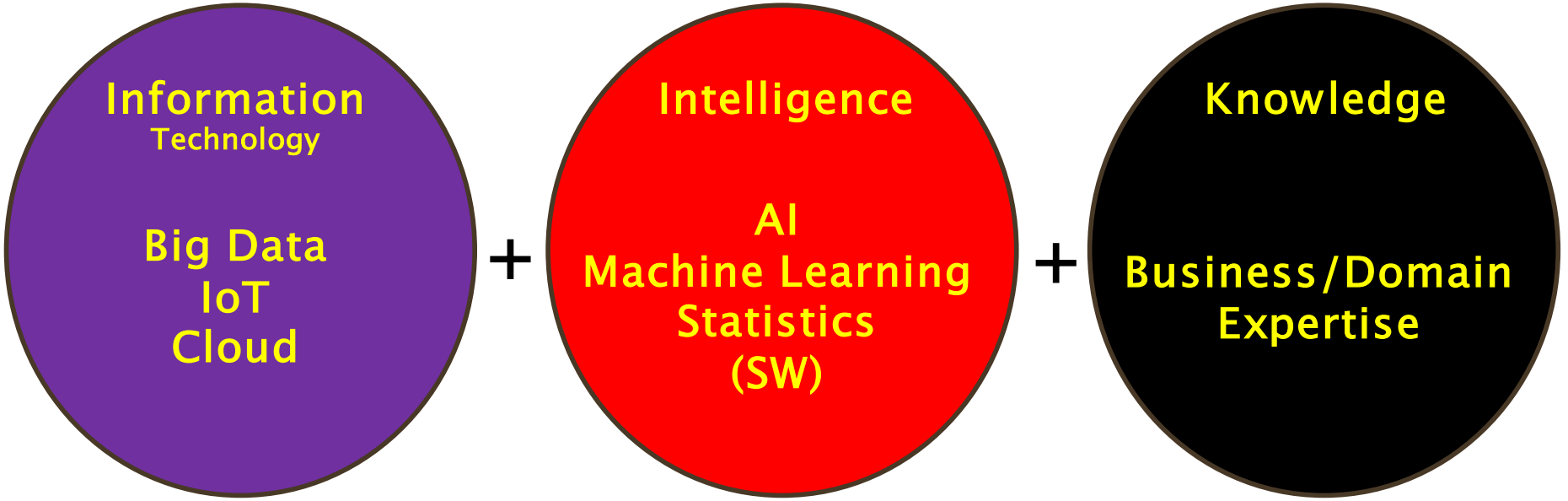
Visualization (Process Discovery + Animation)

2019년 10월 9일 기준

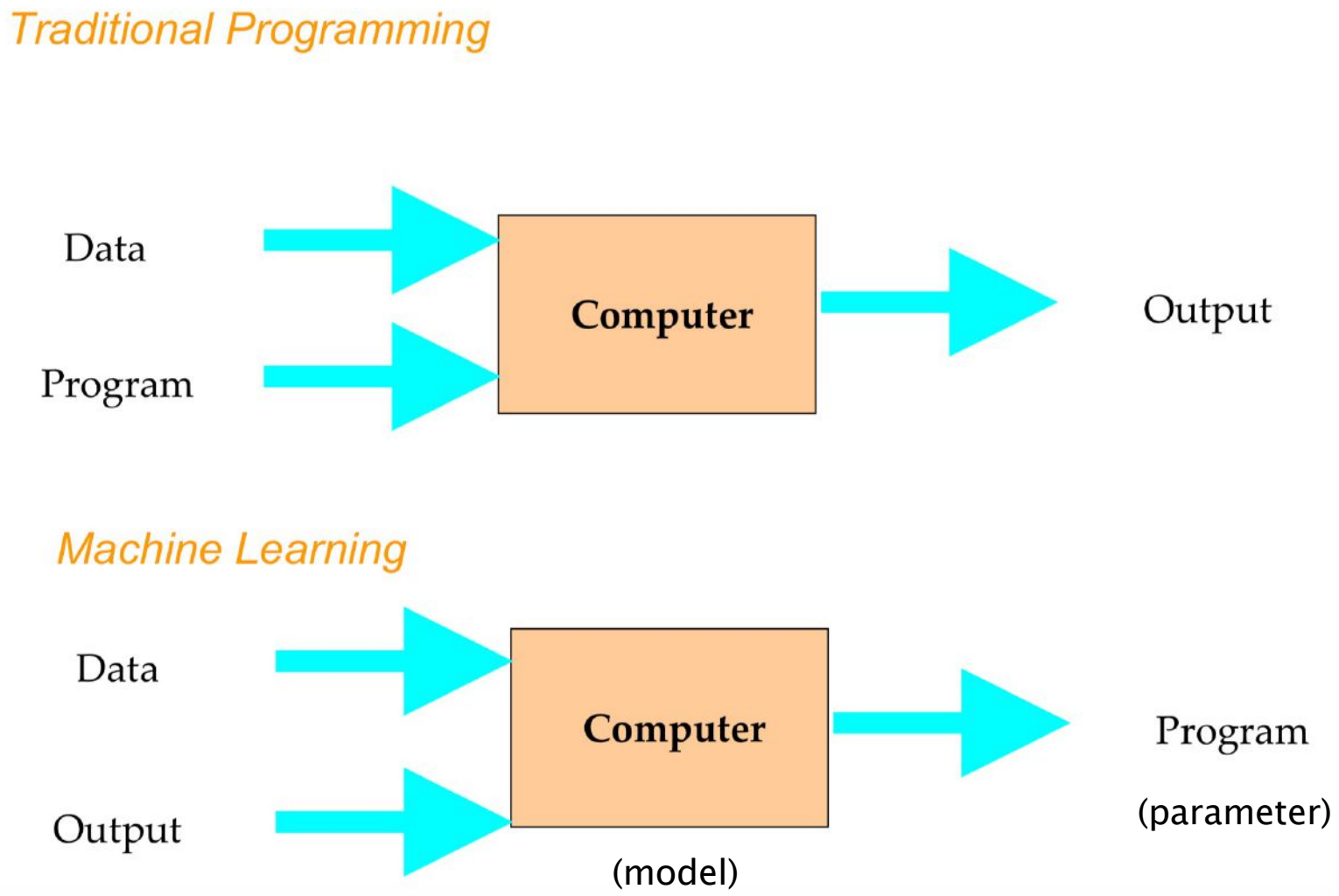
Digitalzation (IoT)

Prediction + Optimization + Simulation

Industrial AI

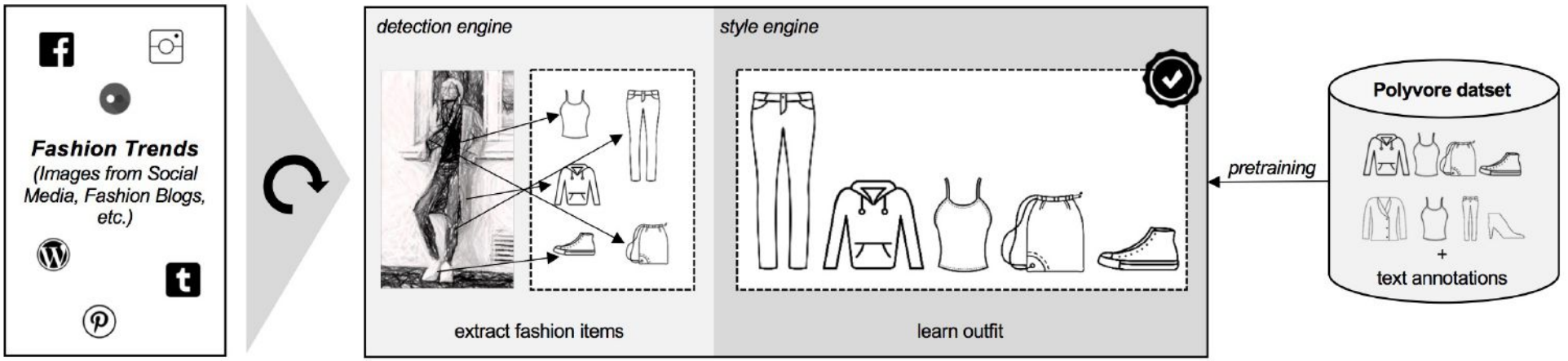


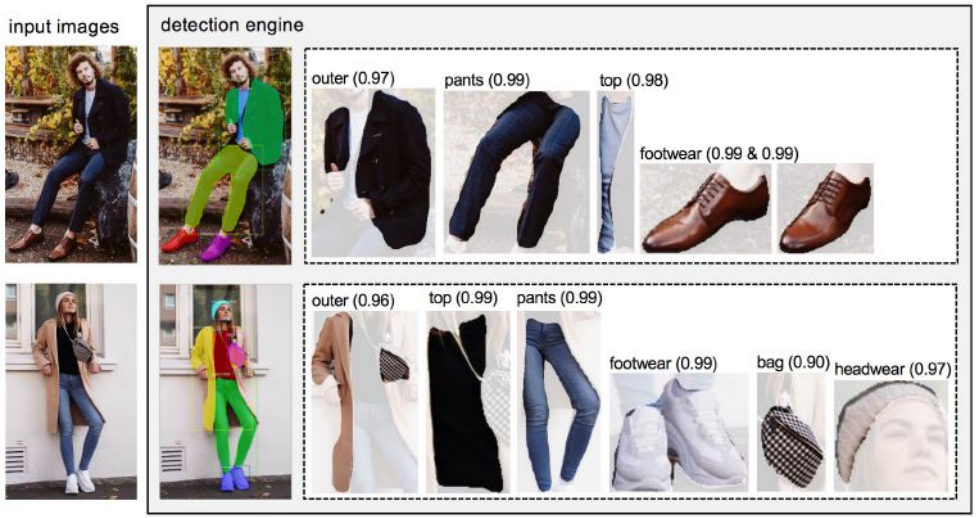
What is Machine Learning?

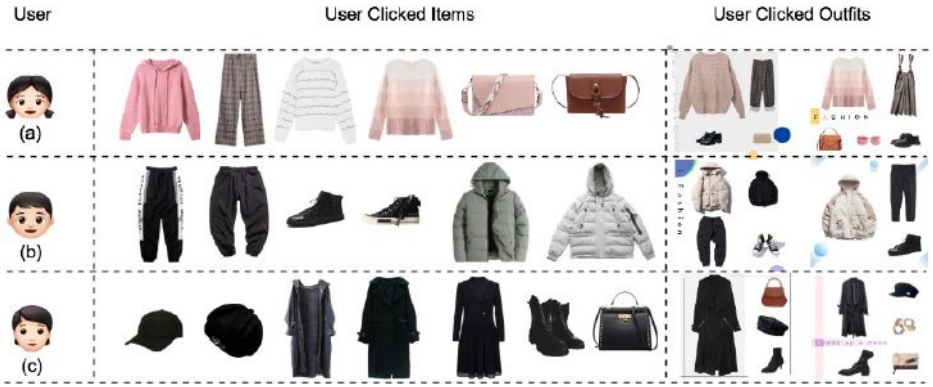


Curated retailing system based on AI

Curated retailing system





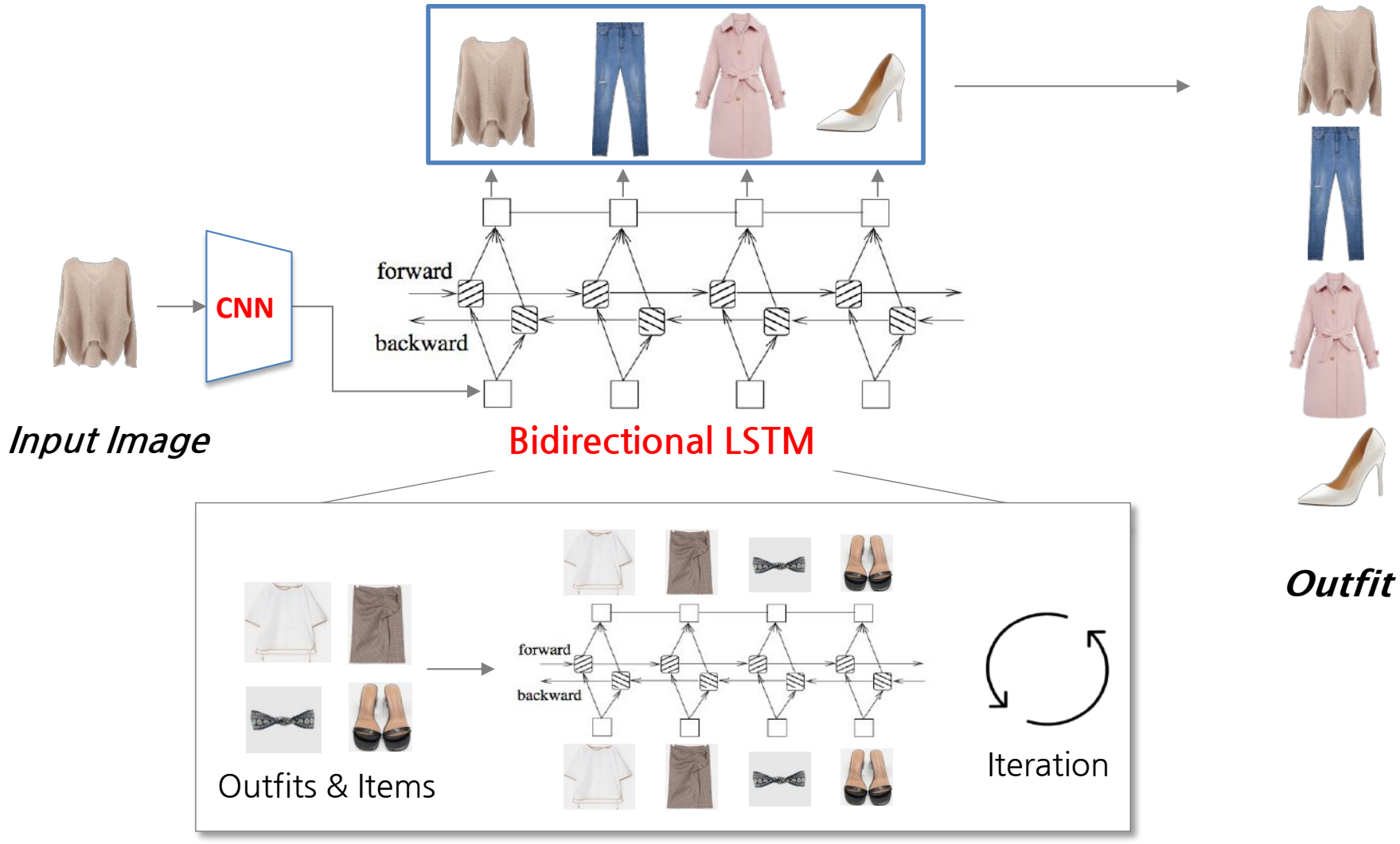


Source: A. KGriebel, M., Welsch, G., Greif, T., & Flath, C. (2019). A PICTURE IS WORTH MORE THAN A THOUSAND PURCHASES: DESIGNING ANIMAGE-BASED FASHION CURATION SYSTEM.

Literature Reviews

Title	year	Data source	Style engine model	Evaluation
Large Scale Visual Recommendations From Street Fashion Images	2014	Images on the web	Markov chain LDA	56%
Collaborative Fashion Recommendation: A Functional Tensor Factorization Approach	2015	Polyvore	Matrix factorization	61%
Learning visual clothing style with heterogeneous dyadic co-occurrences	2015	Amazon	CNN network	52%
Mining Fashion Outfit Composition Using An End-to-End Deep Learning Approach on Set Data	2016	Polyvore	RNN	50%
Learning Fashion Compatibility with Bidirectional LSTMs	2017	Polyvore	Bidirectional LSTM	68.6%
POG: Personalized Outfit Generation for Fashion Recommendation at Alibaba iFashion	2019	Alibaba	Self attentional model	68.71%
Stitch Fix	-	Stitch fix	neural network	-

Curated retailing system overview



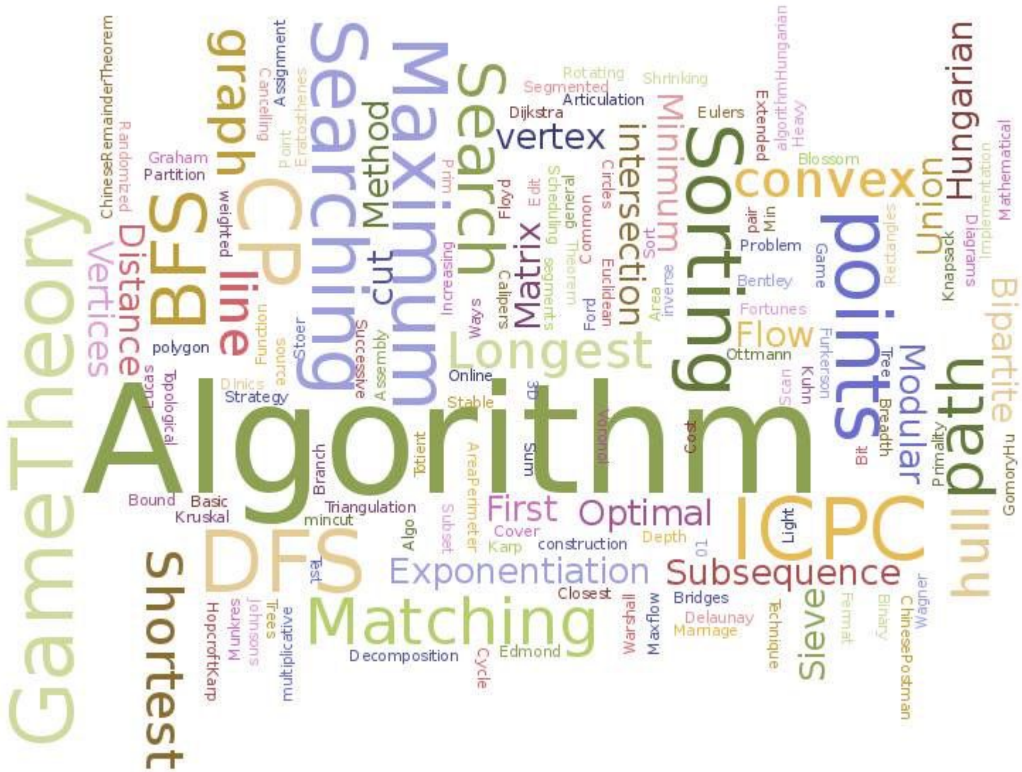
Polyvore, Alibaba

Performance measures

- FITB (Fill in the blank)
  - 무작위 복종 내에서 정답 찾기
  - 주어진 Outfit에서 하나의 아이템을 제외하고, 모델이 정답을 찾을 확률
  - Candidates: 정답 Item + 3개의 무작위 복종 Items
  - **모델이 item을 찾을 확률로 성능 평가**

Performance

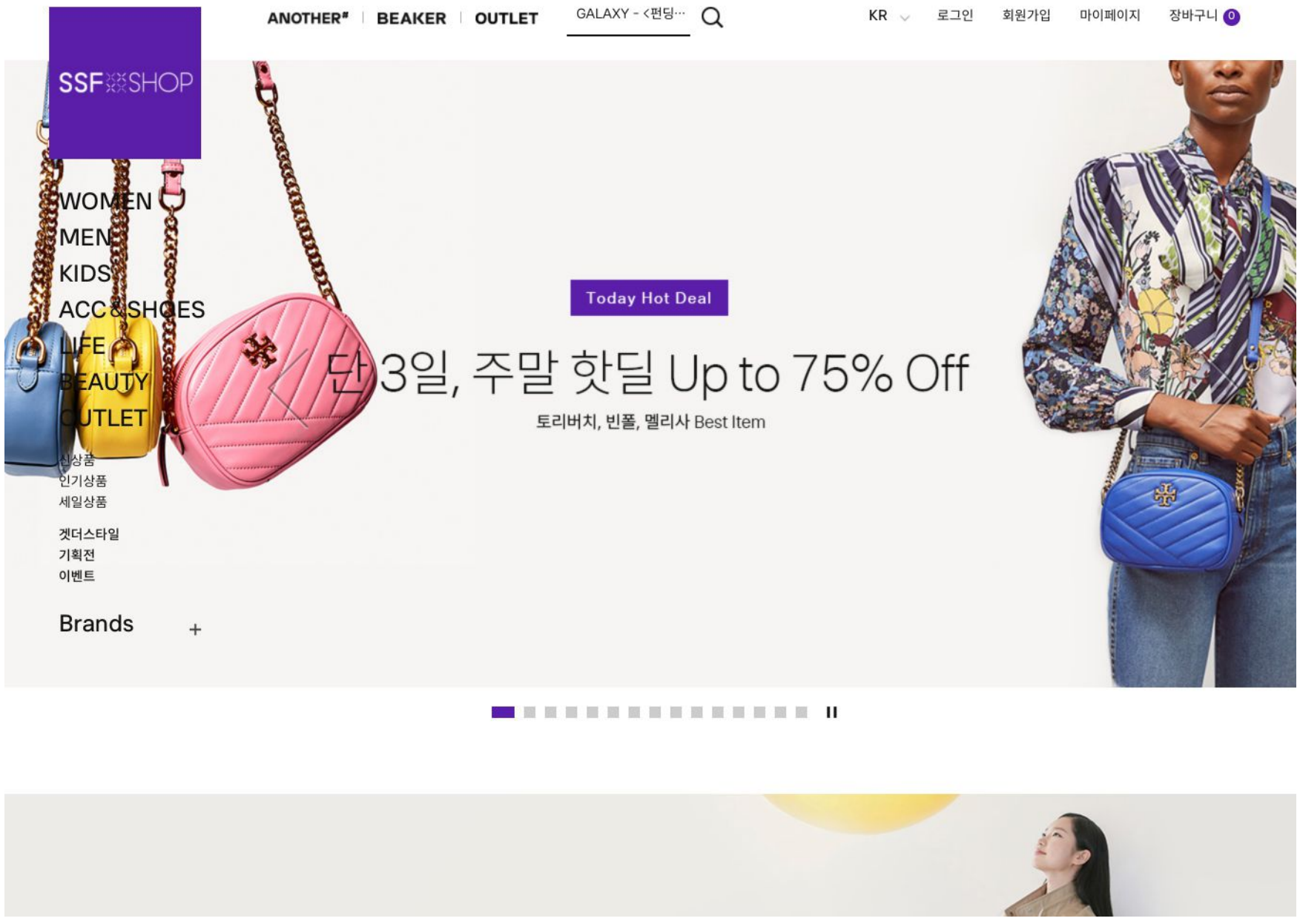
- Generating outfits at night ➔ 30hr



Maintenance

- Modular architecture ➔ reusability, maintainability

Final Result: ssfshop.com



Conclusion: Lessons learned

- Data handling vs Modeling ➔ 80 vs. 20
- Model development vs Implementation ➔ 20 vs. 80
- Management! Management! Management!

Special thanks to the students!

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