Lecture 8: Association Rule Mining

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Type of Machine Learning/Data Mining

- According to the existence of target (Y) variable
  - ✓ Supervised learning vs. Unsupervised learning

Supervised Learning

A given dataset **X** & **Y**

	Var. 1	Var. 2	...	Var. d		Y
Ins. 1	..	..	...	..		..
Ins. 2	..	..	...	..	$y = f(x)$	..
...	...	...	...	...		...
Ins. N	..	..	..	..		..

Unsupervised Learning

A given dataset **X**

	Var. 1	Var. 2	...	Var. d
Ins. 1	..	..	...	..
Ins. 2	..	..	...	..
...	...	...	...	...
Ins. N	..	..	..	..

Semi-supervised Learning

A given dataset **X** & **Y**

	Var. 1	Var. 2	...	Var. d		Y
Ins. 1	..	..	...	..		..
Ins. 2	..	..	...	..	$y = f(x)$	..
...	...	...	...	...		...
Ins. N	..	..	..	..		..
...	...	...	...	...		
...	...	...	...	...		
...	...	...	...	...		
...	...	...	...	...		
Ins. M	..	..	..	..		

Type of Machine Learning/Data Mining

- Unsupervised Learning

$$\mathcal{X} = \{\mathbf{x}_i | i = 1, ..., n,\ \mathbf{x}_i \in \mathbb{R}^d\}$$

Unsupervised learning

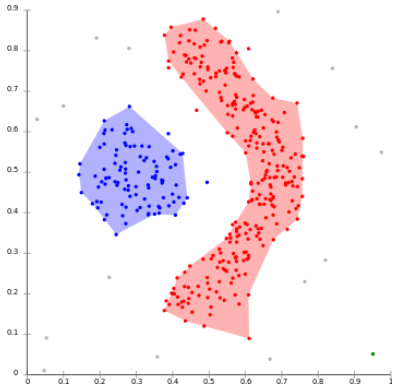
- Explores intrinsic characteristics.
- Estimates underlying distribution.
- Density estimation, clustering, novelty detection, etc.

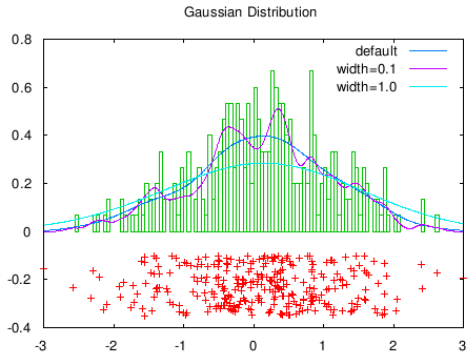
Type of Machine Learning/Data Mining

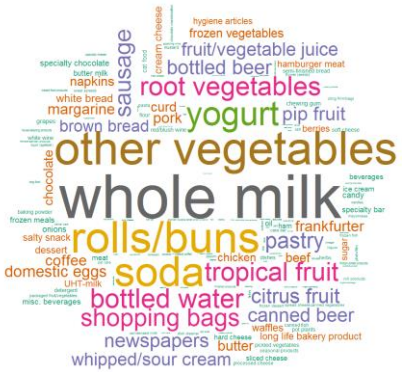
- Unsupervised Learning

A given dataset **X**

	Var. 1	Var. 2	...	Var. d
Ins. 1	..	..	...	..
Ins. 2	..	..	...	..
...	...	...	...	...
Ins. N	..	..	..	..







Type of Machine Learning/Data Mining

- Supervised Learning

$$\mathcal{X} = \{\mathbf{x}_i | i = 1, \ldots, n,\ \mathbf{x}_i \in \mathbb{R}^d\}$$

Supervised learning

- Finds relations between X and Y.
- Estimate the underlying function $y = f(x)$.
- Classification, regression.

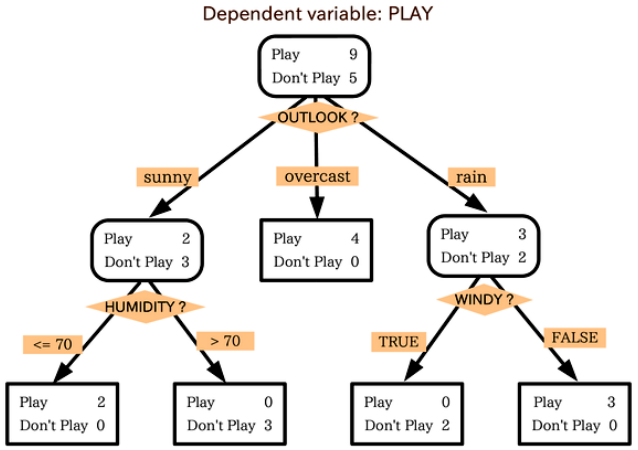
$y = f(x)$

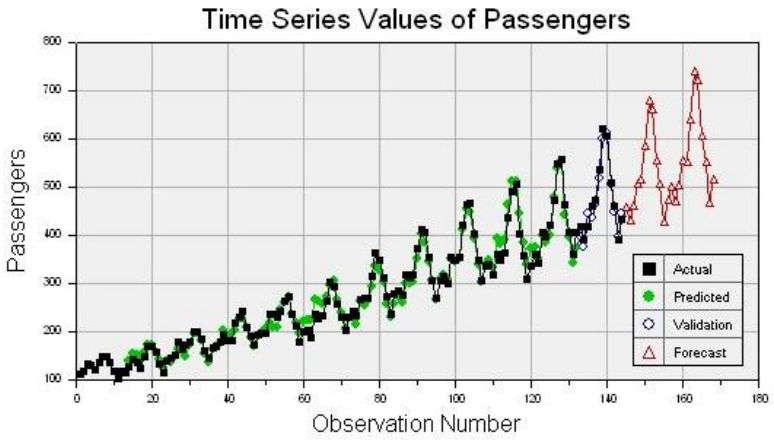
$$\mathcal{Y} = \{y_i | i = 1, \ldots, n,\ y_i = f(\mathbf{x}_i)\}$$

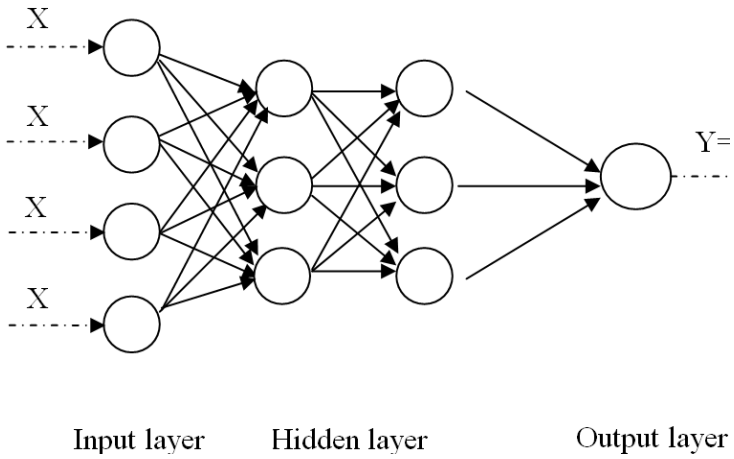
Type of Machine Learning/Data Mining

- Supervised Learning

	Var. 1	Var. 2	...	Var. d	→	Y
Ins. 1	..	..	...	..		..
Ins. 2	..	..	...	..	$y = f(x)$	..
...	...	...	...	...		...
Ins. N	..	..	..	..		..







Association Rule Mining

크게보기 | 미리보기

매장 재고 · 위치 >

키워드 Pick 안내

양로원 갱단 트렁크 데뷔작 율리우스 핵폭탄

이 책의 다른 상품 정보

sam : 한달 3권 9,900원 >

eBook : 9,000원 >

원서/번역서 :
[보유]The Hundred-Year-Old Man Who Climbed Out of the Window and Disappeared >

오늘의책 무료배송 소득공제

창문 넘어 도망친 100세 노인 요나스 요나손 장편소설

요나스 요나손 지음 | 임호경 옮김 | 열린책들 | 2013년 07월 25일 출간

★★★★★ 리뷰 112개 리뷰쓰기 | 9.0(137)

KBS TV책 -김창완과 책읽기

정가 : 13,800원

판매가 : 12,420원 [10%↓ 1,380원 할인]

통합포인트 : [기본적립] 690원 적립 [5% 적립] 안내
[추가적립] 5만원 이상 구매 시 2천원 추가적립
[회원혜택] 우수회원 5만원 이상 구매 시 2~3% 추가적립

추가혜택 : 카드/포인트 안내 | 도서소득공제 안내 | 추가혜택 더보기

배송비 : 무료 배송비 안내

배송일정 : 서울특별시 종로구 세종대로 기준 지역변경
03월 04일 출고 예정 배송일정 안내

바로드림 : 인터넷으로 주문하고 매장에서 직접 수령 안내

주문수량 1 + −

장바구니 담기 | 바로구매 | 바로드림 주문 | 선물하기 | 보관함 담기

Association Rule Mining

이 책을 구매하신 분들이 함께 구매하신 상품입니다

전체선택 | 장바구니 담기

참을 수 없는 존재의 가벼움(양장본)

13,500원

셈을 할 줄 아는 까막눈이 여자(큰글자판)

13,320원

셈을 할 줄 아는 까막눈이 여자

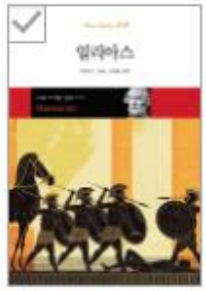
13,320원

자신을 행성이라 생각한 여자

13,320원

마리아(Maria)(고려대학교 청소년문학 시리즈

11,000원



일리아스(클래식 투게더 23)

10,620원

이 상품의 꾸러미

창문 넘어 도망친 100세 노인

+

The 100-Year-Old Man Who Climbed Out

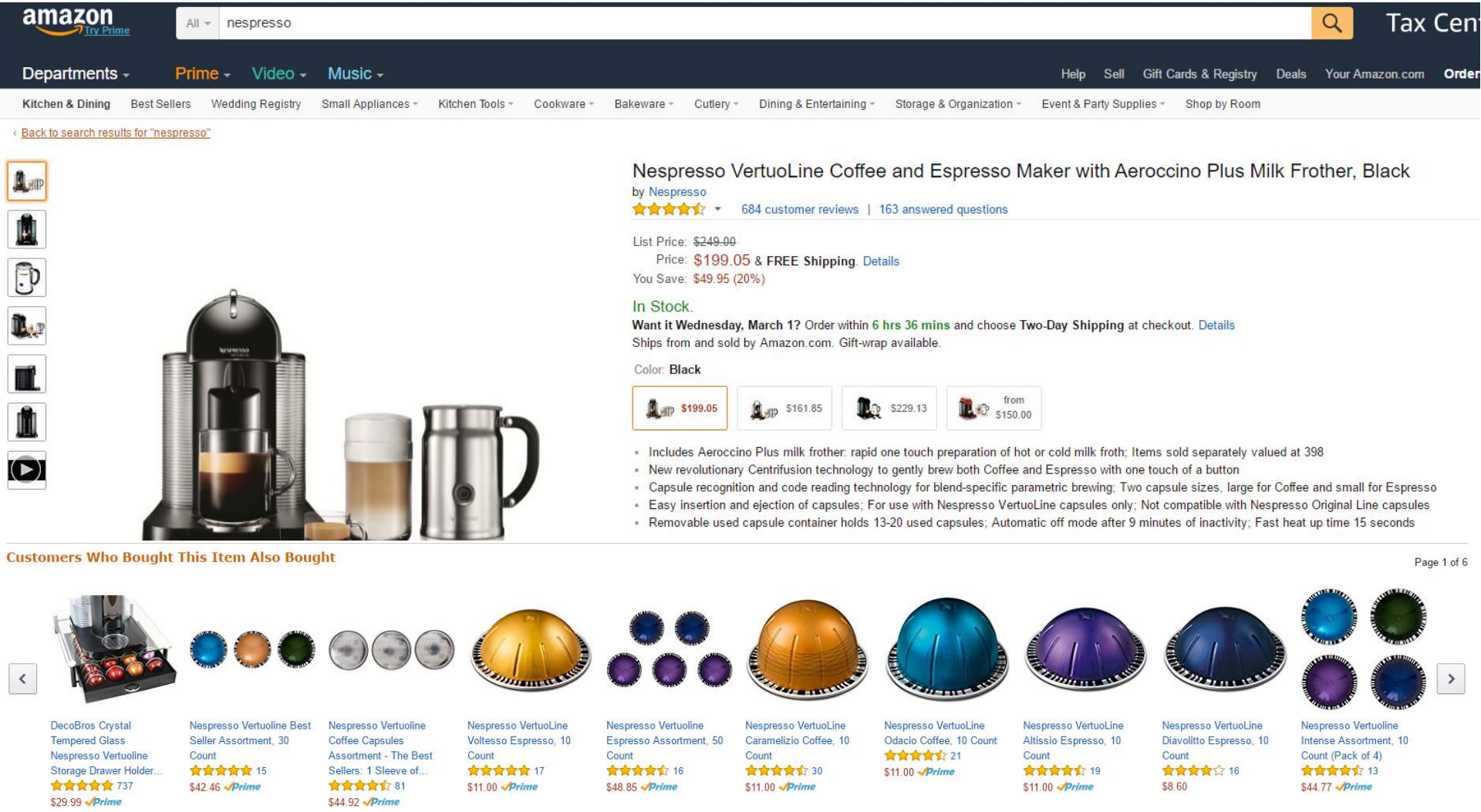
창문 넘어 도망친 100세 노인 한영판 세트 (도서 2종)

25,640원

18,460원 [28%할인] | 690원 [4%적립]

자세히 보기 | 장바구니 담기

Association Rule Mining



Association Rule Mining

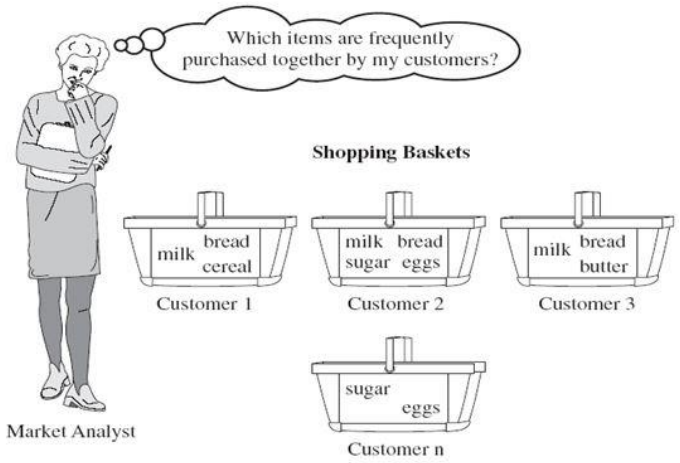
- Also known as "Market Basket Analysis"

Wall Mart (USA)

E-Mart (Korea)

Association Rule Mining

- Goal:
  - ✓ Produce rules that define "what goes with what"
  - ✓ "If X was purchased, then Y was also purchased"
- Features
  - ✓ Rows are transactions
  - ✓ Used in recommendation systems – "Our records show that you bought X, thus you may also like Y"
  - ✓ Also called "affinity analysis" or "market basket analysis"



Association Rule Mining

- Dataset for association rule mining
  - ✓ Each transaction is represented as a record
  - ✓ Two representations are possible: (1) item list and (2) item matrix

[Item list]

Transaction ID	Items
1	Bread, Milk
2	Bread, Diaper, Beer, Eggs
3	Milk, Diaper, Beer, Coke
4	Bread, Milk, Diaper, Beer
5	Bread, Milk, Diaper, Coke

[Item matrix]

Transaction ID	Bread	Milk	Diaper	Beer	Eggs	Coke
1	1	1	0	0	0	0
2	1	0	1	1	1	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	1

Association Rule Mining

- A toy example: a tiny retail market data

Transaction	Item 1	Item 2	Item 3	Item 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Association Rule Mining

- Terminology
  - ✓ Antecedent – "IF" part
  - ✓ Consequent – "THEN" part
  - ✓ Item set – the items comprising the antecedent or consequent
  - ✓ Antecedent and consequent are disjoint (have no items in common)

- Generating rules
  - ✓ Many rules are possible (e.g., for transaction 1)
    - If egg is bought, then noddle is also bought
    - If egg and noddle are bought, then tuna is also bought
    - If tuna is bought, then egg is also bought, etc.

Association Rule Mining

Performance Measures for the rule A → B

- Support

$$\text{support}(A \rightarrow B) = P(A) \quad \text{or} \quad P(A, B)$$

✓ Used to find the frequent item sets

✓ The higher the support, the higher the chance of applying the rule

Transaction	Item 1	Item 2	Item 3	Item 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Association Rule Mining

Performance Measures for the rule A → B

- Confidence

$$\text{confidence}(A \rightarrow B) = \frac{P(A, B)}{P(A)}$$

✓ The conditional probability of B given A

✓ Used to generate meaningful rules

Transaction	Item 1	Item 2	Item 3	Item 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Association Rule Mining

Performance Measures for the rule A → B

- Confidence

$$\text{lift}(A \rightarrow B) = \frac{P(A,B)}{P(A) \cdot P(B)}$$

✓ Used to determine the usefulness of generated rules

- Lift = 1: A and B are statistically independent
- Lift > 1: Positive relationship between A and B
- Lift < 1: Negative relationship between A and B

Transaction	Item 1	Item 2	Item 3	Item 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Association Rule Mining

- How to generate an effective association rules?
  - ✓ Ideally, create all possible combinations of items and see what rules are effective and what rules are not.
  - ✓ Computation time grows exponentially as the number of items increases.

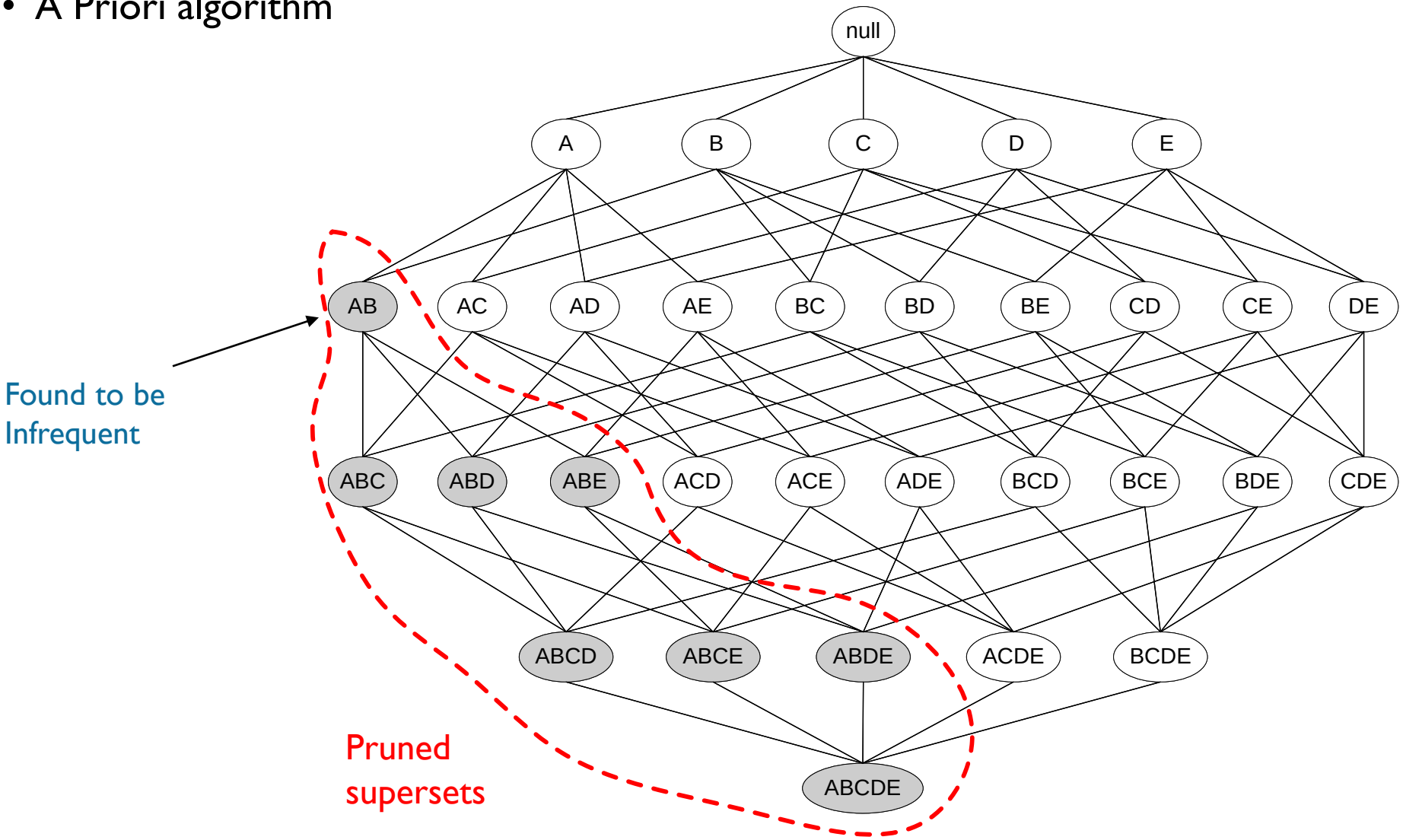
- Brute-force approach
  - ✓ List all possible association rules
  - ✓ Compute the support and confidence for each rule
  - ✓ Prune rules that fail the **minsup** and **minconf** threshold.
  - ✓ Computationally prohibitive!

Association Rule Mining

- A priori algorithm
  - ✓ Consider only "frequent item sets"
  - ✓ "support"
    - Criterion for item set frequency P(A)
    - #(%) of transactions that include both the antecedent and the consequent
    - Support for the item set {egg, noodle} is 4 out of transactions, or 40%
  - ✓ Support of an itemset never exceeds the support of its subsets, which is known as anti-monotone property of support.

Association Rule Mining

- A Priori algorithm



Association Rule Mining

- Generating frequent item sets
  - ✓ Users set a minimum support criterion: e.g. 2 transactions or 20%

Transaction	Item 1	Item 2	Item 3	Item 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Association Rule Mining

- Generating frequent item sets
  - ✓ Generate the list of one-item sets that meets the support criterion

8 (80%)


5 (50%)

5 (50%)

3 (30%)

2 (20%)


1 (10%)

- ✓ Onion is removed because it does not meet the minimum support criterion

Association Rule Mining

- Generating frequent item sets
  - ✓ Use the life of one-item sets to generate list of two-item sets that meet the support criterion

	noodle	egg	cola	rice	tuna
noodle		40%	40%	20%	20%
egg			30%	0%	20%
cola				0%	10%
rice					0%
tuna					

  - ✓ {noodle, egg}, {noodle, cola}, {noodle, rice}, {noodle, tuna}, {egg, cola}, {egg, tuna} are frequent two-item sets

Association Rule Mining

- Generating frequent item sets
  - ✓ Use the list of two-item sets to generate the three-item sets.
  - ✓ Continue up through k-item sets.

Set-size	Item 1	Item 2	Item 3	…	Item 6
1	noodle				
1	egg				
1	cola				
1	rice				
1	tuna				
2	noodle	egg			
2	noodle	cola			
2	noodle	rice			
…	…	…			

Association Rule Mining

- A Priori algorithm
  - ✓ Let k=1
  - ✓ Generate frequent itemsets of length 1
  - ✓ Repeat until no new frequent itemsets are identified
    - Generate length (k+1) candidate itemsets from length k frequent itemsets
    - Prune candidate itemsets containing subsets of length k that are infrequent
    - Count the support of each candidate by scanning the DB
    - Eliminate candidates that are infrequent, leaving only those that are frequent

Association Rule Mining

- Confidence
  - ✓ The % of antecedent transactions that also have the consequent item set
  - ✓ E.g. "if noddle is purchased, then egg is also purchased"

$$\text{support}(noodle) = P(noodle) = \frac{8}{10}, \quad \text{support}(egg) = P(egg) = \frac{5}{10}$$

$$confidence(noodle \rightarrow egg) = \frac{P(noodle, egg)}{P(noodle)} = \frac{4/10}{8/10} = 0.5(50\%)$$

$$lift(noodle \rightarrow egg)$$

$$= \frac{confidence(noodle \rightarrow egg)}{\text{support}(egg)} = \frac{\frac{P(noodle, egg)}{P(noodle)}}{P(egg)} = \frac{P(noodle, egg)}{P(noodle) \times P(egg)}$$

$$= \frac{\frac{4}{10}}{\frac{8}{10} \times \frac{5}{10}} = 1$$

Association Rule Mining

- Generated rules
  - ✓ Set the support to 20%.
  - ✓ Set the confidence to 70%.

Rule #	Antecedent (a)	Consequent	Support	Confidence	Lift
1	tuna=>	egg, noodle	2	100	2.5
2	tuna=>	egg	2	100	2
3	noodle, tuna=>	egg	2	100	2
4	rice=>	noodle	3	100	1.25
5	egg, tuna=>	noodle	2	100	1.25
6	tuna=>	noodle	2	100	1.25
7	cola=>	noodle	5	80	1
8	egg=>	noodle	5	80	1

Association Rule Mining

- Summary
  - ✓ Produce rules on associations between items from a database of transactions
  - ✓ Widely used in recommender systems
  - ✓ Most popular method is A-priori algorithm
  - ✓ To reduce computation, consider only "frequent" item sets (=support)
  - ✓ Performance is measured by confidence and lift


ANY
questions?