SHUTTLE BUS PLANNING

FANTASTIC FOUR

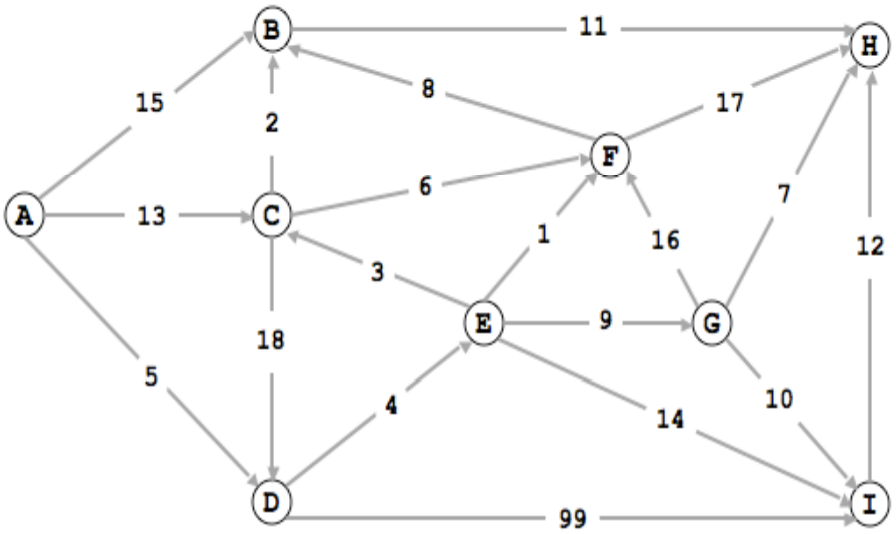
Kastroll, Benjamin
Nair, Mihir
Ravi, Sriganesh
Zhou, Yan

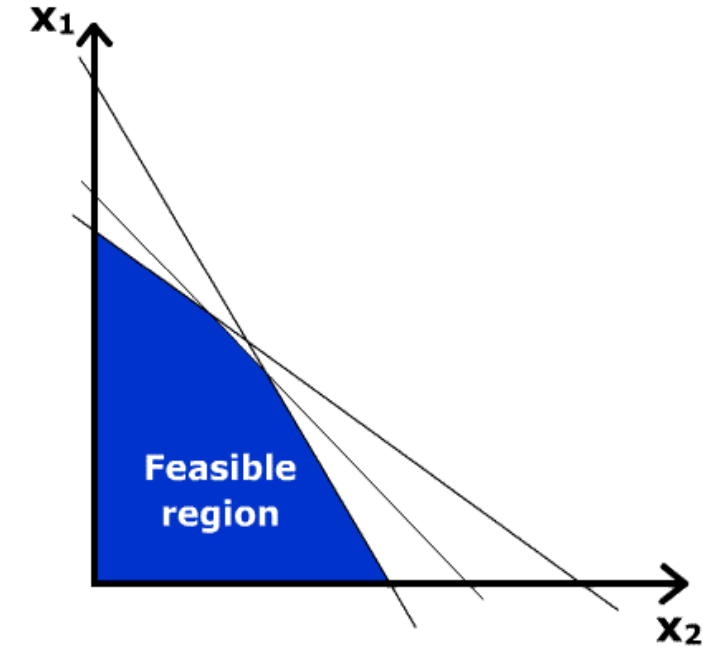
Agenda

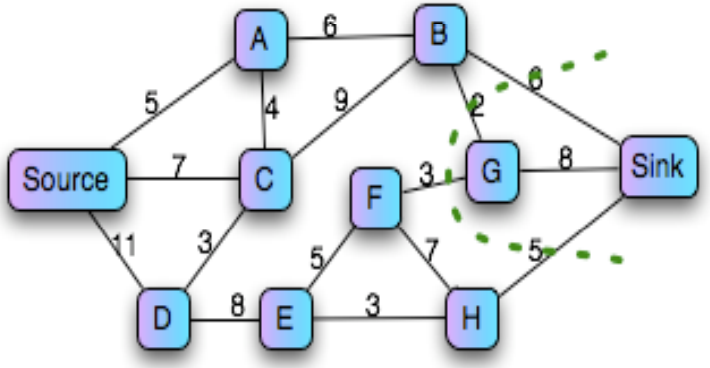
- The Approach
- Team Progress
- Optimal Function & Constraints
- Shortest Path
- Popular Stops & Maximum Flow
- Final Route
- Tram Occupancy
- Schedule
- Frequency
- Conclusion & Questions

The Approach

- Linear Programming
- Shortest Path
- Maximum Flow

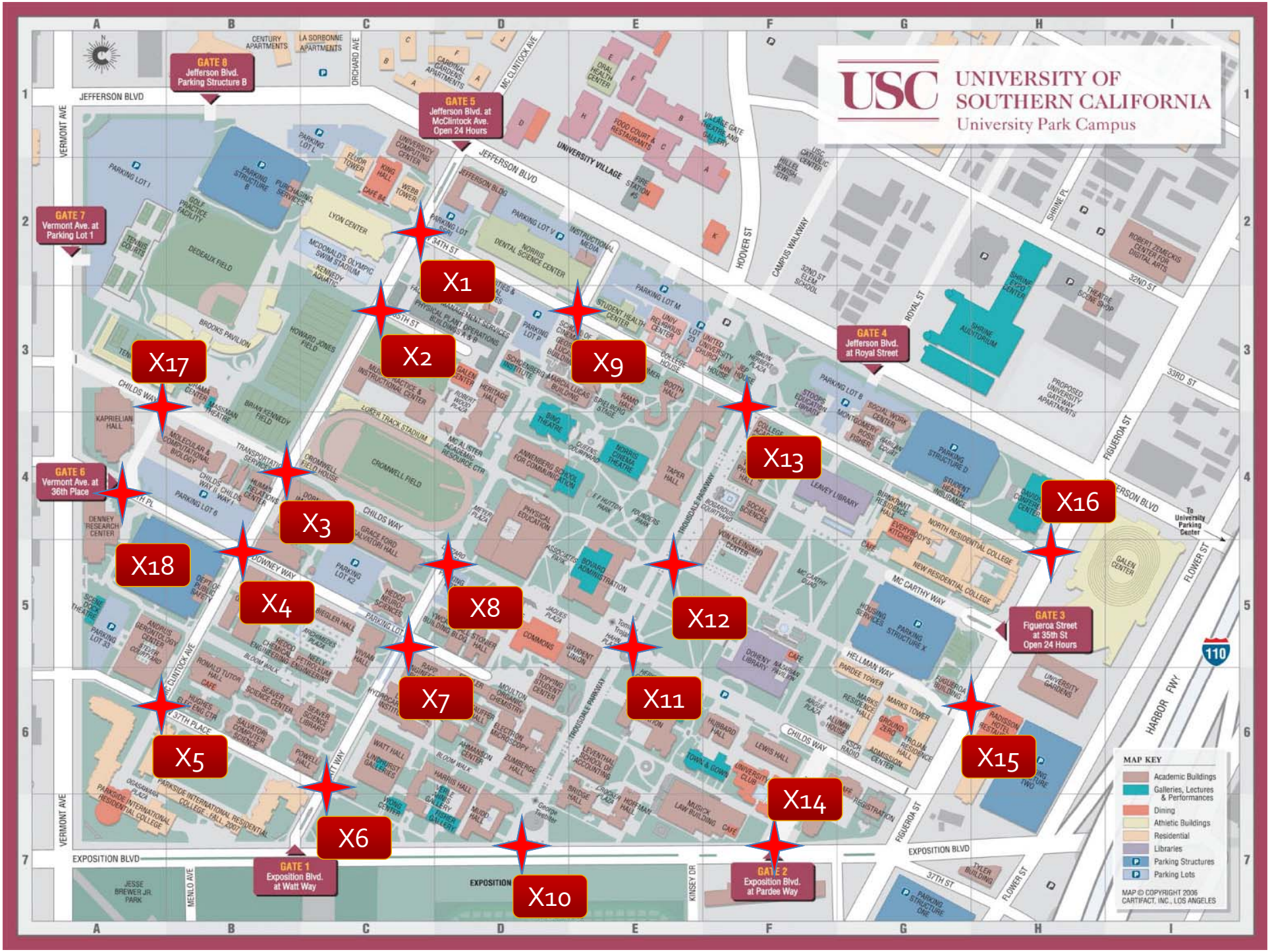






Team Progress

- ✓Project scope
- ✓Bus stops
- ✓Routes
- ✓Bus schedule
- ✓Conclusion


USC
UNIVERSITY OF SOUTHERN CALIFORNIA
University Park Campus
GATE 8
Jefferson Blvd. Parking Structure B
GATE 5
Jefferson Blvd. at McClintock Ave. Open 24 Hours
GATE 7
Vermont Ave. at Parking Lot 1
GATE 4
Jefferson Blvd. at Royal Street
GATE 6
Vermont Ave. at 36th Place
GATE 3
Figueroa Street at 35th St Open 24 Hours
GATE 1
Exposition Blvd. at Watt Way
GATE 2
Exposition Blvd. at Pardee Way
X1
X2
X3
X4
X5
X6
X7
X8
X9
X10
X11
X12
X13
X14
X15
X16
X17
X18
JEFFERSON BLVD
EXPOSITION BLVD
VERMONT AVE
HOOVER ST
FIGUEROA ST
HARBOR FWY
110
MAP KEY
Academic Buildings
Galleries, Lectures & Performances
Dining
Athletic Buildings
Residential
Libraries
Parking Structures
Parking Lots
MAP © COPYRIGHT 2006 CARTIFACT, INC., LOS ANGELES

Objective Function

- Maximize:

$$z = x_1 + x_2 + x_3 + x_4 + x_5 + x_6 +$$

$$x_7 + \frac{1}{3}x_8 + x_9 + x_{10} + 5x_{11} + \frac{1}{5}x_{12} +$$

$$x_{13} + x_{14} + \frac{1}{2}x_{15} + x_{16} + x_{17} + x_{18}$$

Constraints

$$(1)\ x_1 + x_2 + x_3 + x_4 + x_5 \leq 4$$

$$(2)\ x_5 + x_6 \leq 2$$

$$(3)\ x_6 + x_7 + x_8 + x_9 \leq 3$$

$$(4)\ x_{10} + x_{11} + x_{12} + x_{13} \leq 2$$

$$(5)\ x_1 + x_9 + x_{13} + x_{16} \leq 3$$

$$(6)\ x_{12} + x_{15} \leq 1$$

$$(7)\ x_{12} + x_{18} \leq 1$$

Constraints (Cont'd)

$$(8)\ x_{10} + x_{14} \leq 1$$

$$(9)\ x_{15} + x_{16} \leq 2$$

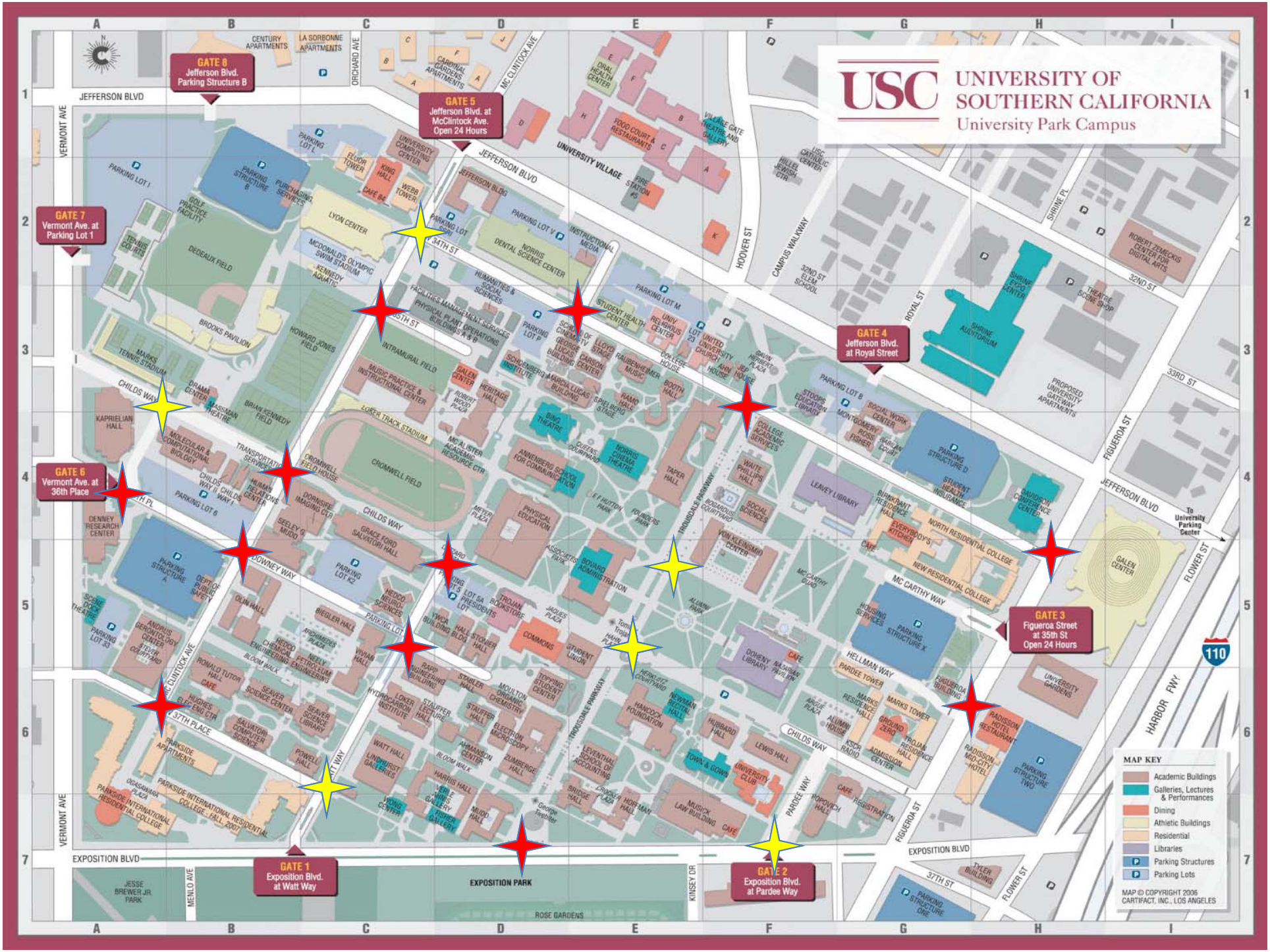
$$(10)\ x_3 + x_8 + x_{11} + x_{17} \leq 2$$

$$(11)\ x_4 + x_7 + x_{18} \leq 3$$

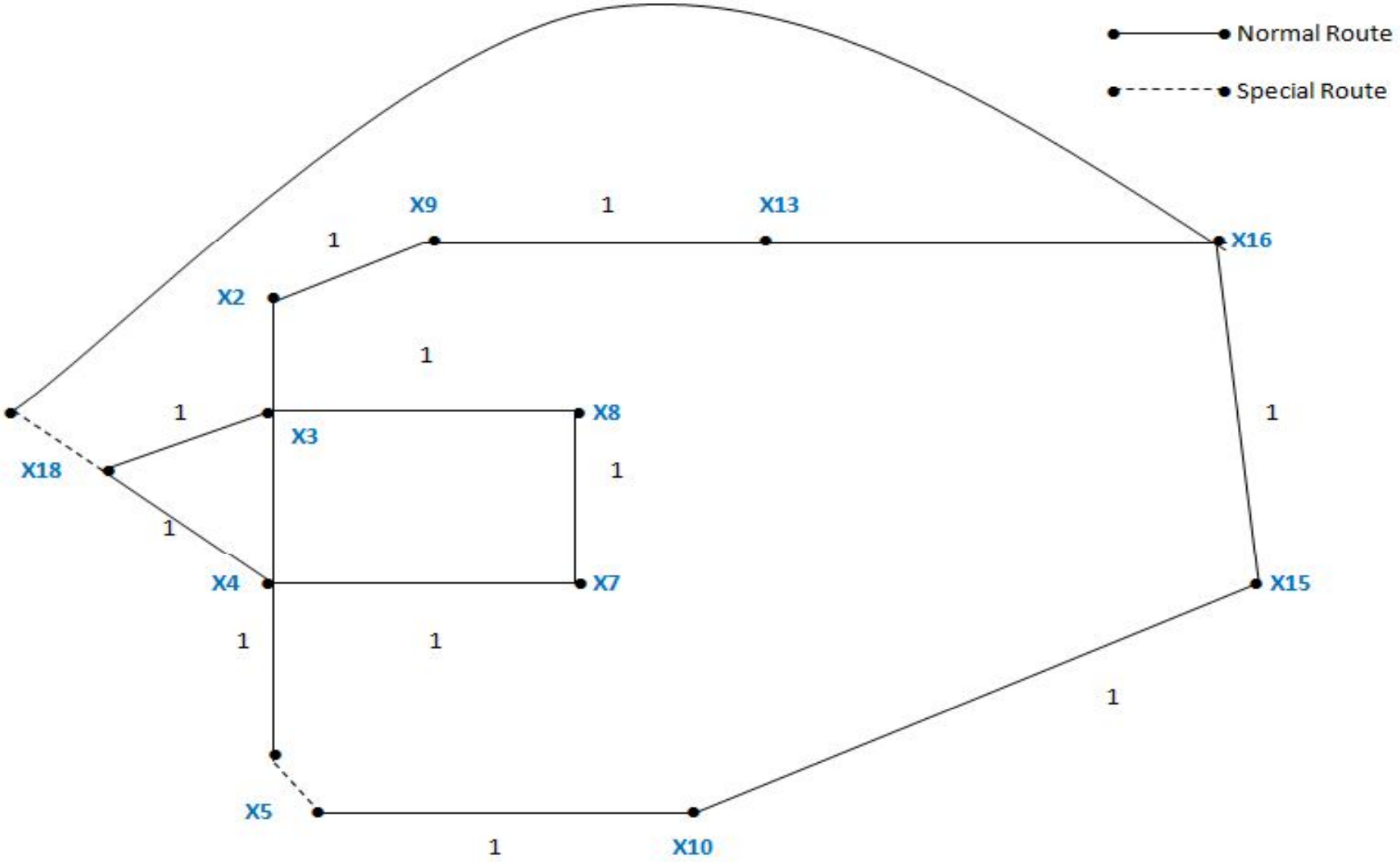
$$(12)\ 0 \leq x_j \leq 1$$

$$(13)\ x_j = Integer$$

Binary Integer Constraints


USC
UNIVERSITY OF SOUTHERN CALIFORNIA
University Park Campus
GATE 8
Jefferson Blvd. Parking Structure B
GATE 5
Jefferson Blvd. at McClintock Ave. Open 24 Hours
GATE 7
Vermont Ave. at Parking Lot 1
GATE 4
Jefferson Blvd. at Royal Street
GATE 6
Vermont Ave. at 36th Place
GATE 3
Figueroa Street at 35th St Open 24 Hours
GATE 1
Exposition Blvd. at Watt Way
GATE 2
Exposition Blvd. at Pardee Way
JEFFERSON BLVD
VERMONT AVE
EXPOSITION BLVD
EXPOSITION PARK
ROSE GARDENS
JESSE BREWER JR. PARK
MENLO AVE
KINSEY DR
ORCHARD AVE
MC CLINTOCK AVE
HOOVER ST
ROYAL ST
FIGUEROA ST
FLOWER ST
HARBOR FWY
110
34TH ST
33RD ST
32ND ST
37TH ST
37TH PLACE
CHILDS WAY
DOWNEY WAY
MC CARTHY WAY
HELLMAN WAY
PARDEE WAY
TROUSDALE PARKWAY
CAMPUS WALKWAY
UNIVERSITY VILLAGE
To University Parking Center
MAP KEY
Academic Buildings
Galleries, Lectures & Performances
Dining
Athletic Buildings
Residential
Libraries
Parking Structures
Parking Lots
MAP © COPYRIGHT 2006 CARTIFACT, INC., LOS ANGELES

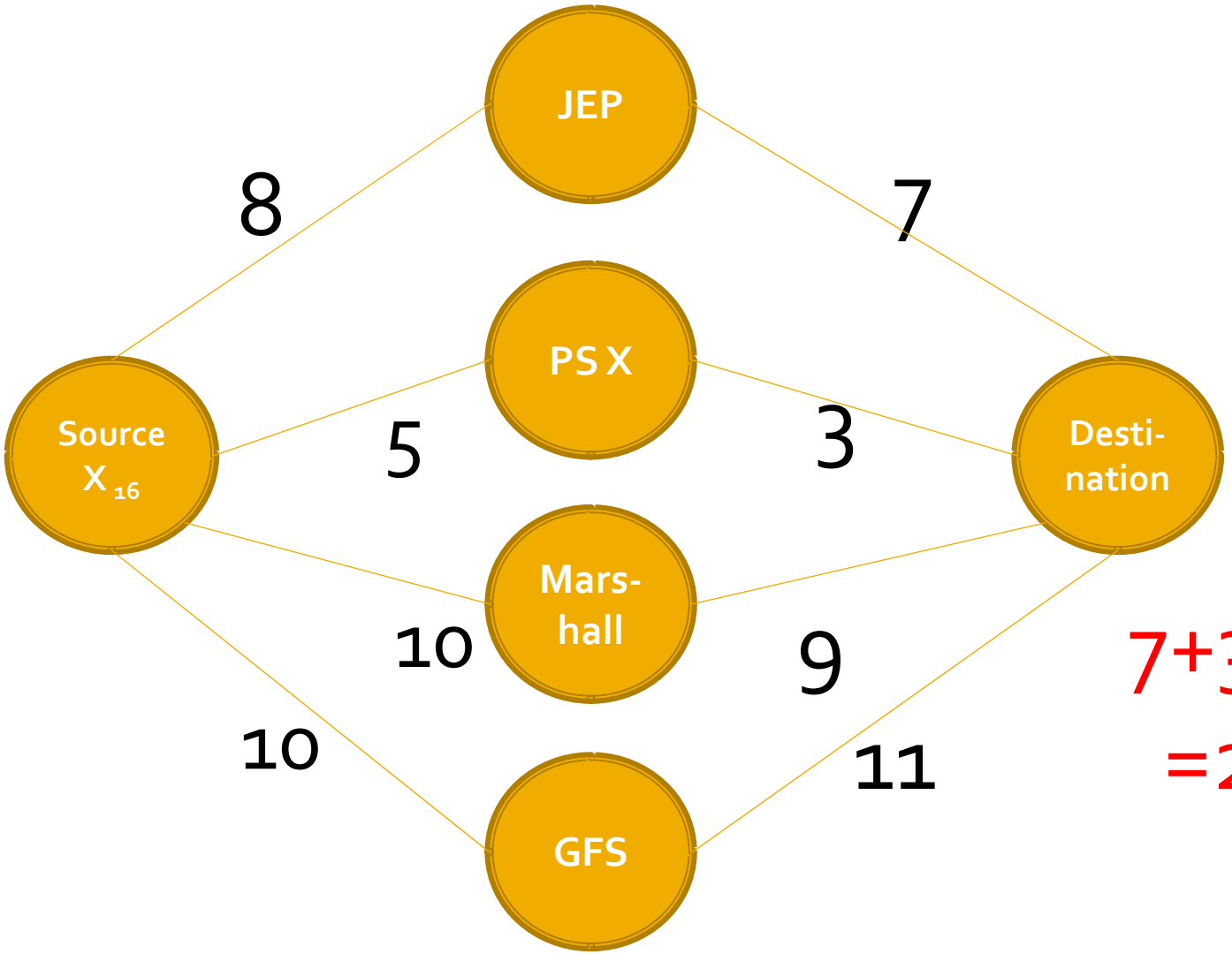
Shortest Path: Network Flow



Popular Stops

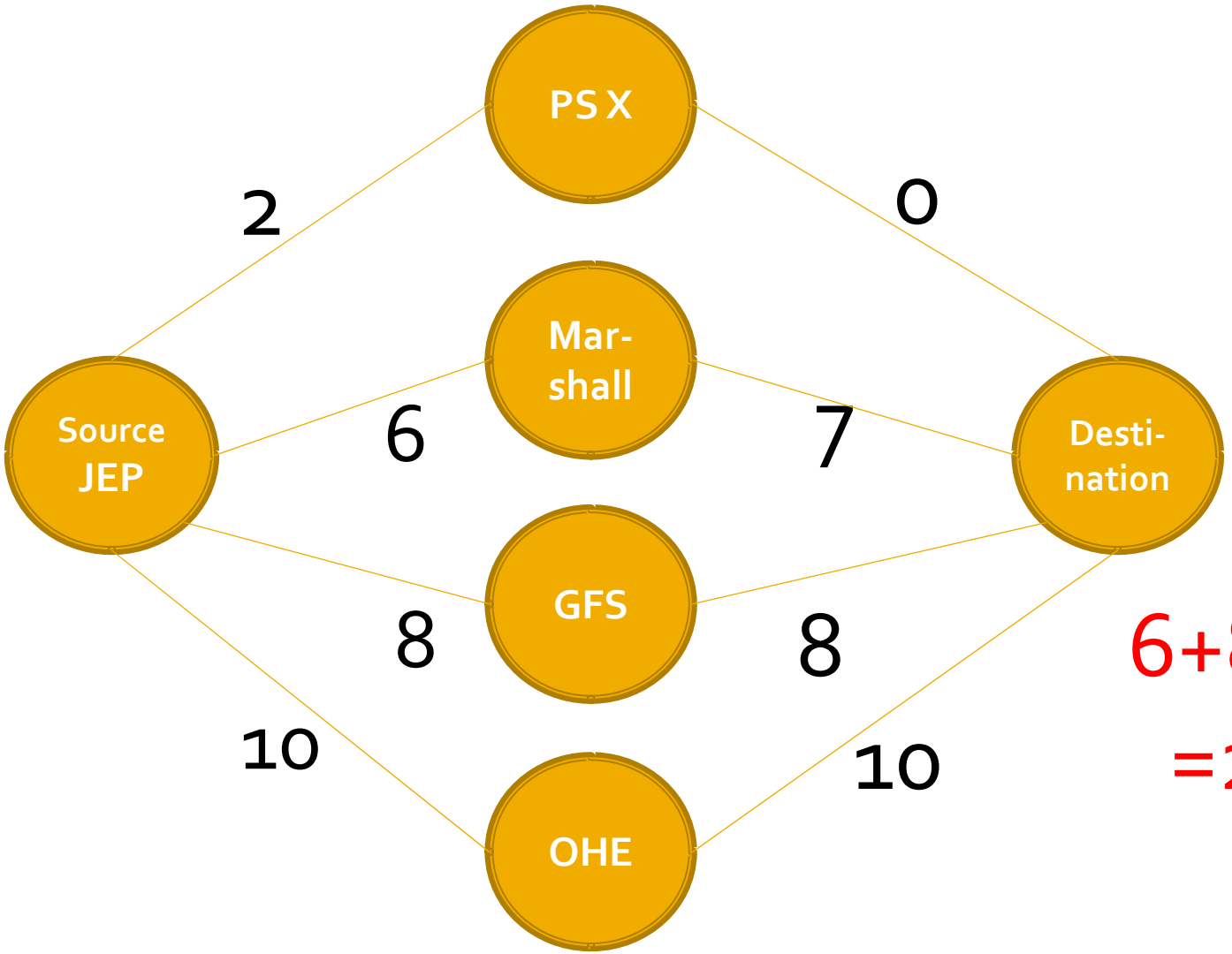
- X_{16} (Parking Structure D)
- JEP
- Marshall School
- OHE
- Parking Structure X
- GFS (Anticipated)

Maximum Flow: Case I, Source: X_{16}



7+3+9+10
=29

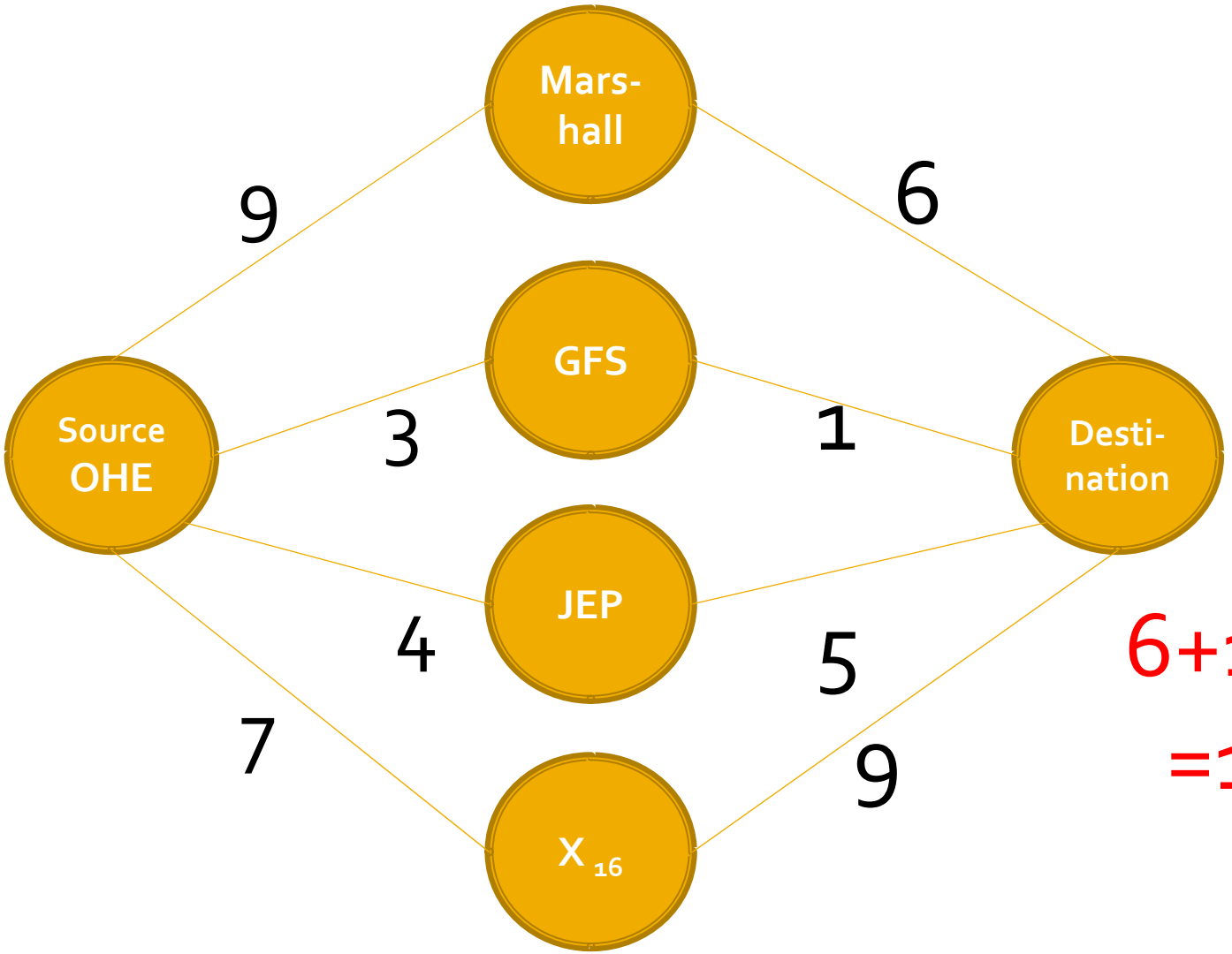
Maximum Flow : Case II,Source: JEP



6+8+10

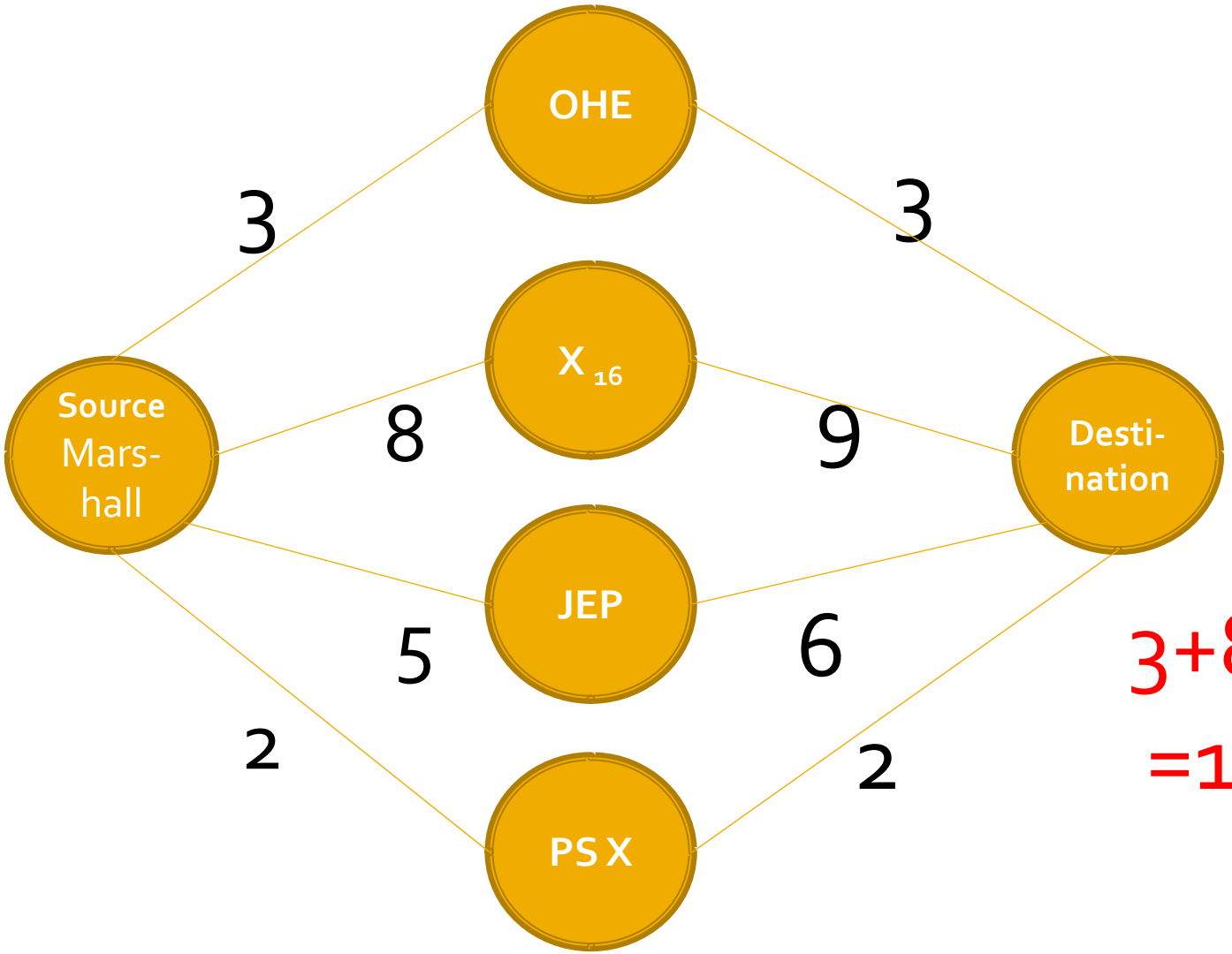
=24

Maximum Flow :Case III,Source:OHE

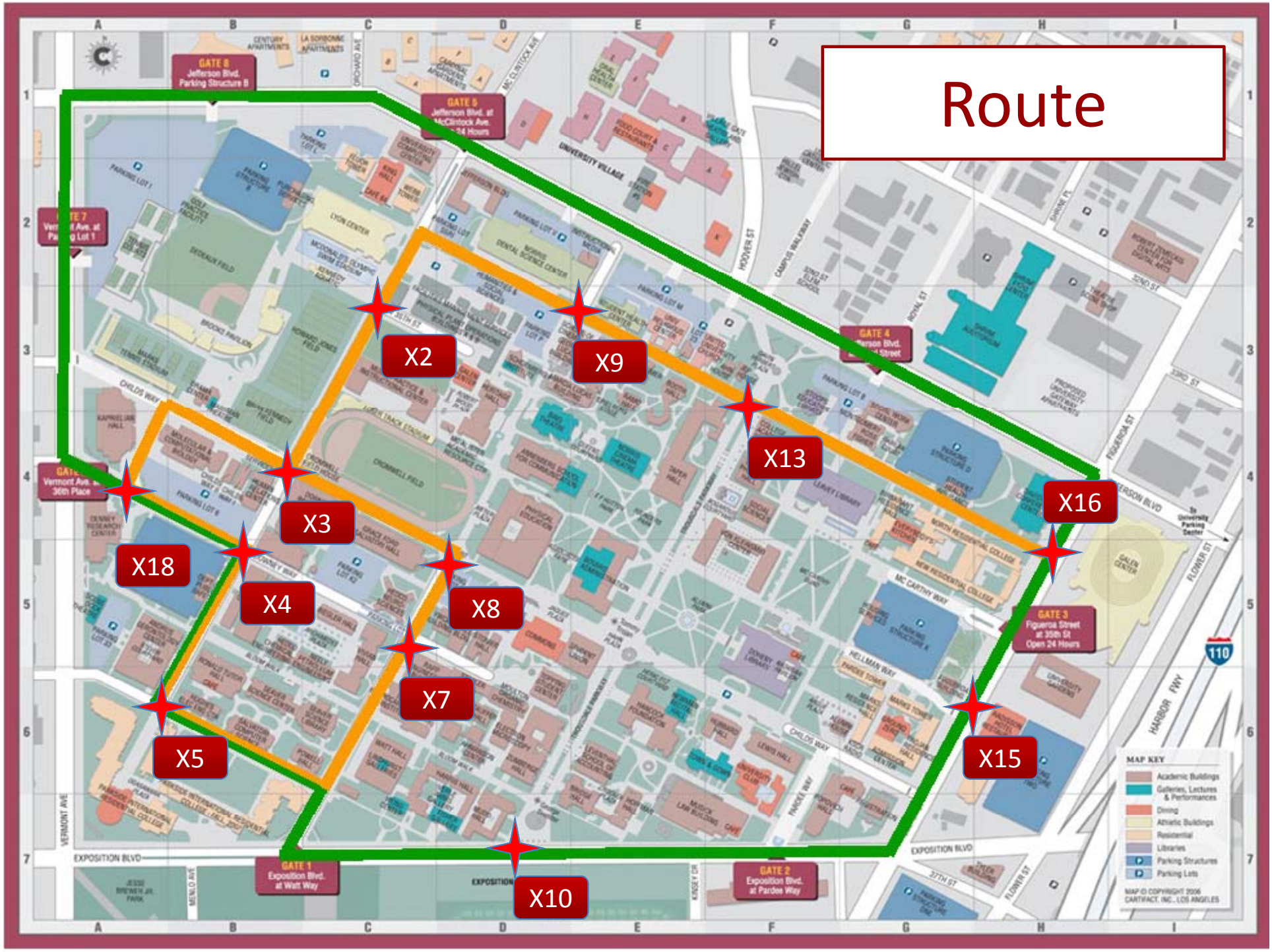


6+1+4+7
=18

Maximum Flow : Case IV,Source: Marshall



3+8+5+2
=18


Route
X2
X9
X13
X16
X3
X18
X4
X8
X7
X5
X15
X10
GATE 8
Jefferson Blvd.
Parking Structure B
GATE 5
Jefferson Blvd. at
McCarthick Ave.
24 Hours
GATE 4
GATE 3
Figueroa Street
at 35th St
Open 24 Hours
GATE 1
Exposition Blvd.
at Watt Way
GATE 2
Exposition Blvd.
at Pardee Way
EXPOSITION BLVD
VERMONT AVE
HOOVER ST
FIGUEROA ST
HARBOR FWY
110
MAP KEY
Academic Buildings
Galleries, Lectures & Performances
Dining
Athletic Buildings
Residential
Libraries
Parking Structures
Parking Lots

Parking Center Tram Occupancy

7:00-8:00 AM → 0.7-1
8:00-9:00 AM → 0.9
9:00-10:00 AM →0.8
10:00-11:00 AM → 0.7
11 :00-12:00 PM → 0.6
12 :00-1:00 PM → 0.4
1:00-2:00 PM → 0.2

Tram Occupancy (Cont'd)

2 :00-3:00 PM → 0.1
3:00-4:00 PM → 0.5
4:00-5:00 PM → 0.9
5:00-6:00 PM → 1
6:00-7:00 PM → 1
7 :00-8:00 PM → 0.6
8:00-9:00 PM → 0.4
9:00-10:00 PM → 0.2

Optimization

- Tram route split into 2:
  - “ON Campus”
  - “OFF Campus”
- Covers more spots on campus
- More flexible to optimize

Parking Structure Tram

Increased activity between following time slots for the "OFF Campus Tram" or "Parking Structure Tram":

- 7:30 am – 9:30 am
- 1:30 pm – 2:00 pm
- 4:30 pm – 6:30 pm
- 8:45 pm -10:00pm

On Campus Tram

Increased on campus activity between schools between:

- 8:45 am – 12:00 pm
- 2:00 pm – 7:30 pm
- 9:15 pm – 10:15 pm

Final Route and Schedule

- Final routes
    1. Route OUT
    2. Route IN
- Identify Peak Hours
    - Route OUT
        - 7:45 am – 10:00 am
        - 4:30 pm – 7:00 pm
        - 9:30 pm - 10:00 pm
    - Route IN
        - 8:00 am – 12:00 pm
        - 2:00 pm – 7:00 pm
        - 9:00 pm – 10:00 pm

Frequency

- Route A
  - Peak hour – Every 15 minutes
  - Non Peak hour – Every 45 minutes
- Route B
  - Peak hour – Every 15 minutes
  - Non Peak hour – Every 30 minutes

Conclusion

- Used binary & integer constraints to derive and maximize an LPP
- Found shortest path
- Analyzed 4 cases of Maximum Flow based on popular stops
- Optimized 2 separate tram routes to increase flexibility and range
- Found that during peak hours they run every 15 minutes

QUESTIONS ?

FANTASTIC 4

Kastroll Benjamin
Nair Mihir
Ravi Sriganesh
Zhou Yan

References

- USC Transportation: http://transnet.usc.edu/transit/tansit.aspx
- Maximum Flow and Minimum Cut:http://scienceblogs.com/goodmath/2007/08/maximum_flow_and_minimum_cut_1.php
- "Introduction to Operations Research" (includes class lectures and notes)