University of Colorado
Boulder

CSCI 4502/5502
Data Mining

Fall 2019
Lecture 08 (Sep 19)

Announcements

- Homework 2
  - due at 9:30am, Thursday, Sep 19
  - late submission: up to 2 days (w/ penalty), email instructor directly
- Homework 3
  - posted at moodle
  - due at 9:30am, Thursday Sep 26

Review

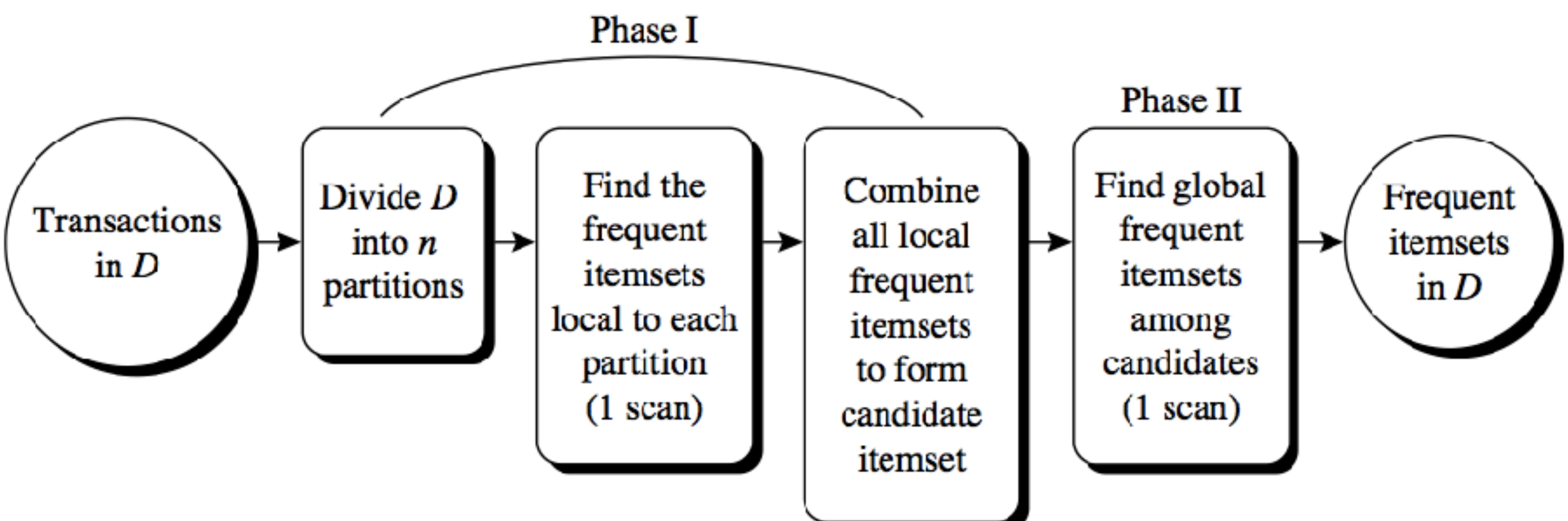
- Chapter 6: Mining Frequent Patterns
  - basic concepts
    - frequent patterns, association rules
    - support, confidence
  - Apriori algorithm
    - Apriori pruning, itemsets: k ==> k+1
  - interestingness measure
    - correlation: lift

Frequent Pattern Mining

- Challenges
  - multiple scans of the whole data set
  - a huge number of candidates
  - tedious support counting for candidates
- Improving Apriori: general ideas
  - reduce data scans
  - reduce number of candidates
  - facilitate support counting of candidates

Partition: Two Data Scans

- A frequent itemset must be frequent in at least one partition
- Partition size? # of partitions?
  - each partition fits into main memory



Sampling for Freq. Patterns

- Select a sample data set
- Mine frequent patterns within sample
  - may use a lower min_sup
- Scan whole data set for actual support
  - only check closed patterns
  - e.g., check abcd instead of ab, acd, ..., etc.
- Scan again to find missed frequent patterns
- Sample size?

Transaction Reduction

- If a transaction T does not contain any frequent k-itemset
  - then for any h > k, no need to check T when searching for frequent h-itemset

- Implementation
  - sequential scan vs. random access

Reduce #Candidates

- Hash itemsets to buckets
- If a hash bucket count is below support threshold
  - then itemsets in that hash bucket are not frequent itemsets

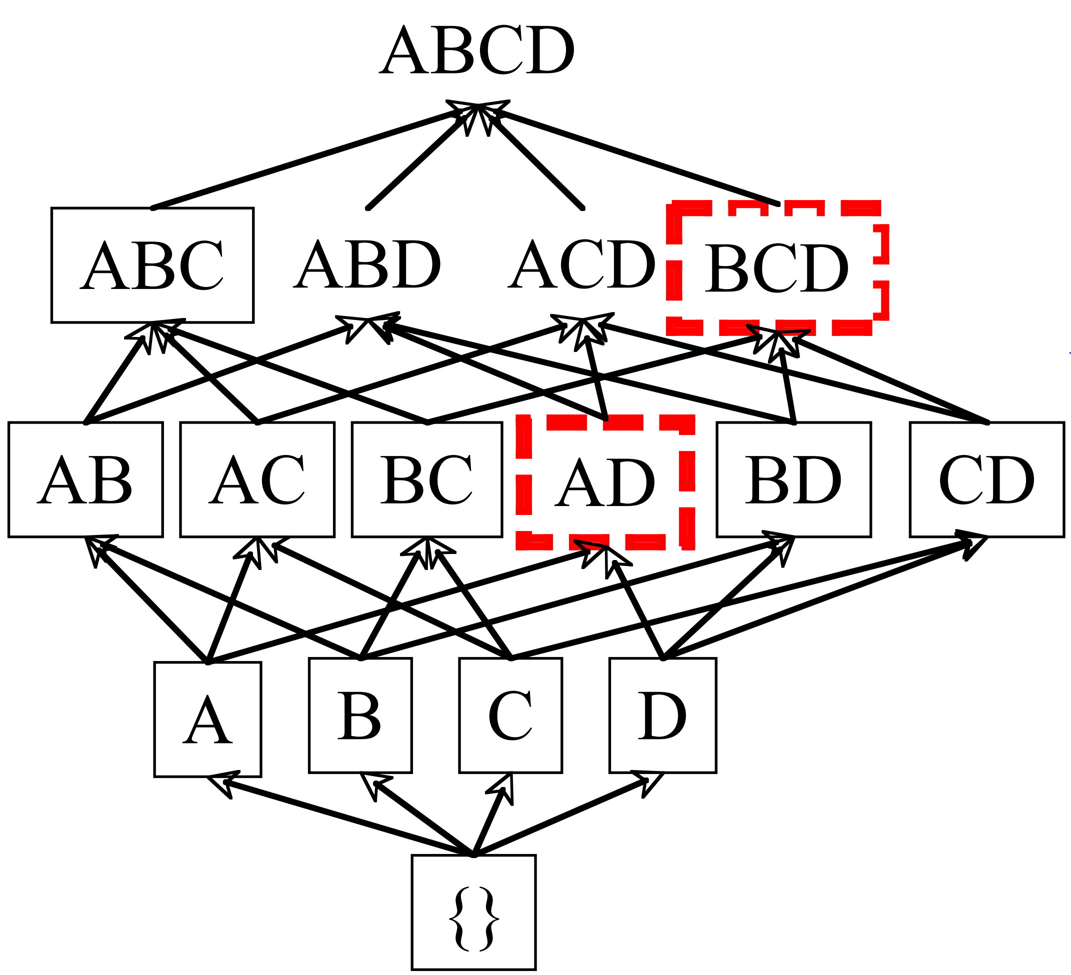
Create hash table H_2 using hash function $h(x, y) = ((order\ of\ x) \times 10 + (order\ of\ y))\ mod\ 7$

H_2

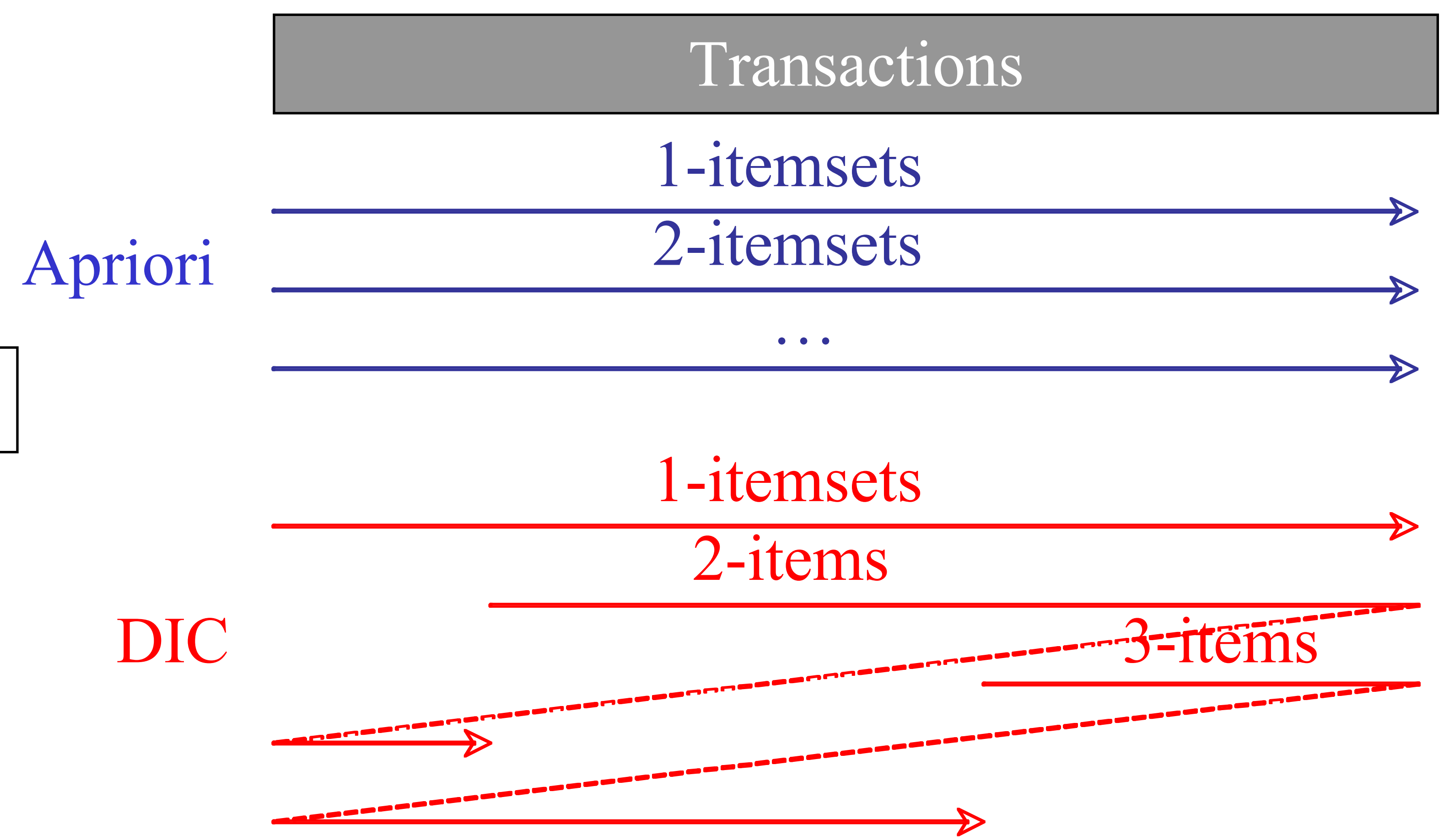
bucket address	0	1	2	3	4	5	6
bucket count	2	2	4	2	2	4	4
bucket contents	{I1, I4} {I3, I5}	{I1, I5} {I1, I5}	{I2, I3} {I2, I3} {I2, I3} {I2, I3}	{I2, I4} {I2, I4}	{I2, I5} {I2, I5}	{I1, I2} {I1, I2} {I1, I2} {I1, I2}	{I1, I3} {I1, I3} {I1, I3} {I1, I3}

Dynamic Itemset Counting

- If A & D are freq., start count for AD
- If BC, BD, CD are freq., start count for BCD



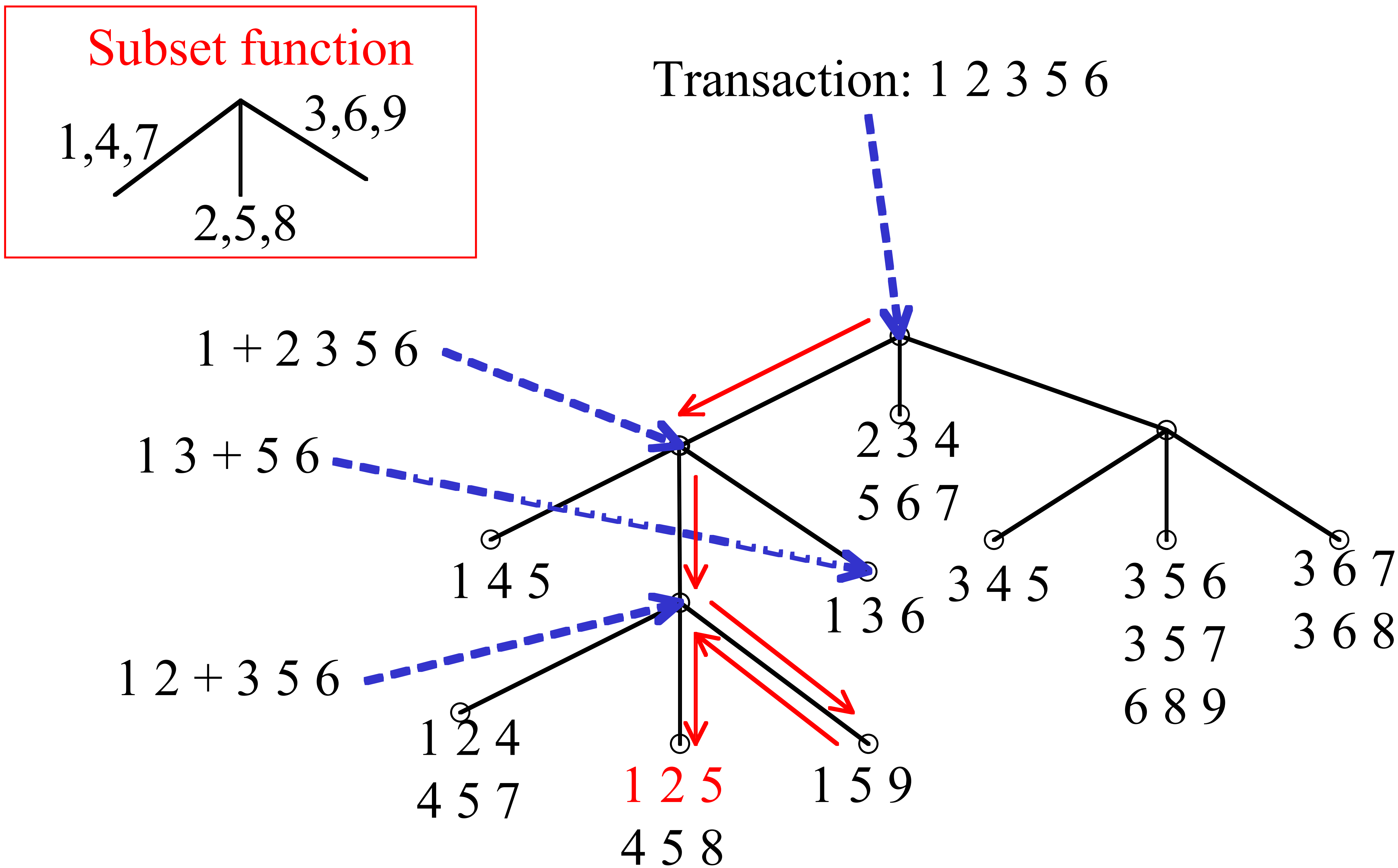
Itemset lattice



Count Support of Candidates

- Why counting candidate support a problem?
  - #candidates: total, per transaction
- Method
  - store candidate itemsets in a hash-tree
  - leaf-node contains a list of itemsets and counts
  - interior node contains a hash table
  - subset function: finds all candidates contained in a transaction

Example


Subset function
1,4,7
3,6,9
2,5,8
Transaction: 1 2 3 5 6
1 + 2 3 5 6
1 3 + 5 6
1 2 + 3 5 6
2 3 4
5 6 7
1 4 5
1 3 6
3 4 5
3 5 6
3 5 7
6 8 9
3 6 7
3 6 8
1 2 4
4 5 7
1 2 5
4 5 8
1 5 9

Vertical Data Format

- Horizontal data format
  - T1: {A, D, E, F}
- Vertical data format
  - t(AD) = {T1, T6, …}
- Derive closed pattern via vertical intersection
  - t(X) = {T1, T2, T3} and t(Y) = {T1, T3, T4}
  - t(XY) = {T1, T3}

Frequent Itemset Mining

- Multiple data scans are costly
- Mining long patterns needs many scans and generates lots of candidates
  - e.g., 100 items: #scans, #candidates
- Bottleneck
  - candidate generation & test
- Can we avoid candidate generation?

FP-growth (1)

- Find frequent itemsets without candidate generation
- Grow long patterns from short ones using local frequent items
- Example
  - abc is a frequent itemset
  - get all transactions with abc: DB | abc
  - d is a local frequent item in DB | abc
  - then abcd is a frequent itemset

FP-tree Construction

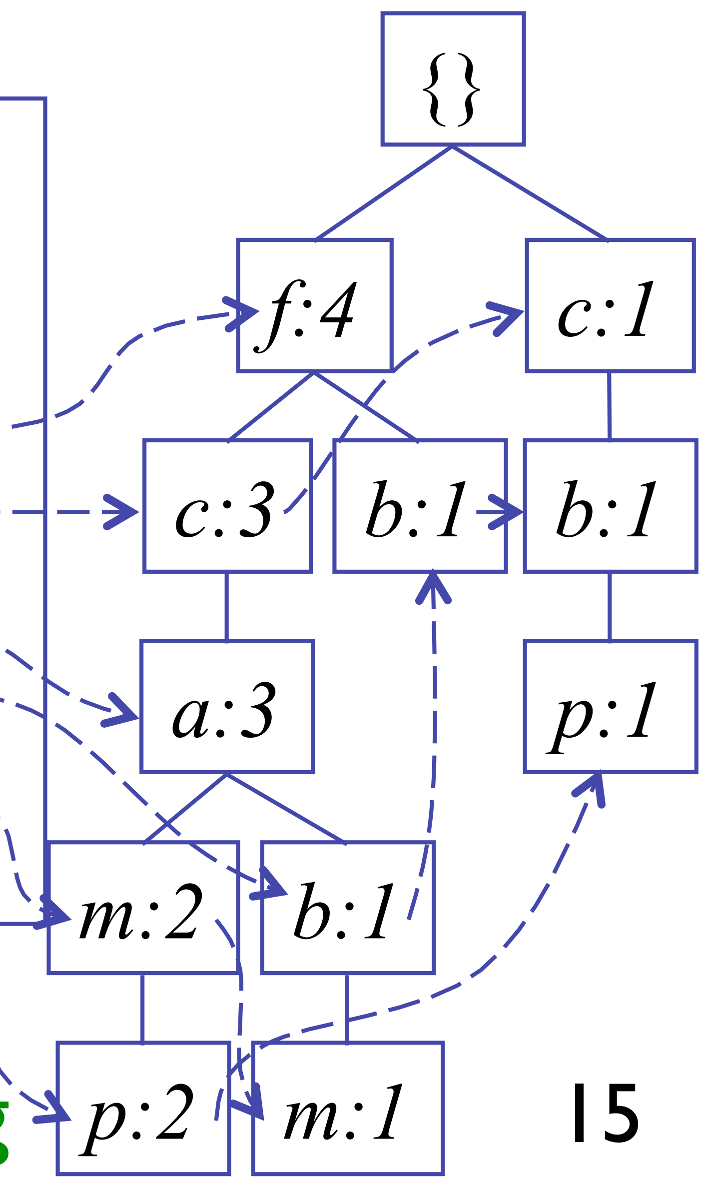
TID	*Items bought*	*(ordered) frequent items*
100	*{f, a, c, d, g, i, m, p}*	*{f, c, a, m, p}*
200	*{a, b, c, f, l, m, o}*	*{f, c, a, b, m}*
300	*{b, f, h, j, o, w}*	*{f, b}*
400	*{b, c, k, s, p}*	*{c, b, p}*
500	*{a, f, c, e, l, p, m, n}*	*{f, c, a, m, p}*

min_sup = 0.6

- Scan, find freq. 1-itemset
- Sort freq. items in descending frequency
- Scan, construct FP-tree

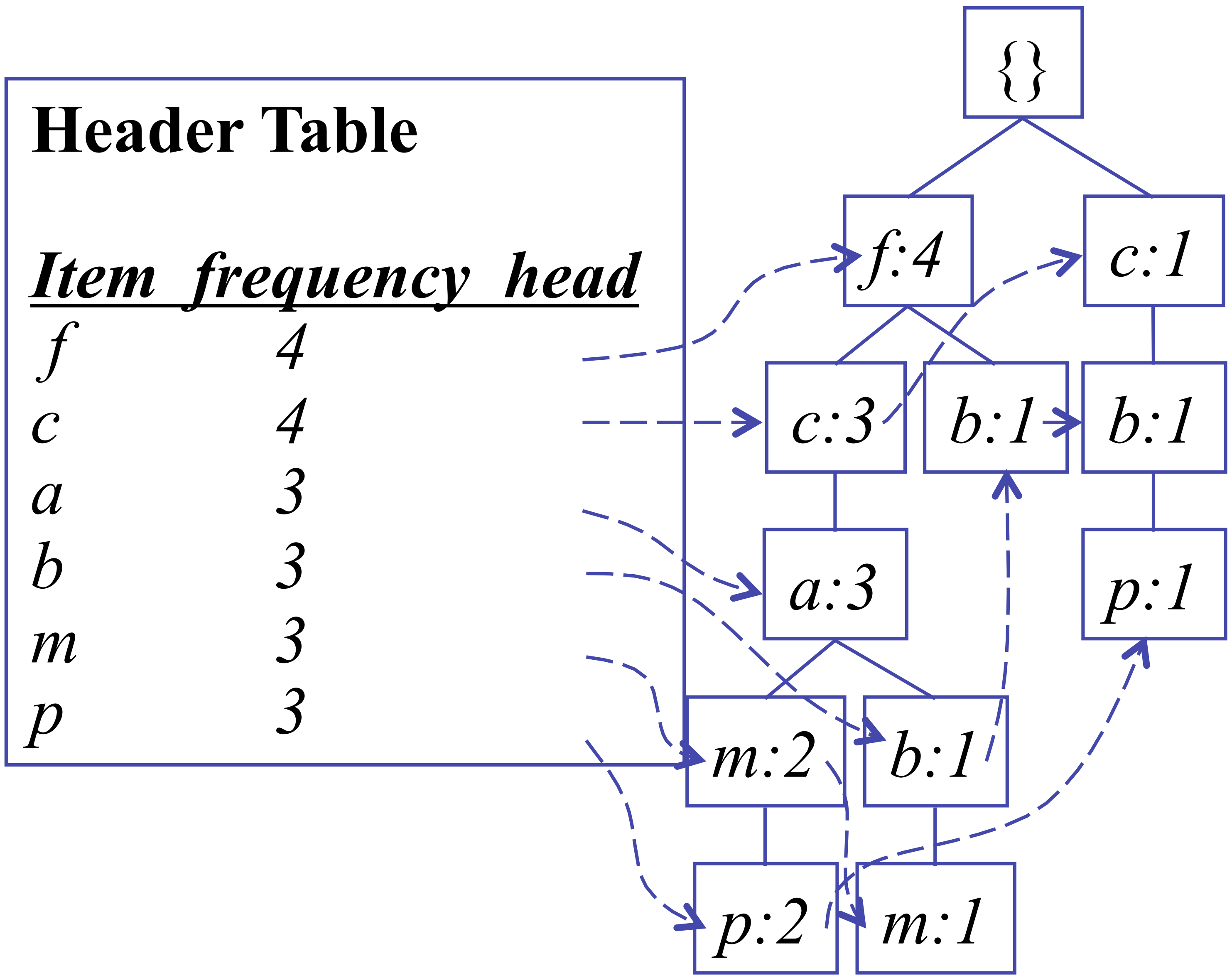
Header Table

Item	*frequency*	*head*
f	4	
c	4	
a	3	
b	3	
m	3	
p	3	



Conditional Pattern Base

- Traverse links of each frequent item, prefix paths

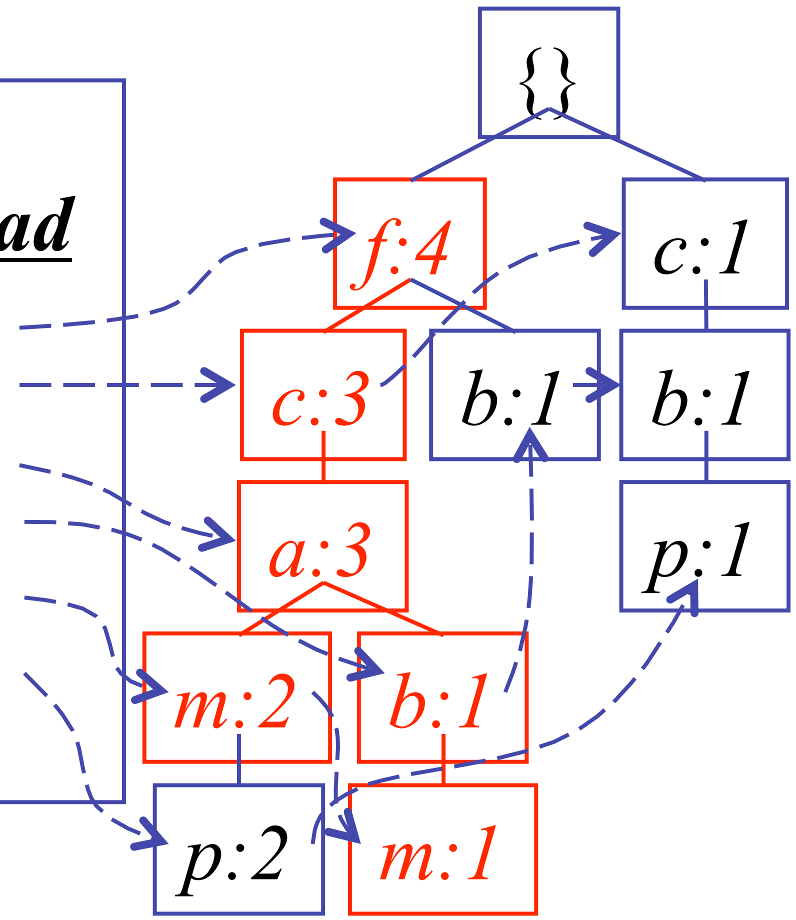


Conditional **pattern bases**

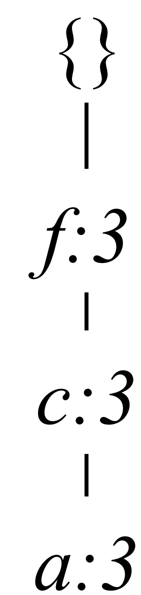
item	***cond. pattern base***
c	***f:3***
a	***fc:3***
b	***fca:1, f:1, c:1***
m	***fca:2, fcab:1***
p	***fcam:2, cb:1***

Conditional FP-trees

Header Table		
Item	***frequency***	***head***
f	4	
c	4	
a	3	
b	3	
m	3	
p	3	



m-conditional **pattern base:**
fca:2, fcab:1



m-conditional **FP-tree**

All frequent patterns relate to *m*

m,
fm, cm, am,
fcm, fam, cam,
fcam

FP-growth (2)

- Idea: Frequent pattern growth
  - recursively grow freq. patterns by pattern and data partition
- Method
  - freq. item => conditional pattern base => conditional FP-tree
  - repeat on each newly created FP-tree
  - until FP-tree is empty or single path

FP-growth vs. Apriori