אלגוריתמים היוריסטיים ומקורבים ויישומם 65344

Heuristic and Approximation Algorithms and Applications

סמסטר ק', תשע"ט

Professor Eugene LEVNER

הרצאות 1

סווג אלגוריתמים היוריסטיים.

מה יהיה בקורס הזה?

מבנה הקורס

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3 עבודות מעבדה ומשימות בPYTHON

5 עבודות בית

פרוֹיֶקט

What is AI?

Artificial intelligence (AI) is an area of computer science that includes the creation of intelligent machines that work and react like humans.

Some of the activities, computers with artificial intelligence are designed for include:

Speech recognition

Learning

Planning

Problem solving

Algorithms

בינה מלאכותית

היא תחום של
מדעי המחשב, הכולל יצירת מכונות חכמות
שעובדות ומגיבות כמו בני אדם.
חלק מהפעילות עם מחשבים
בינה מלאכותית מתוכננים לכלול:
זיהוי דיבור
למידה
תכנות
FUZZY LOGIC; SMART ALGORITHMS…

בעיות בקורס

- 1 . **SPP with obstacles** (מכשולים)
- **2. TSP**
- **3. Knapsack**
- **4. Routing of Robots and UAVs**

  (מטוס ללא טייס מל"ט)
- **5. Urgent Evacuation from burning buildings and ships**

אלגוריתמים בקורס

- **1.PRM** (מפת דרכים הסתברותית)
- **2.A***
- **3. Ant Colony**
- **4. PageRank**
- **5-6. Multi-criterial Algorithms:TOPSIS and BORDA**
- **7-8. DP and FPTAS (“almost-optimal”)** עם הבטחת ביצועים
- **9. Genetic Algorithms**

APPLICATIONS IN INDUSTRY AND HEALTHCARE

PRM; A*: ROBOTS IN THE SPACE TODAY
בחלל

מאדים

UAV

Search for Hidden onjects and Failures

Detection of Mines

למה הקורס הזה ?

1. האלגוריתמים הם הליבה של כל מערכת מחשב.
2. אלגוריתמים קירוב הם הרבה יותר **מעשי** מאשר האלגוריתמים המדויקים.

3 . תוכל לציין את PYTHON (ברובוטיקה) בקורות החיים שלכם

מטרות הקורס:

- מטרת הקורס היא:
  - לתת לסטודנטים ידע בסיסי של **התיאוריה, עיצוב ויישומים** מעשיים של אלגוריתמים מקורבים והיוריסטיים.
  .
  - להקנות לסטודנטים כלים **לניתוח והבנה של פיתוח** ויישום אלגוריתמים באמצעות תכנות PYTHON .

- הנושאים שיילמדו בקורס: מבוא לתכנות ב- PYTHON, מבנה תכנית בשפה, טיפוסי נתונים, קלט ופלט, ביטויים חשבוניים ולוגיים, משפטי בקרה, לולאות, פתרון בעיות ואלגוריתמים, בניית ממשק גרפי למשתמש (GUI) במטרה לשקף תהליכים ותוצאות.

הרכב הציון בקורס:

2% - נוכחות והשתתפות בכל שעורים

50%- ציון עבור מעבדות

50%- ציון עבור פרויקט

שעות קבלה: יום ב' 15:00-16:00

שעות קבלה: יום ג' 16:00-17:00

הפרויקט יכלול:

- תיאור של בעיה 15
- תיאור של האלגוריתם היוריסטי 15 %
- תיאור של השוואה ביין האלגוריתם האוריסטי ואלגוריתם מדויק ב- PYTHON 20%
- סימולאציה ב- PYTHON 0%2
- Results and comclusions 10 %
- תרגילי בית10%
- Poster and Sirton 10%

תוכנית של היום

1. מקום של רובוטים בחיים המודרניים.
2. מקום של אלגוריתמים AI ממוחשבים בחיים המודרניים.
3. PRM

1.מקום של AI ורובוטים בחיים המודרניים.

We live in extraodunary, accelerating times

אנחנו חיים בזמנים יוצאי דופן , בזמנים מאיצים

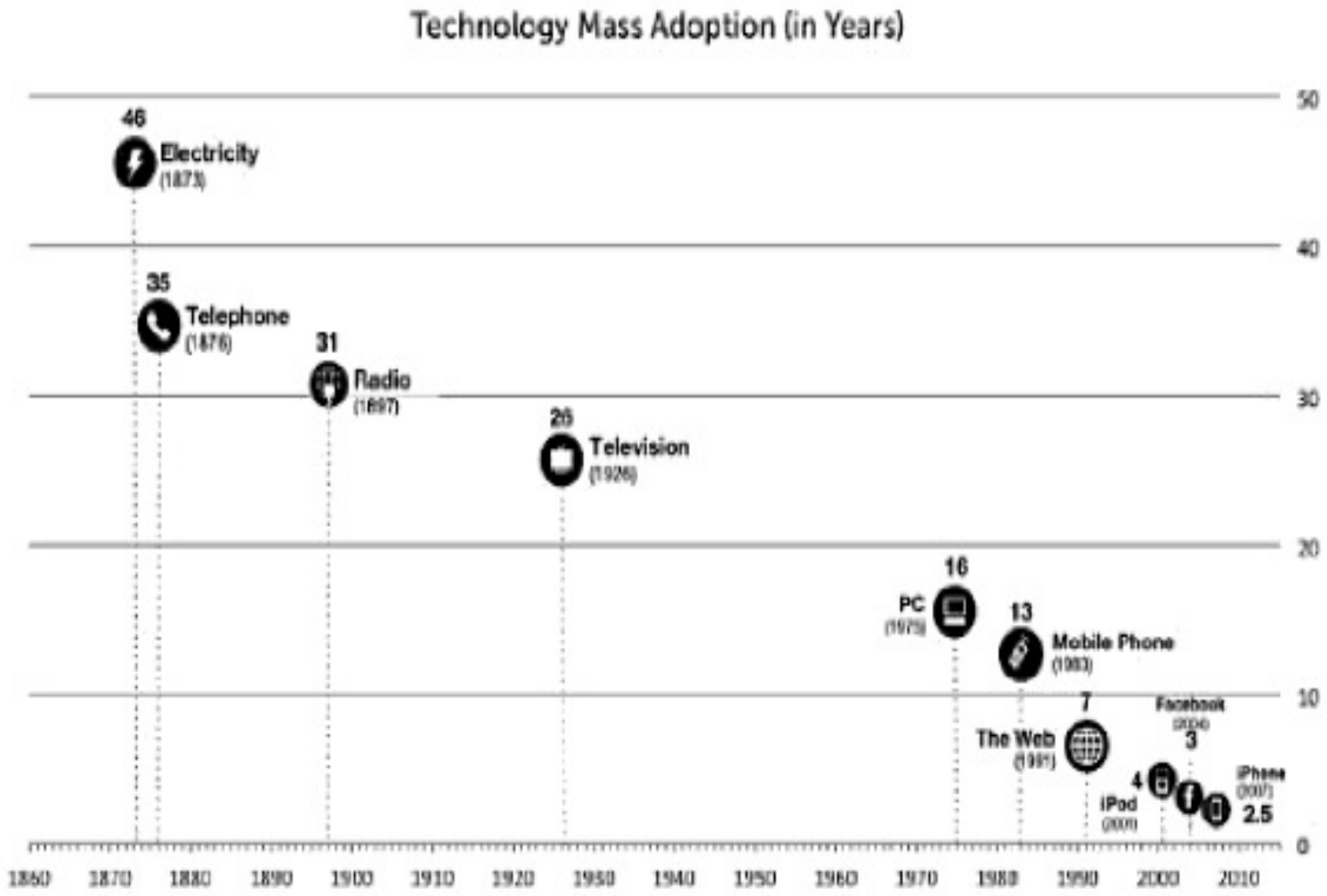
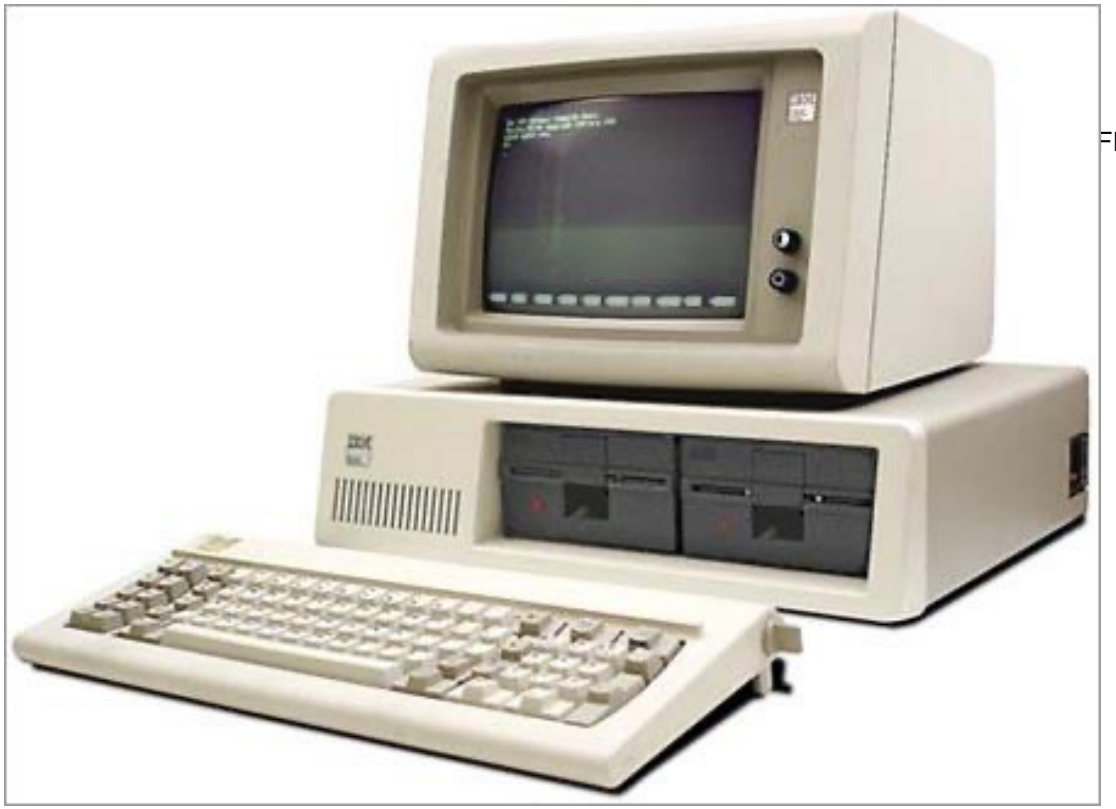
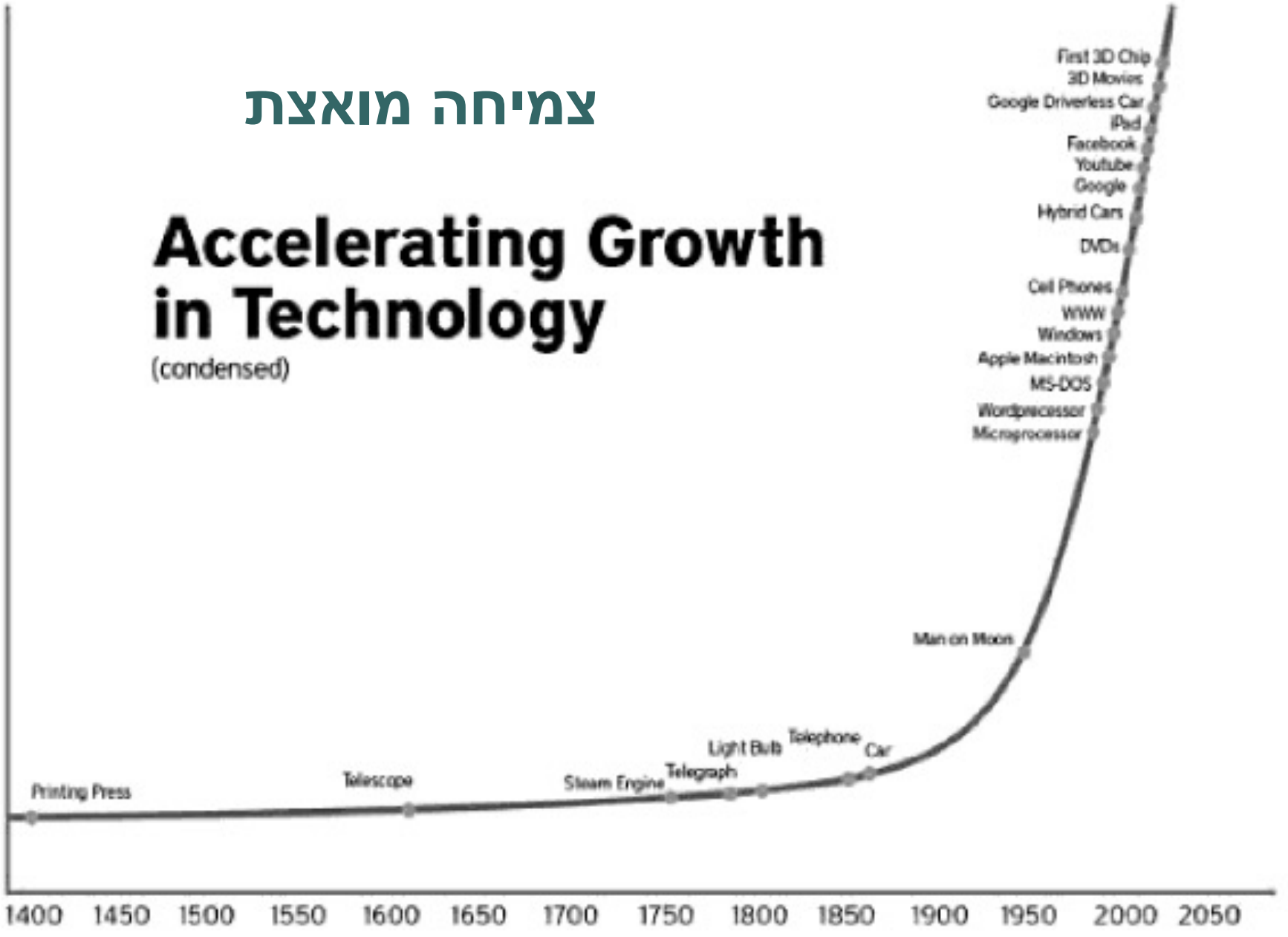


Figure 1.1: Years till mass adoption of specific technologies[2] (Source: Various)



FIRST PC

צמיחה מואצת


Accelerating Growth in Technology
(condensed)
First 3D Chip
3D Movies
Google Driverless Car
iPad
Facebook
Youtube
Google
Hybrid Cars
DVDs
Cell Phones
WWW
Windows
Apple Macintosh
MS-DOS
Wordprocessor
Microprocessor
Man on Moon
Light Bulb
Telephone
Car
Telegraph
Steam Engine
Telescope
Printing Press
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
2050

Three Industrial Revolutions

שלוש מהפכות תעשייתיות

1. The Industrial or Machine Age (1760-1945)
[use of steam power and automated machine-tools]

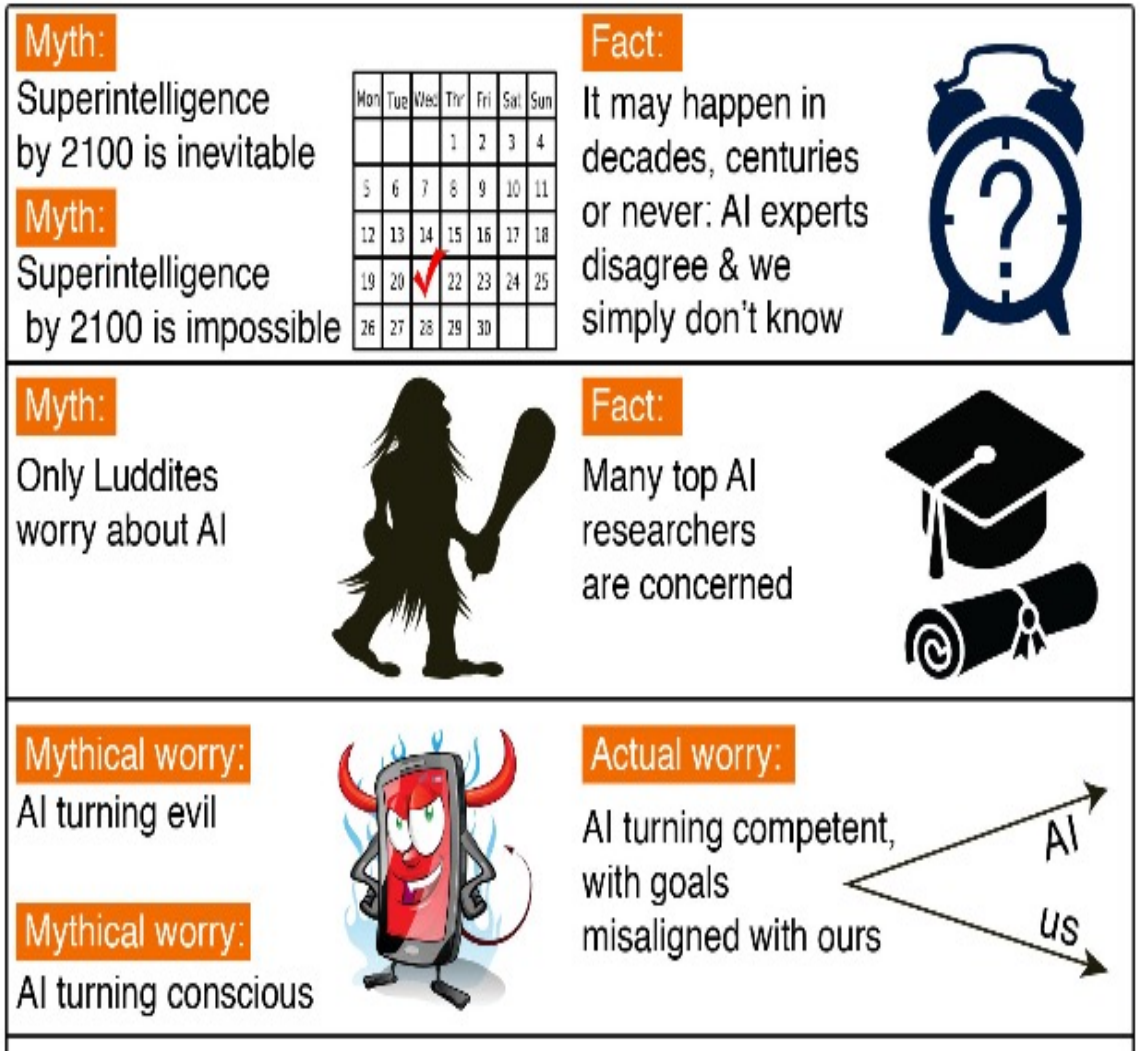
2. The Atomic, Space and Robotic Age (1945-1985)

3. The Information or Digital Age (1985-present)

The total number of books printed up to 1985 is 130 Million, ~~today we produce the same amount 1,000 times every~~ second, or 80,000,000 times every day.

Whether Robots are Dangerous? Benefits and Risks of AI.

האם הרובוטים מסוכנים ? היתרונות והסיכונים של AI.



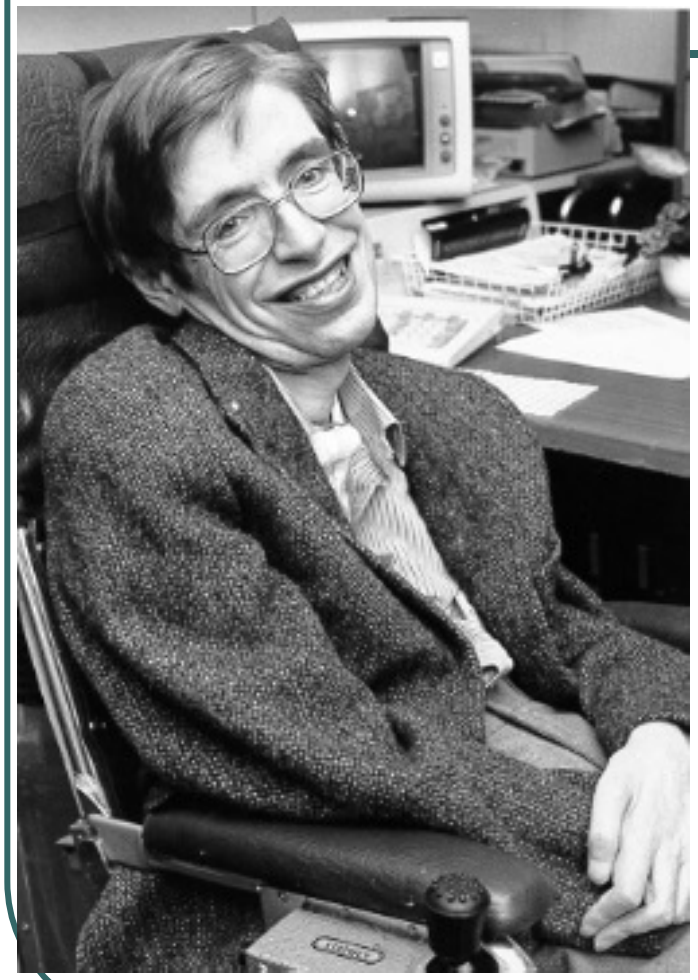
https://futureoflife.org/background/benefits-risks-of-artificial-intelligence/

Stephen Hawking, Elon Musk and Bill Gates warn us about the dangers of robots

http://observer.com/2015/08/stephen-hawking-elon-musk-and-bill-gates-warn-about-artificial-intelligence/

Bill Gates warns that the robots may take most of the human's jobs and do not pay taxes

Stephen William Hawking



(born 8 January 1942) is an English theoretical physicist, cosmologist, author and Director of Research at the Centre for Theoretical Cosmology within the University of Cambridge
His scientific works: gravitational singularity theorems in the framework of general relativity and the theoretical prediction that black holes emit radiation, often called Hawking radiation.
He is a vigorous supporter of the many-worlds interpretation of quantum mechanics,
and a recipient of the Presidential Medal of Freedom the highest civilian award in the usa
his book *A Brief History of Time* appeared on thebest-seller list for a record-breaking 237 weeks.

PROFESSOR STEPHEN HAWKING BELIEVES AI DEVELOPMENTS COULD BE DISASTROUS; robots may replace human by superhumans and destroy the human civilization

פרופ 'סטיבן הוקינג מאמין ההתפתחויות AIיכול היות הרסני

Elon Reeve Musk

Elon Reeve Musk ; born June 28, 1971) is a South African-born Canadian-American business magnate, investor,[engineer and inventor]

He is the founder, CEO, and CTO of SpaceX, a co-founder, a Series A investor, CEO, and product architect of Tesla Inc. co-chairman of OpenAI; founder and CEO of NeuralinkHe was previously co-founder and chairman of SolarCity, co-founder of Zip2; and founder of X.com, which merged with Confinity and took the name PayPal As of May 2017, he has an estimated net worth of $15.2 milliard, making him the 80th-wealthiest person in the world.[22] In December 2016, Musk was ranked 21st on the *Forbes* list of The World's Most Powerful People

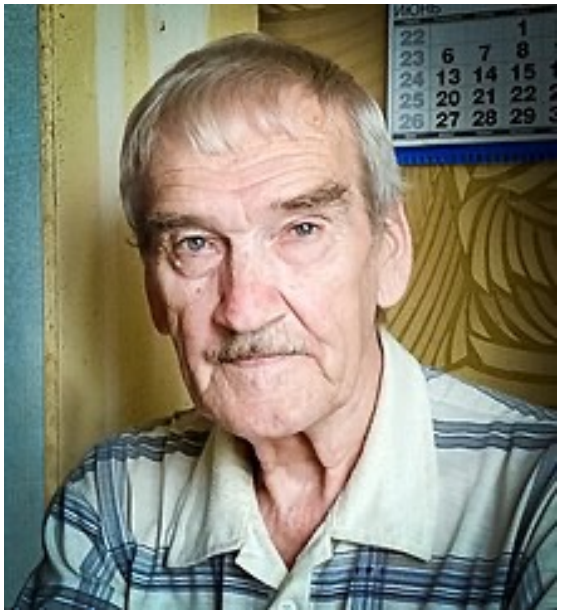
9 of the most jaw-dropping things Elon Musk said about robots and AI in 2019

The global arms race for AI will cause World War III

(see 1983 Soviet nuclear false alarm incident and a story of Stanislav Petrov)

Stanislav Pterov
Vasily Archipov

Google



While Professor Hawking admitted AI could be used for good, he also stated humans need to find a way to control it so that it doe not become more powerful than us as "computers can, in theory, emulate human intelligence, and exceed it."

משימה בית 1. מה היתרונות והחסרונות של AI בעתיד?
(לפי השקפותיהם של הוקינג, מוסק וגייטס)

סווג אלגוריתמים לפי דיוק

- אלגוריתמים מדויקים
- אלגוריתמים מקורבים
- אלגוריתמים היוריסטיים
- אלגוריתמים עם הבטחת ביצועים

4 סוגי בעיות עיקריים בקורס

סוגי בעיות

1. SPP / SPP with obstacles (מכשולים).

2. R-SPP

3 TSP

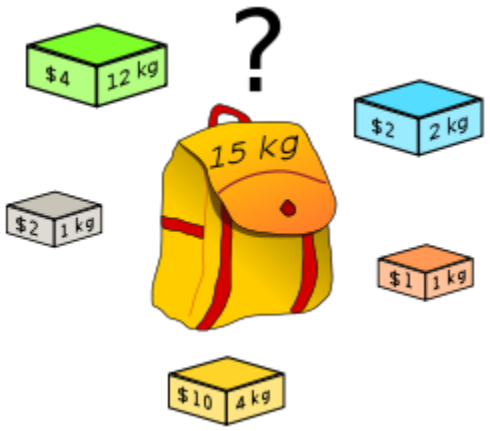
4 Knapsack

TSP and SPP


Check the cities you want to include
Total Distance: 9332 miles.
Stop when no improvement is found after 5 seconds
Find Route
Clear All
Check All


MONTANA
NORTH DAKOTA
MINN.
OREGON
S DAK.
WYOMING
IOWA
Chicago
MICHIGAN
Toronto
UNITED STATES
NEBR.
Denver
NEVADA
UTAH
COLORADO
KANSAS
MO
New York
Philadelphia
Washington, D.C.
Los Angeles
Phoenix
ARIZONA
NEW MEXICO
Santa Fe
Oklahoma City
OKLA.
TEXAS
Dallas
Houston
Memphis
Atlanta
MEXICO

Knapsack



$$x_j = \begin{cases} 1 & \text{if the article is included} \\ 0 & \text{otherwise} \end{cases}$$

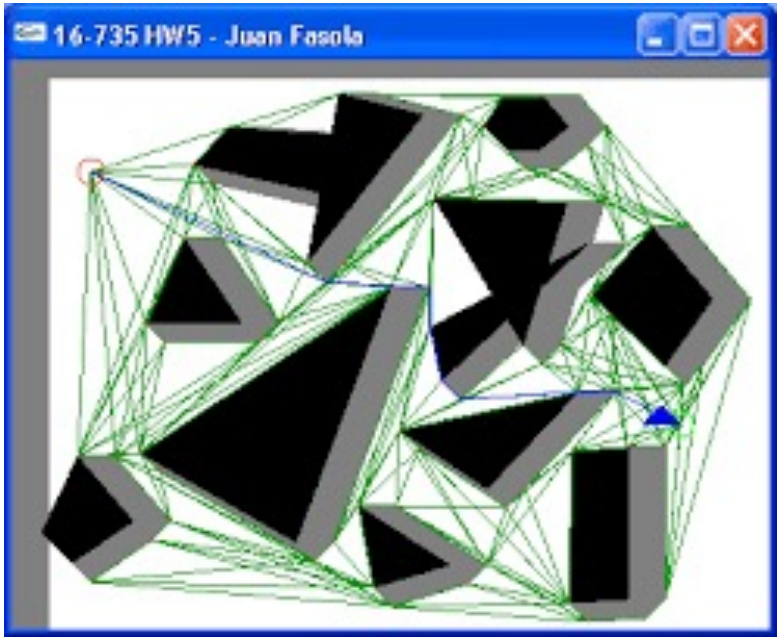
The problem consists in optimizing the objective function

$$\text{Max } f(x) = \sum_{j=1}^{n} x_j u_j$$

subject to the constraint

$$\sum_{j=1}^{n} w_j x_j \leq w$$

. SPP with obstacles (מכשולים)



Approximation Algorithms

- An approximation produces a solution s
  - s is called a **δ-approximation** to the optimal solution if
  - c(s) ≤ δ OPT (for the minimization problem).
  - OPT ≤ δ c(s), (for a maximization problem)
    - In the both cases we assume that δ>1

I. Classification of Heuristic Algorithms

- Deteministic versus stochastic
- Single solution based vs population based
- Nature inspired vs non-nature inspired
- Greedy vs Iterative
- With-memory vs memoryless

Greedy Algorithms

- Local search,
- random search,
- PRM <probabilistic roadmap path algorithm>,.
- A*

The main principle of s-heuristics

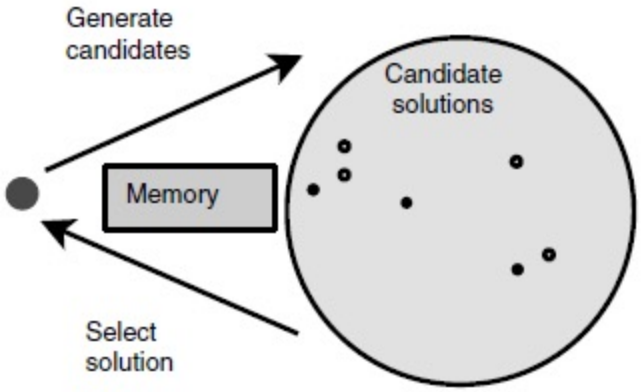


FIGURE 2.1 Main principles of single-based metaheuristics.

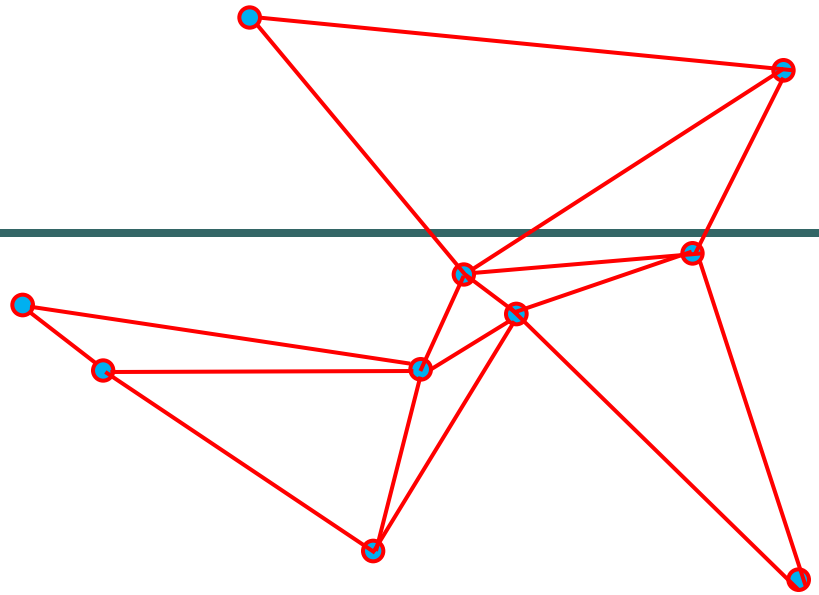
Template of the s-heuristics

Algorithm 2.1 High-level template of S-metaheuristics.

Input: Initial solution s_0.
$t = 0$;
Repeat
  /* Generate candidate solutions (partial or complete neighborhood) from s_t */
  Generate($C(s_t)$) ;
  /* Select a solution from $C(s)$ to replace the current solution s_t */
  s_{t+1} = Select($C(s_t)$) ;
  $t = t + 1$;
Until Stopping criteria satisfied
Output: Best solution found.

C(s_i) - the set of candidate solutions

leed to define init.solut., neighbothood, obj. function and stopping rule.



Nearest Insertion (NI): הכניסה הקרובה ביותר

1.Start with 2-city tour consisting of the some city and its nearest neighbor.

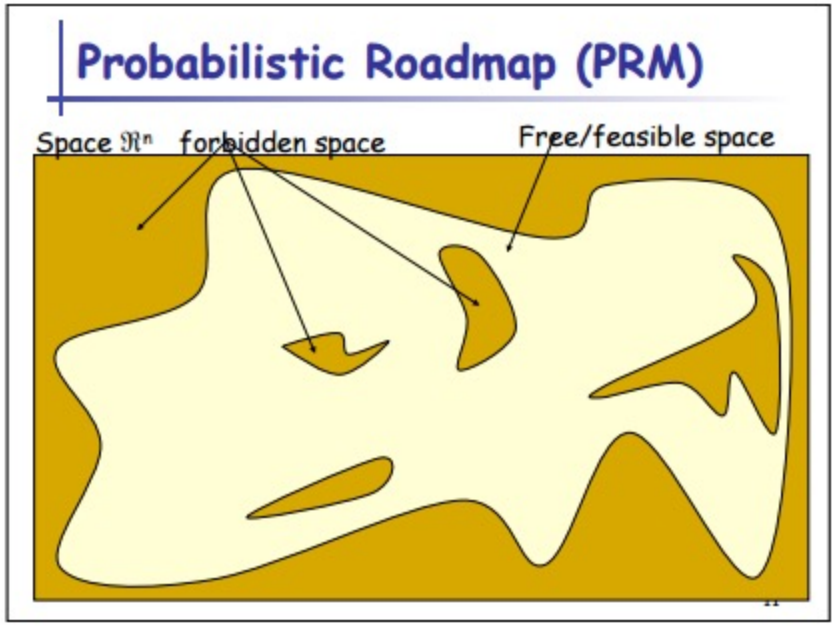
2.Repeatedly insert the non-tour city that is closest to a tour city (in the location that yields the smallest increase in tour length).

- **PRM**

The basic idea behind PRM

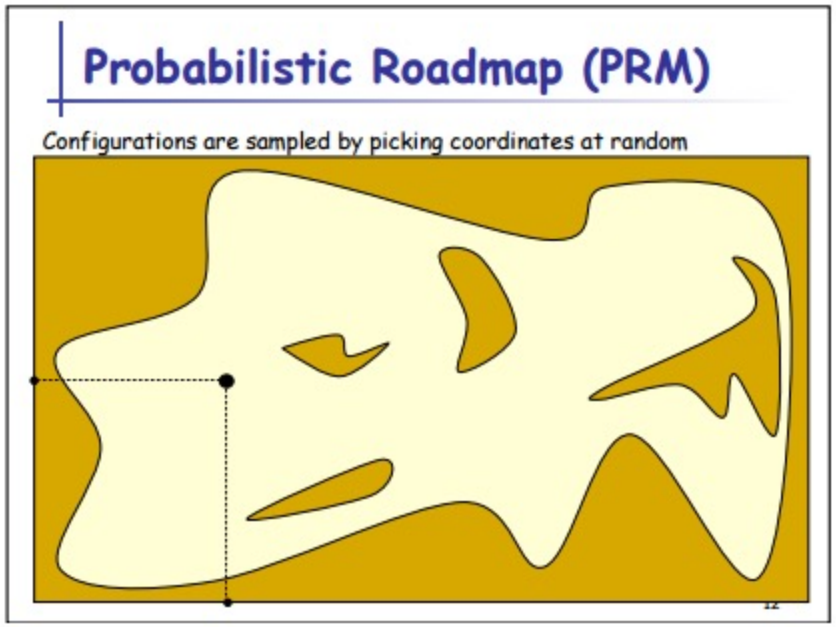
- Phase 1 (construction, בְּנִיָה). Take random samples from the configuration space of the robot, test them for whether they are in the free space, and attempt to connect these configurations (תְצוּרָות ,points) to other nearby configurations (points). The starting and goal configurations are added in
- Phase 2 (query, חֲקִירָה, שְׁאֵלָה,)
- . A graph search algorithm determines a path between the starting and goal configurations.

PRM Initialization



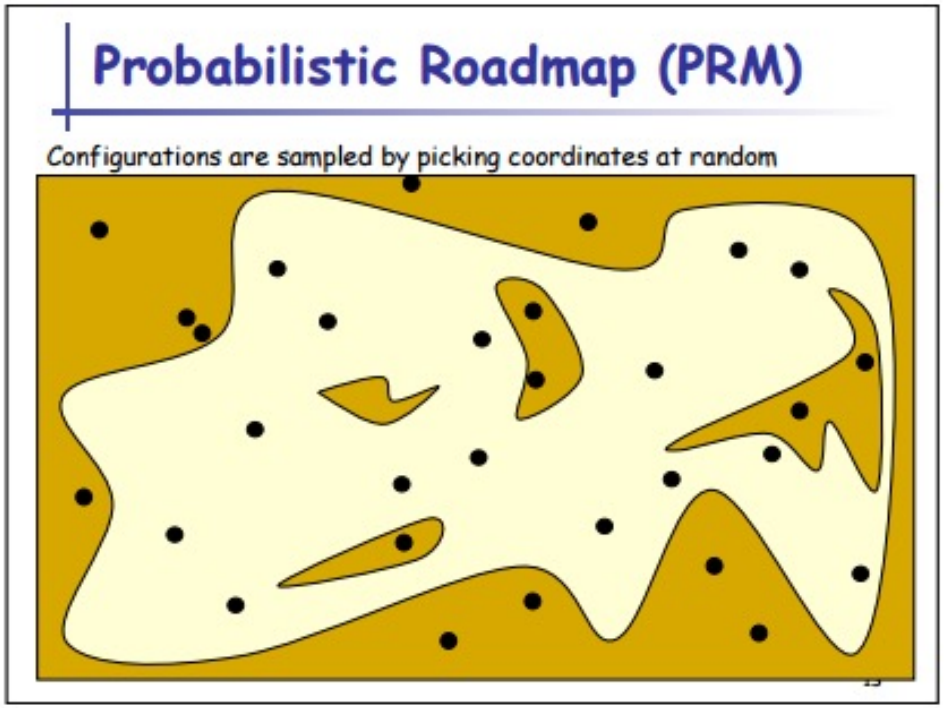
PRM - Phase 1 Construction

- 1



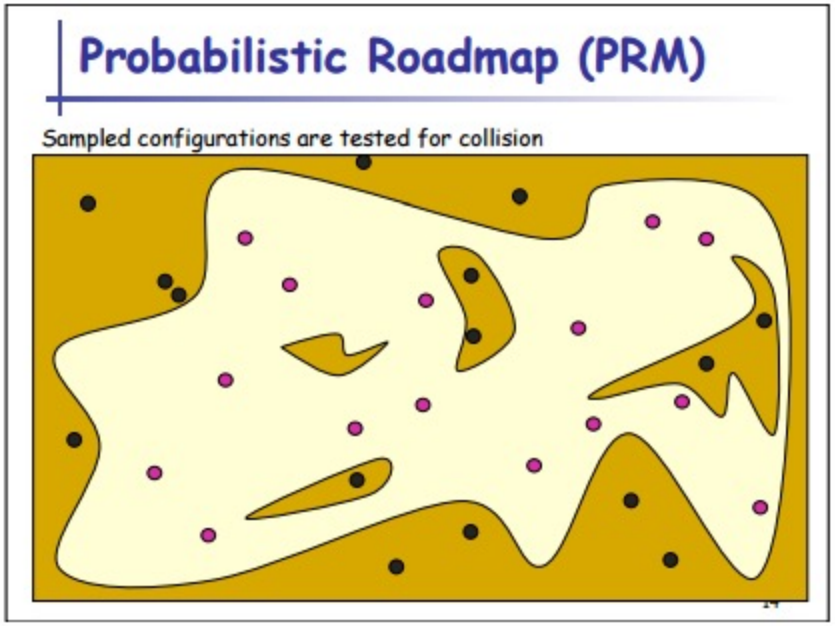
PRM

- 2


Probabilistic Roadmap (PRM)
Configurations are sampled by picking coordinates at random

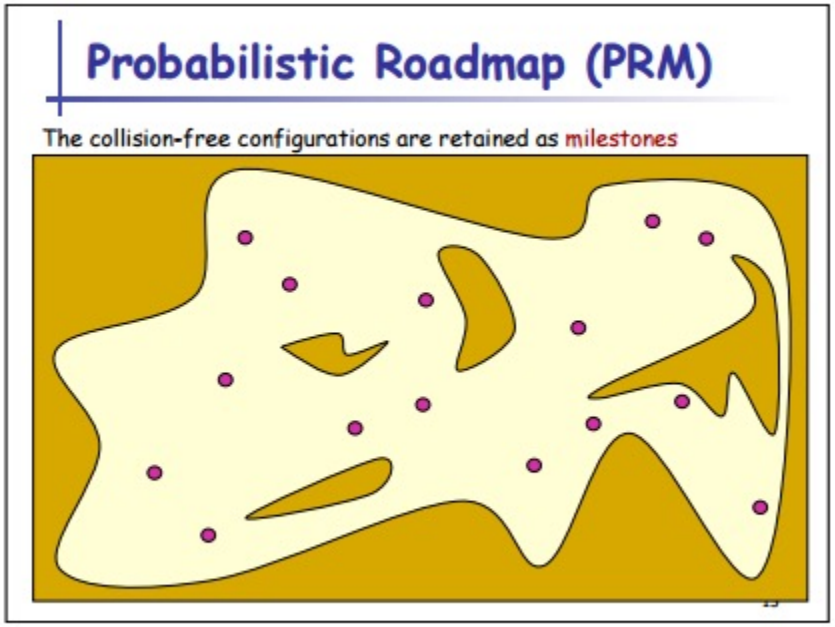
PRM

3


Probabilistic Roadmap (PRM)
Sampled configurations are tested for collision

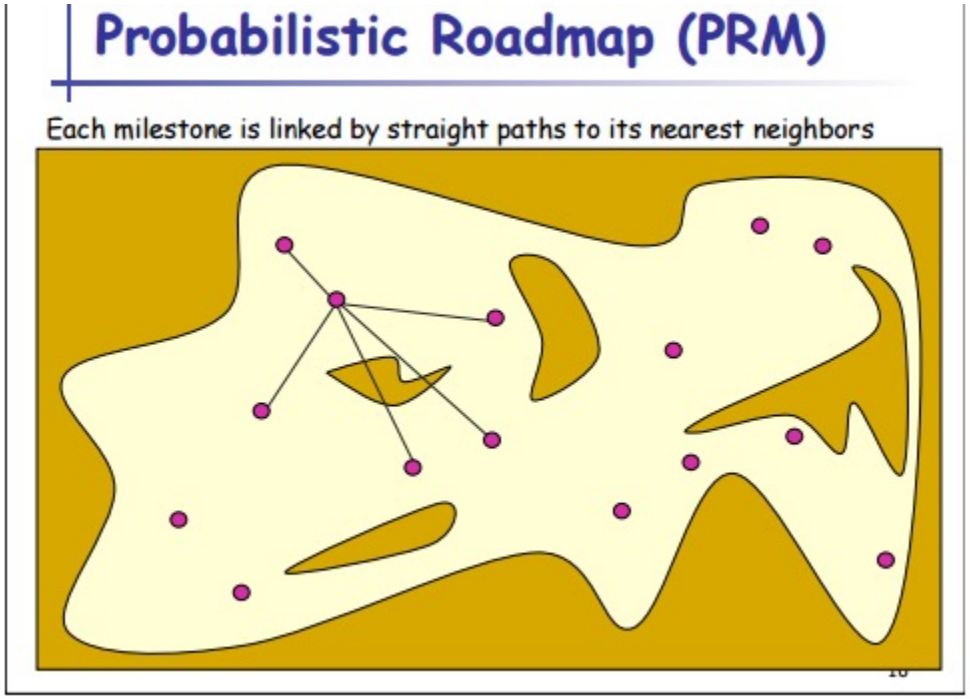
PRM

4


Probabilistic Roadmap (PRM)
The collision-free configurations are retained as milestones

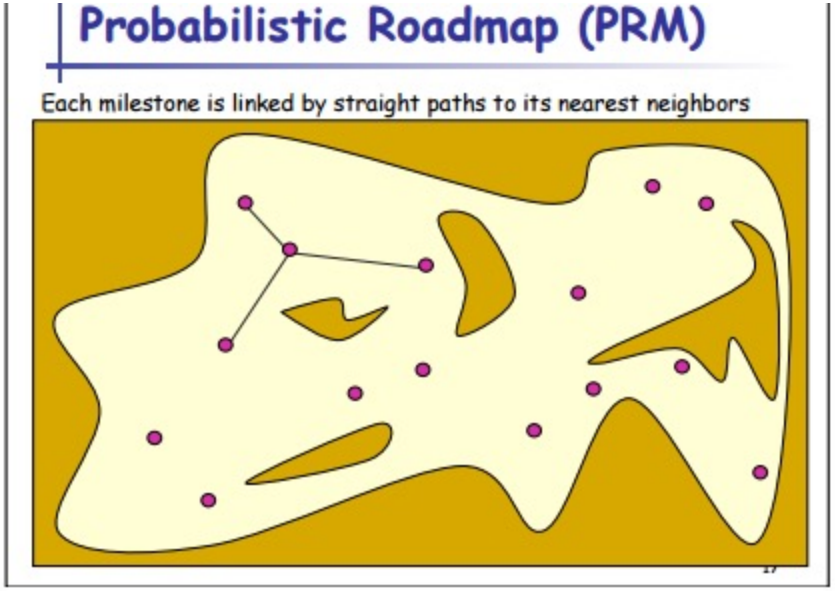
PRM

- 5


Probabilistic Roadmap (PRM)
Each milestone is linked by straight paths to its nearest neighbors

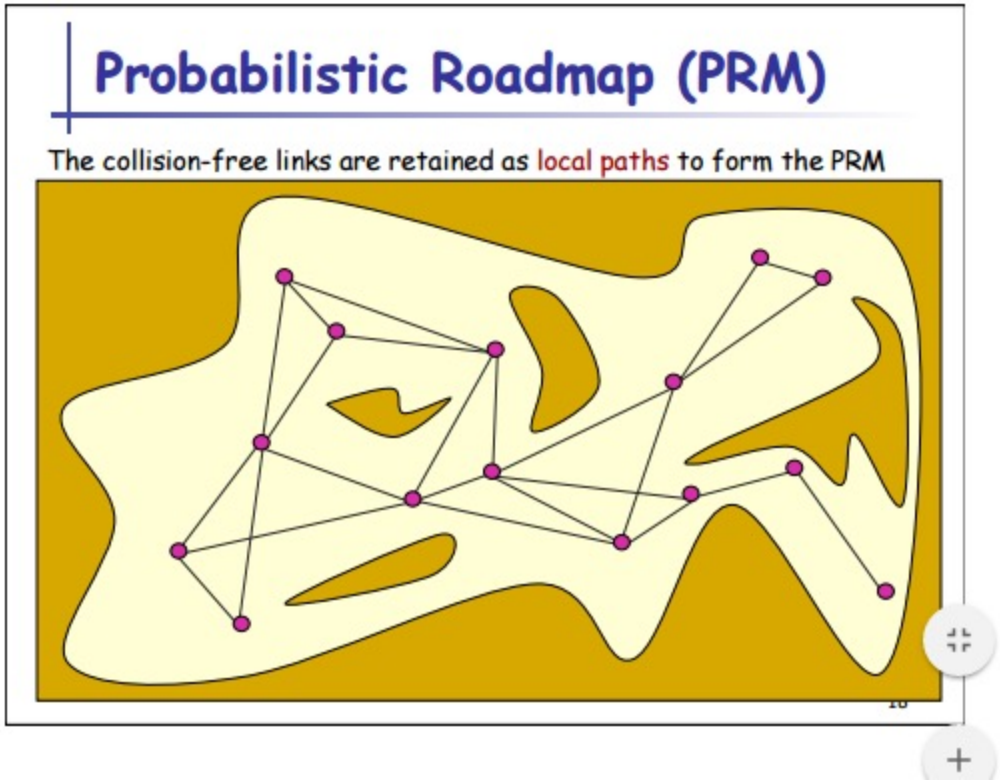
PRM

6


Probabilistic Roadmap (PRM)
Each milestone is linked by straight paths to its nearest neighbors

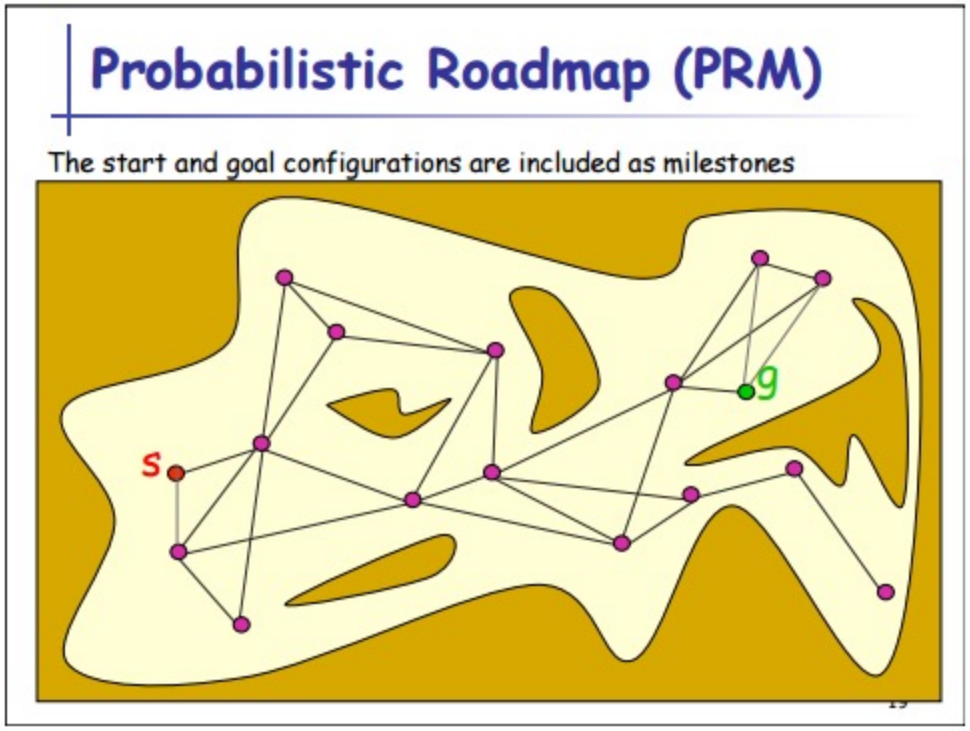
PRM

- 7


Probabilistic Roadmap (PRM)
The collision-free links are retained as local paths to form the PRM

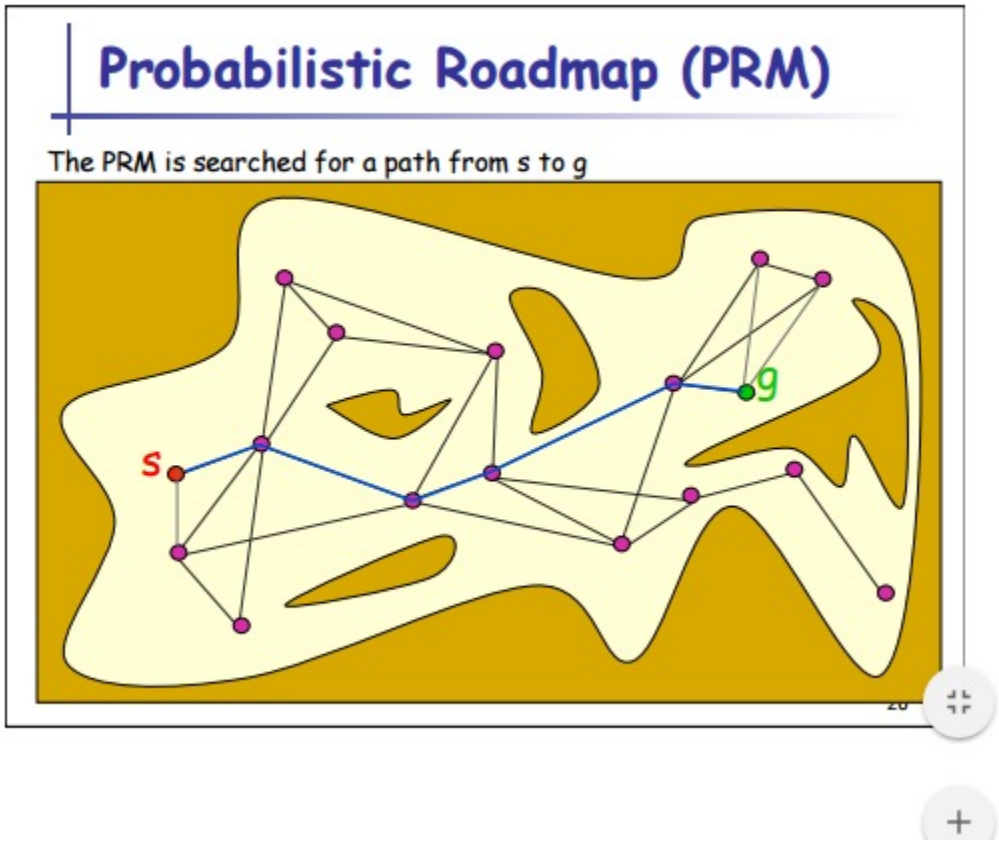
PRM

- 8


Probabilistic Roadmap (PRM)
The start and goal configurations are included as milestones
s
g

PRM Stage 2 Dijkstra Algorithm

- 9



Important terms from graph theory

Distance between nodes (input)
Tentative (temporary) distance of the node (intermediate computation)
Final shortest distances from s to each node (output)

Initial node. Current node; Neigbour node

Marked node (*-node, visited node))

Not-marked (not-*) nodes

Label; Relabeling (updating);

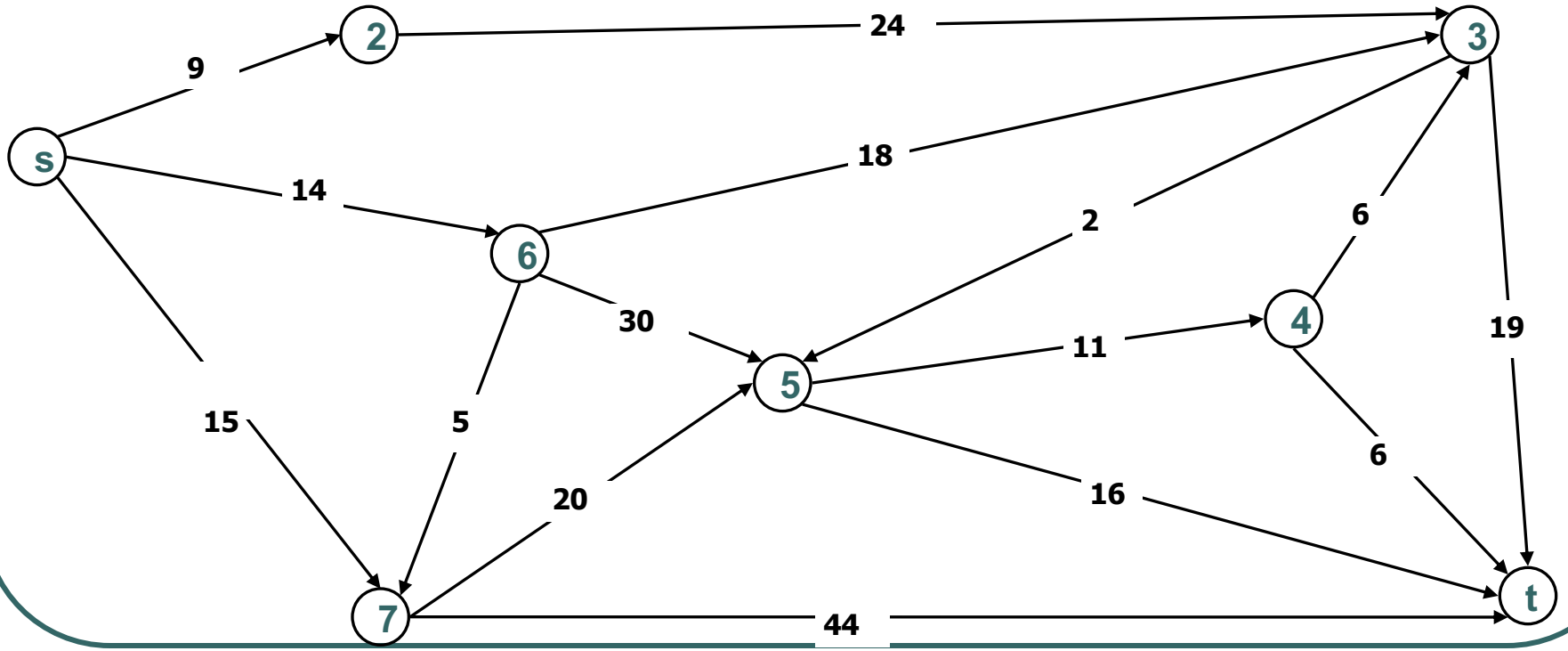
Stopping rule

Selection rule

Updating rule

Dijkstra's Shortest Path Algorithm

- To find a shortest path from s to t.

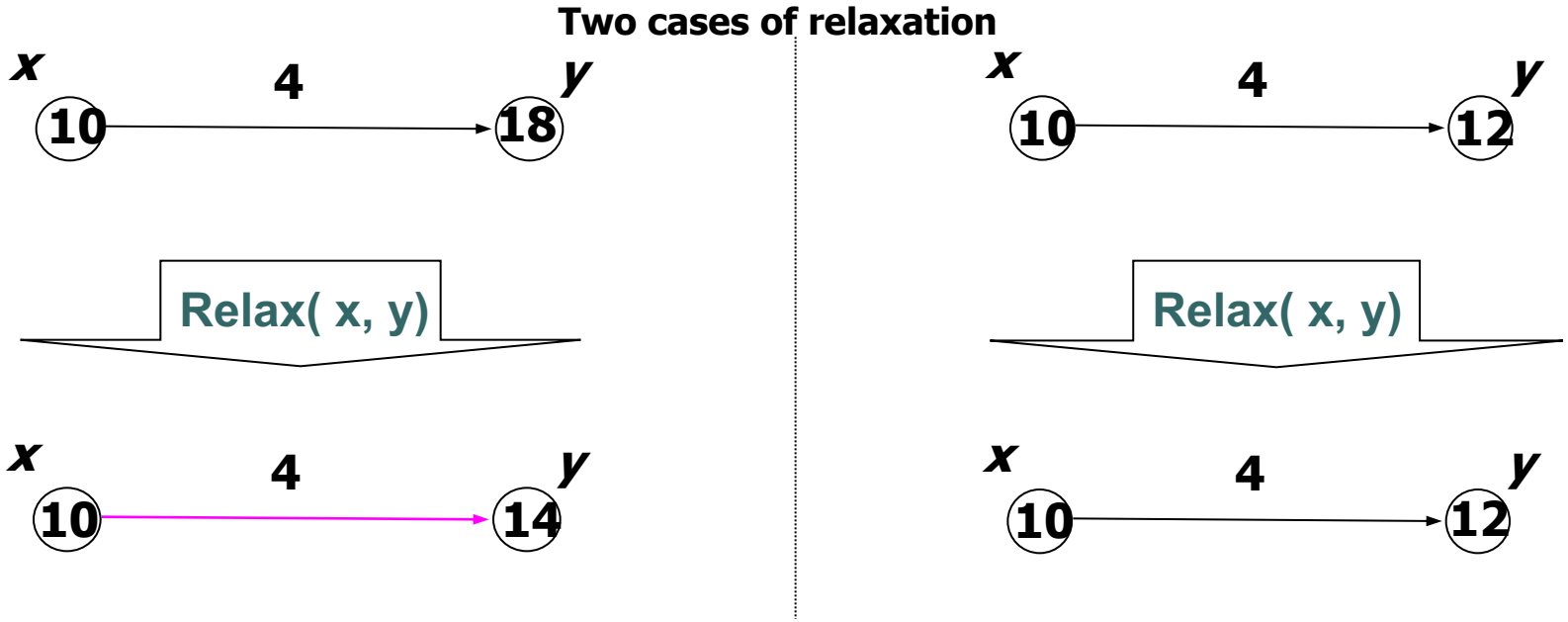


Relaxation פונקצית הקלה:

בודקת האם ניתן לשפר את המסלול הקצר ביותר אל v שמצאנו עד כה ע"י מעבר דרך u.

Relax(u, v)

Two cases of relaxation



rose edge => current immediate predecessor of *y* is

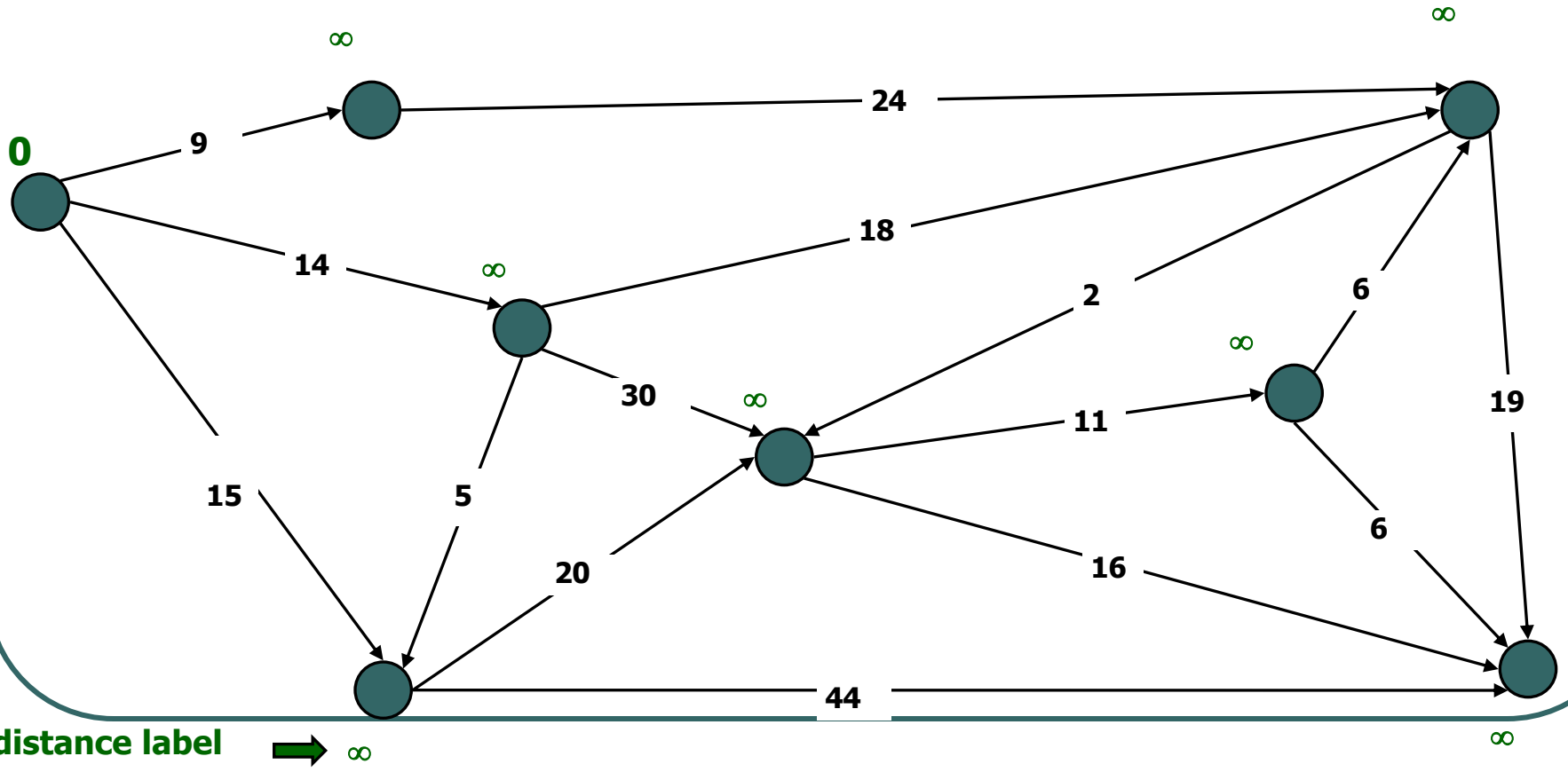
Dijkstra's Shortest Path Algorithm

S = { }

Q = { 2, 3, 4, 5, 6, 7, t }

S = set of nodes for which we know the shortest distance from s

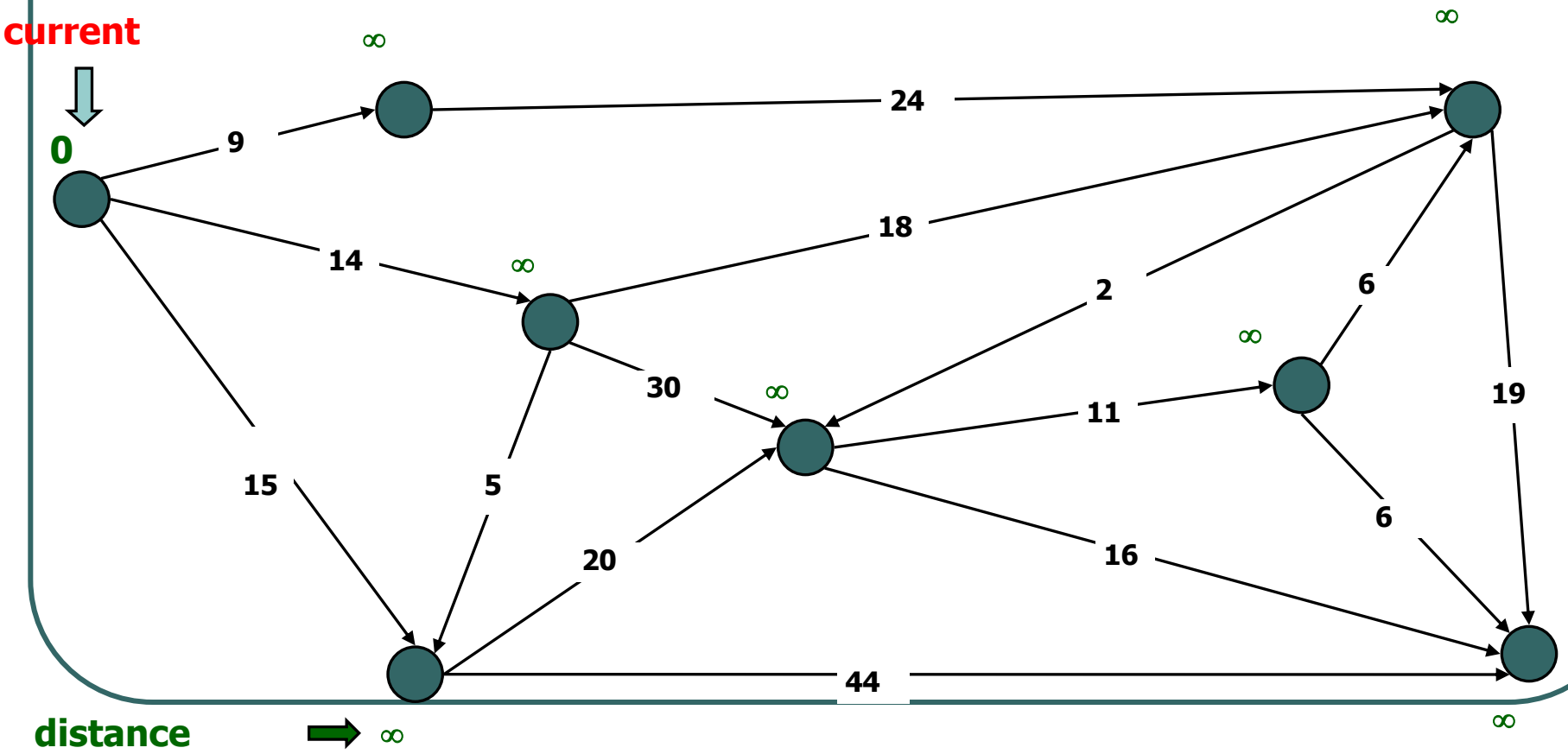
Q = unvisited set of nodes in the graph



Dijkstra's Shortest Path Algorithm

S = {s }

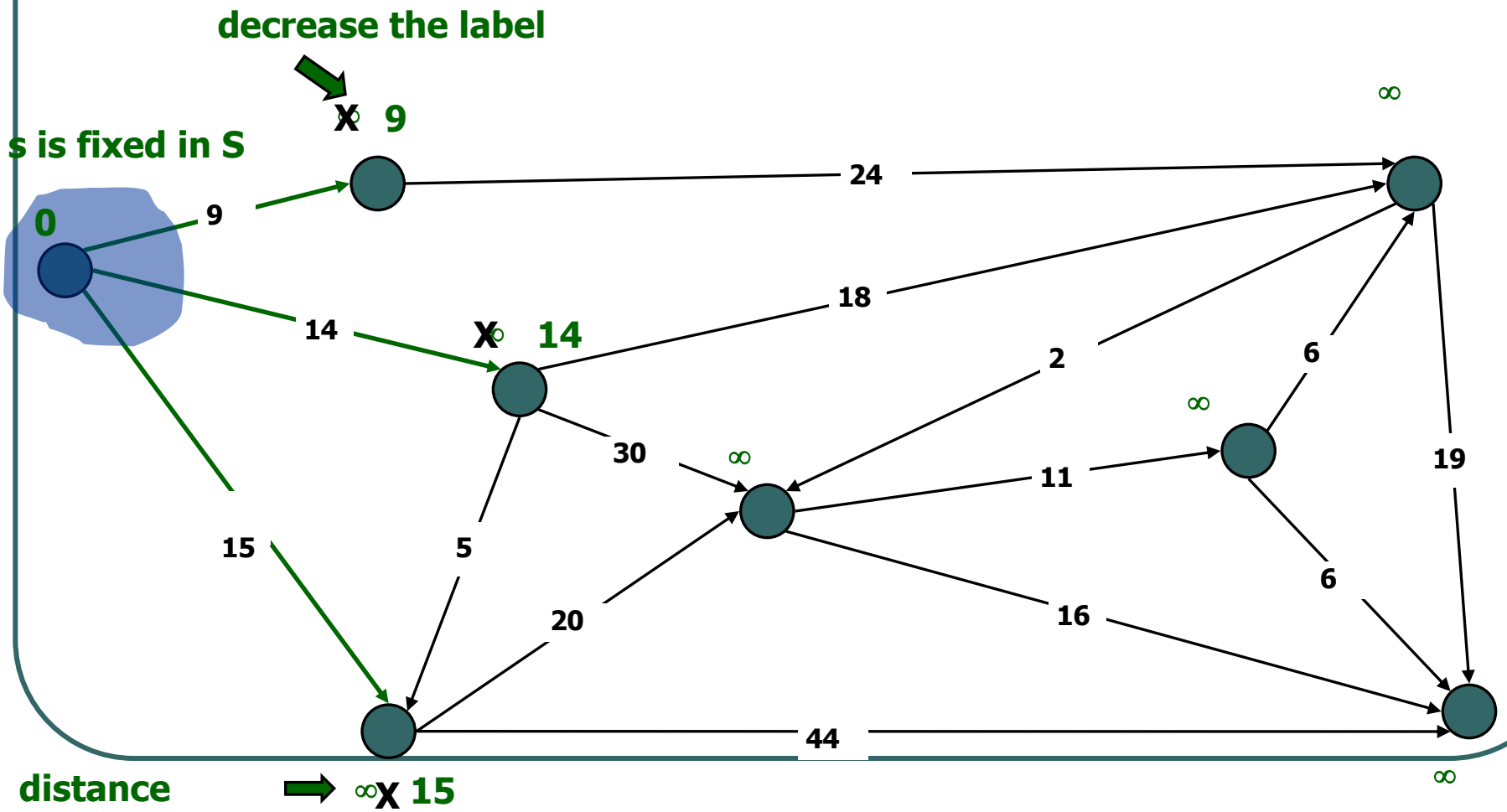
Q = { 2, 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s }

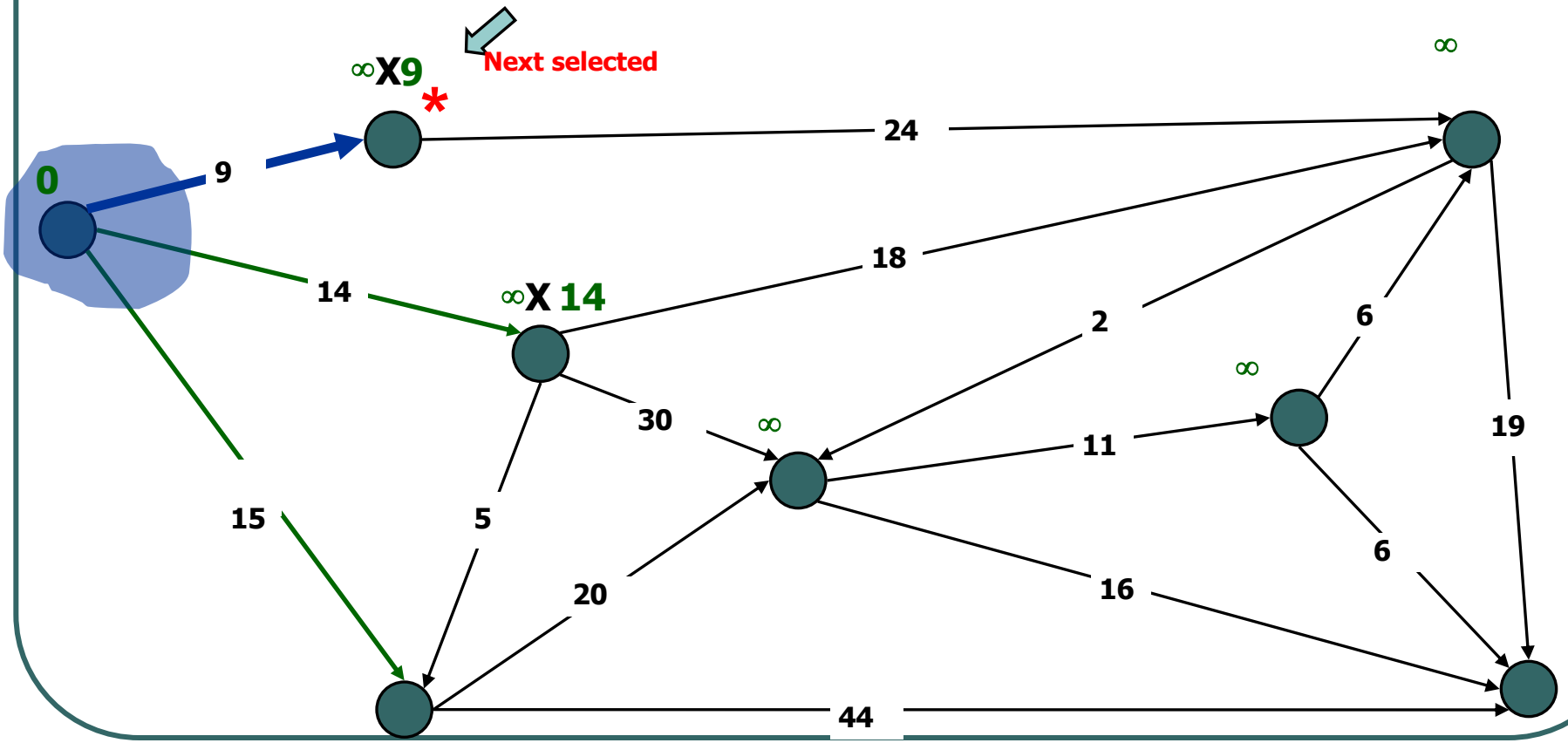
Q = { 2, 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s }

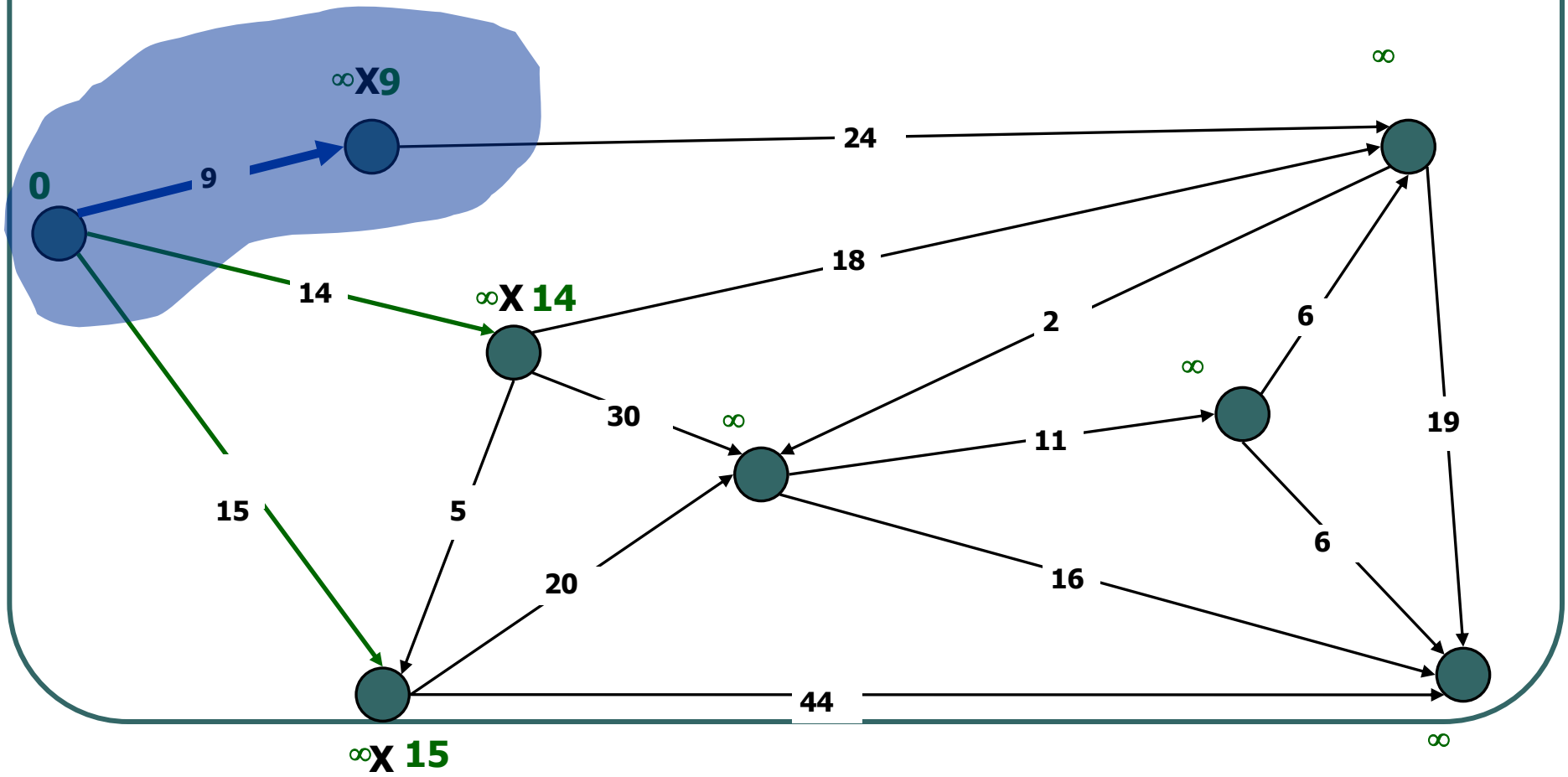
Q = { 2, 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2 }

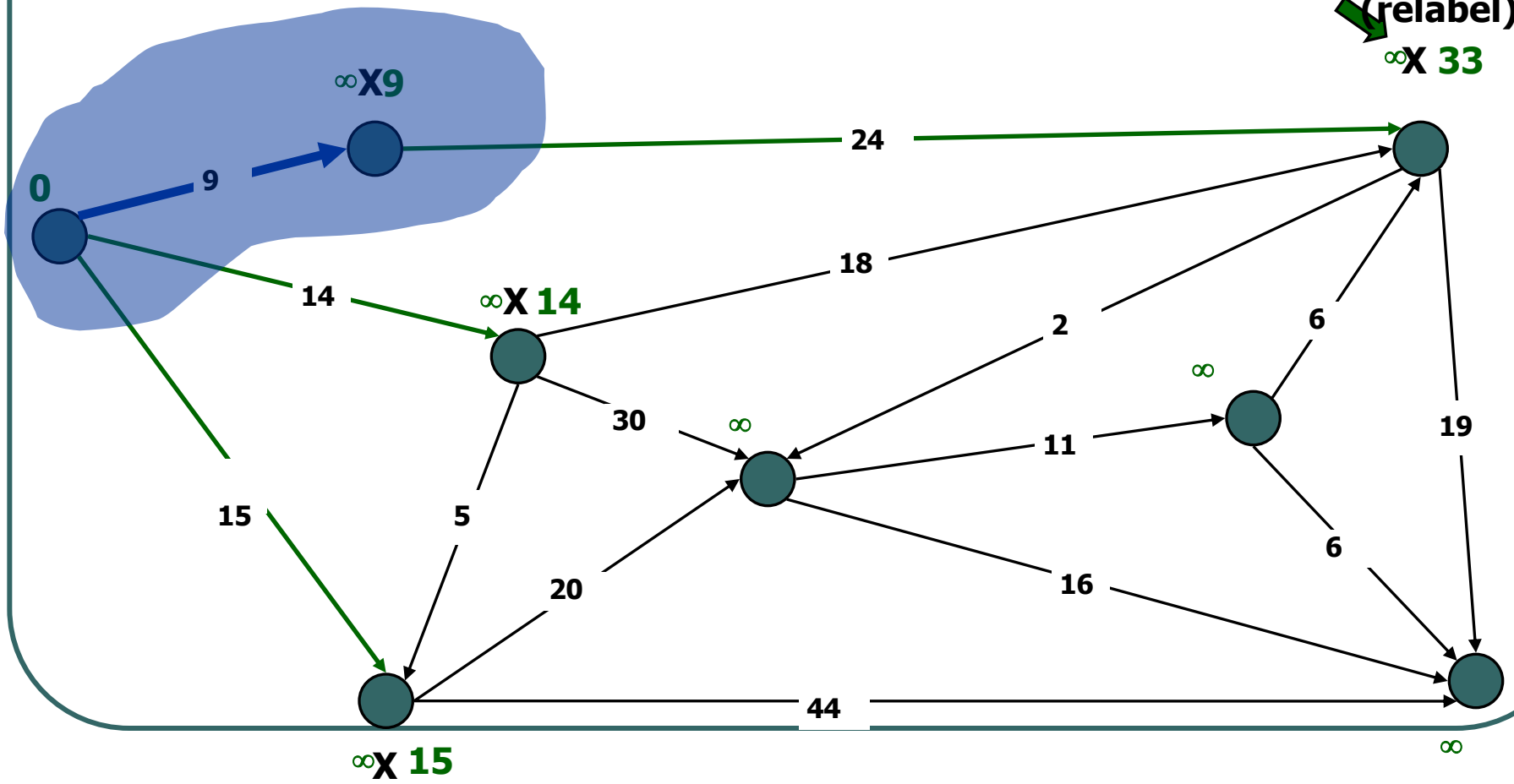
Q = { 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2 }

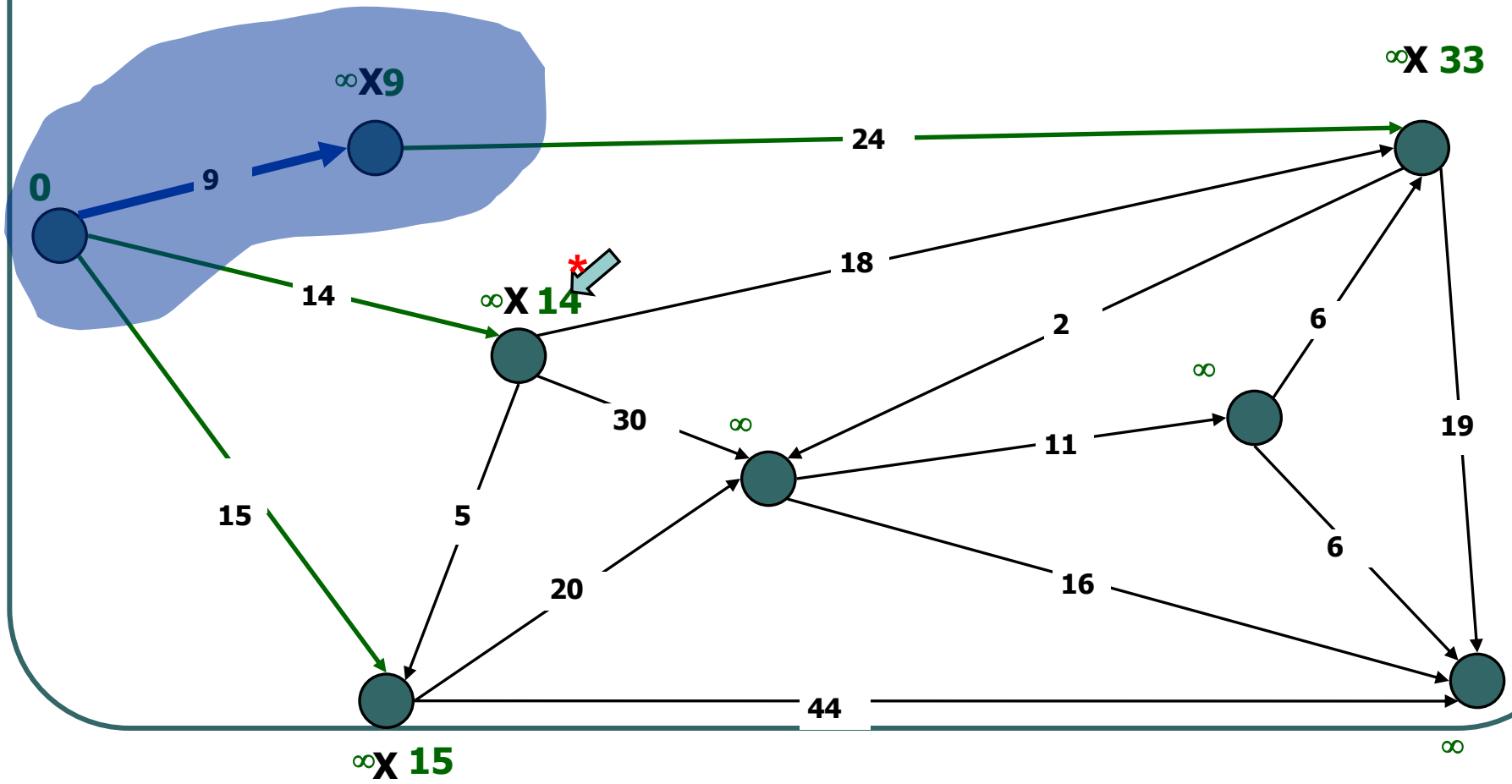
Q = { 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2 }

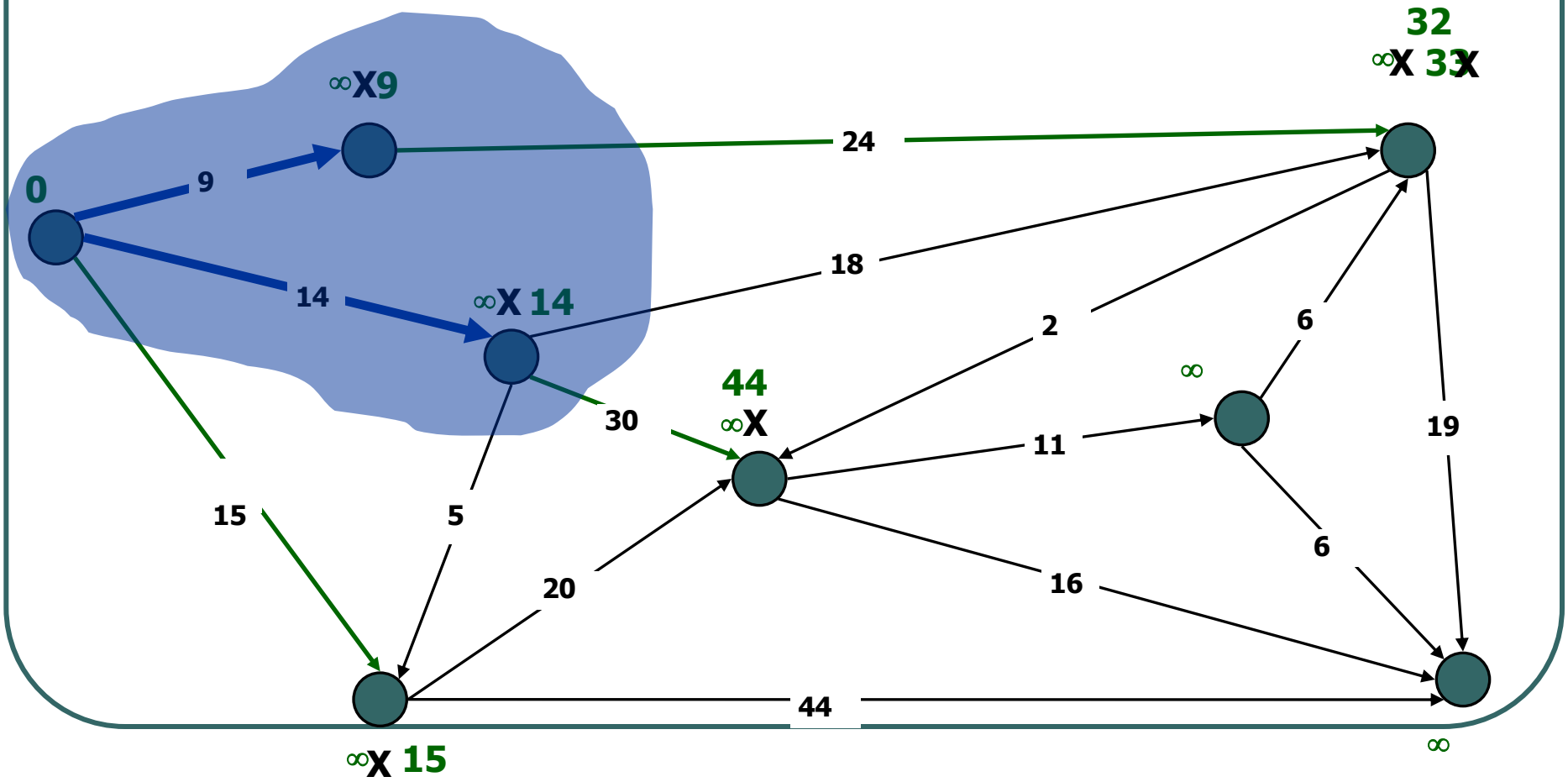
Q = { 3, 4, 5, 6, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2, 6 }

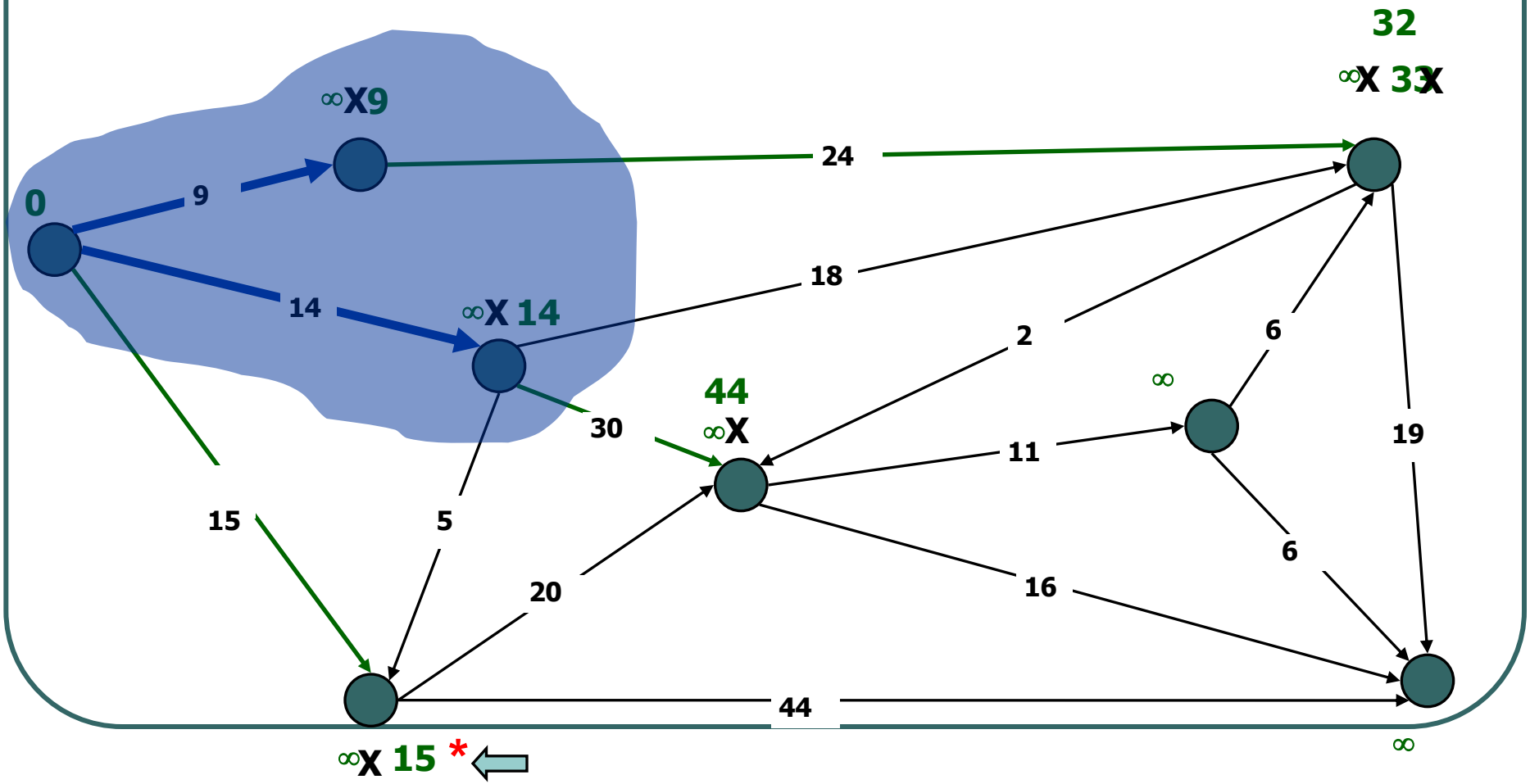
Q = { 3, 4, 5, 7, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2, 6 }

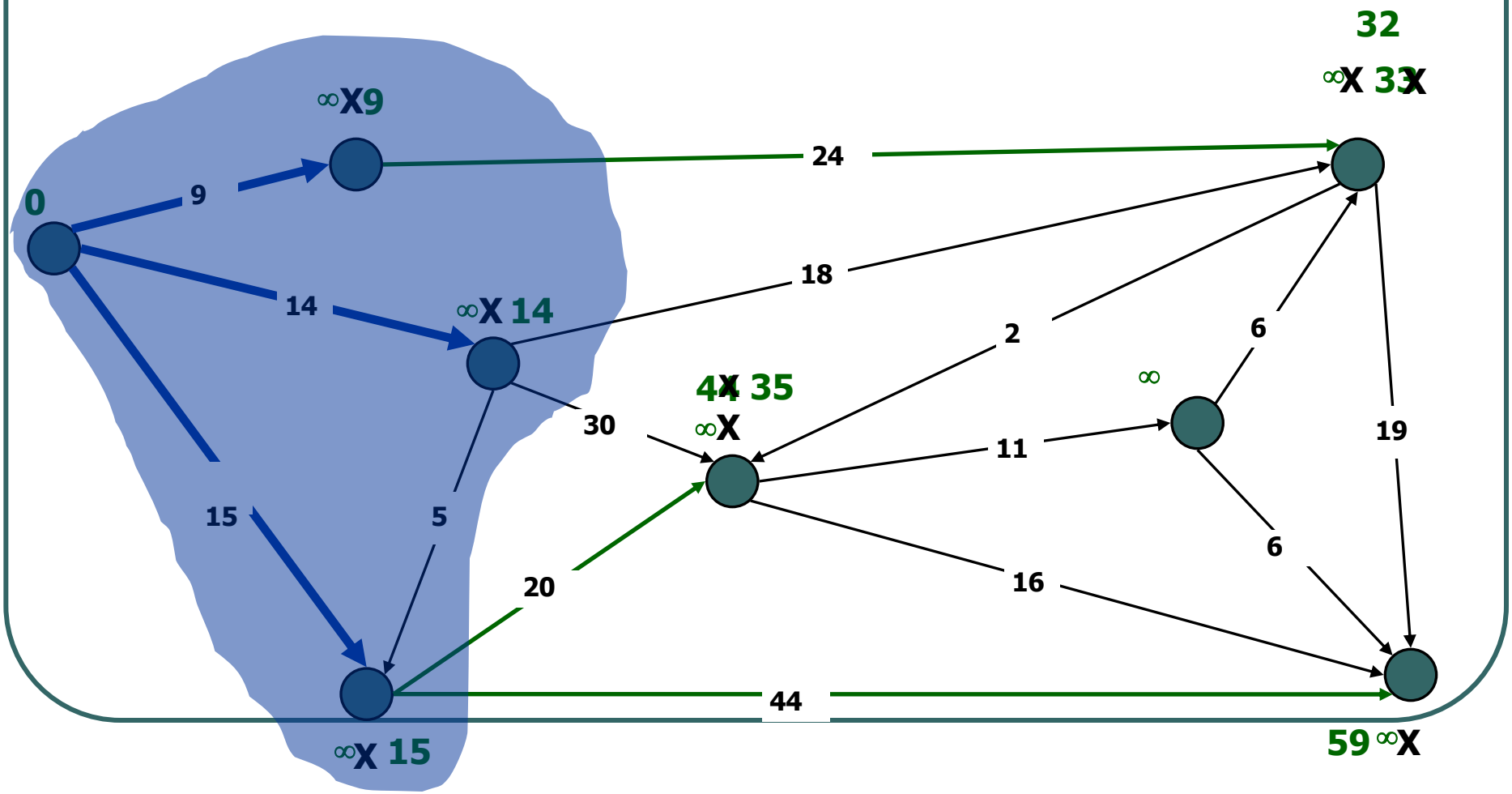
Q = { 3, 4, 5, 7, t }



Dijkstra's Shortest Path Algorithm

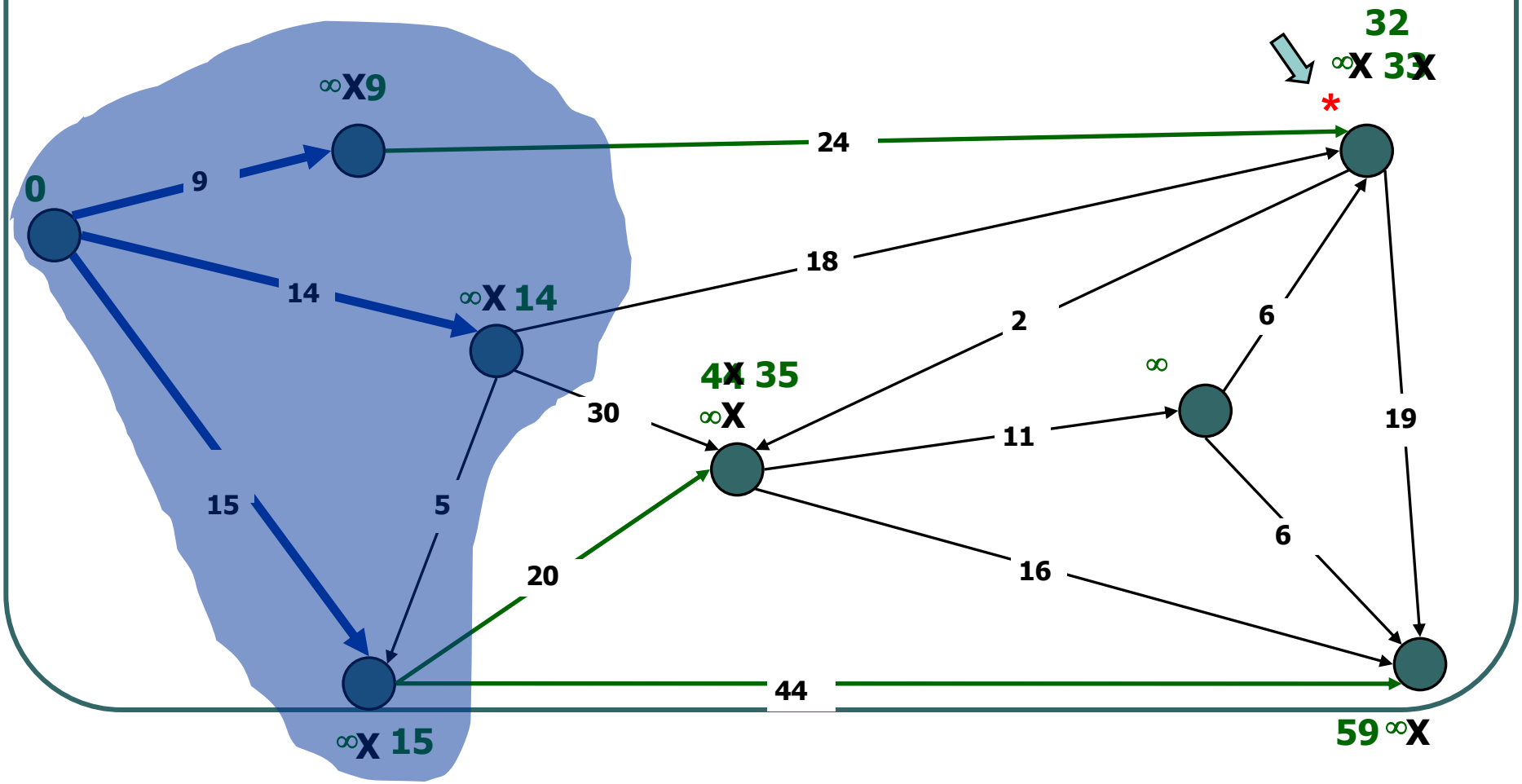
S = { s, 2, 6, 7 }

Q = { 3, 4, 5, t }



Dijkstra's Shortest Path Algorithm

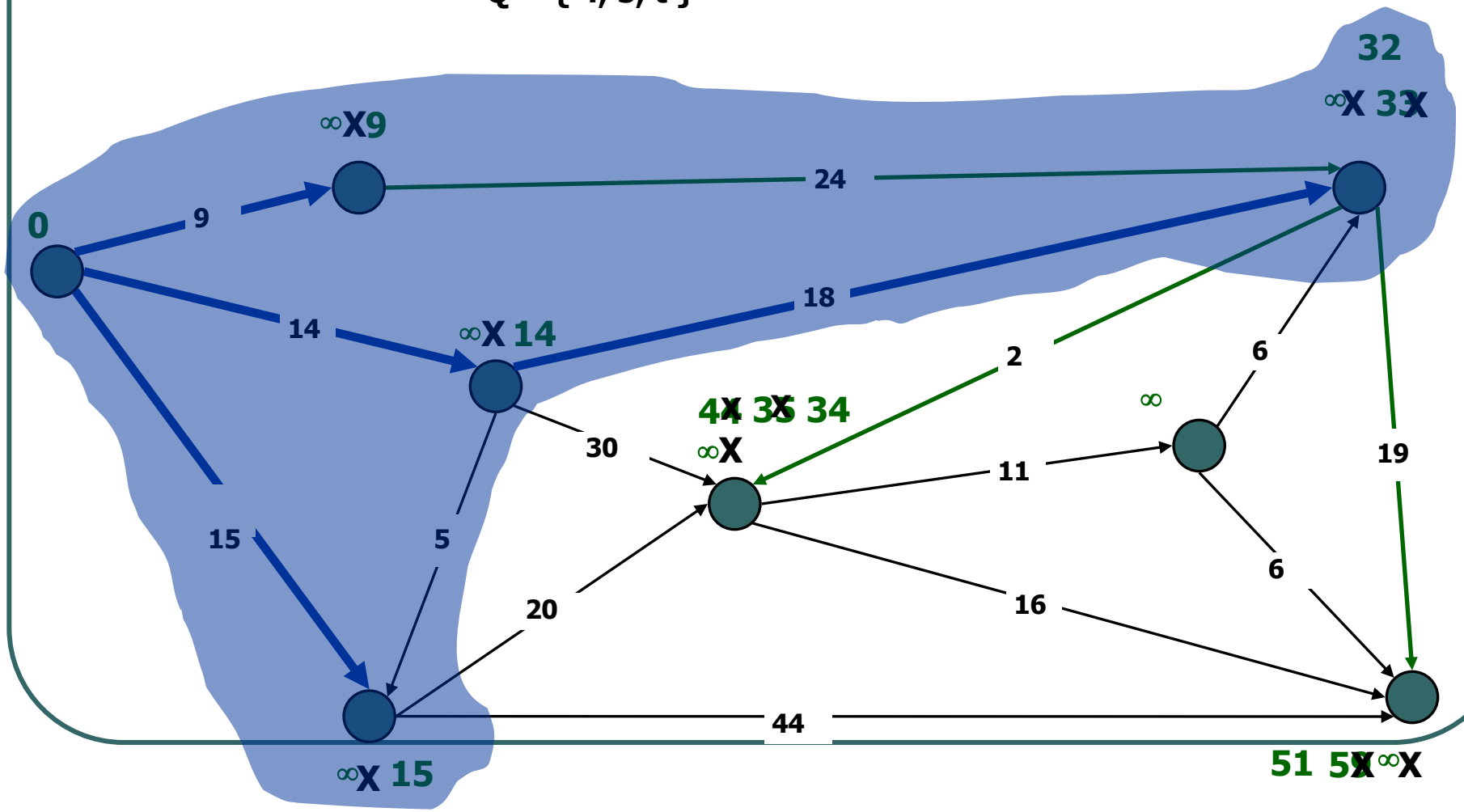
S = { s, 2, 6, 7 }
Q = { 3, 4, 5, t }



Dijkstra's Shortest Path Algorithm

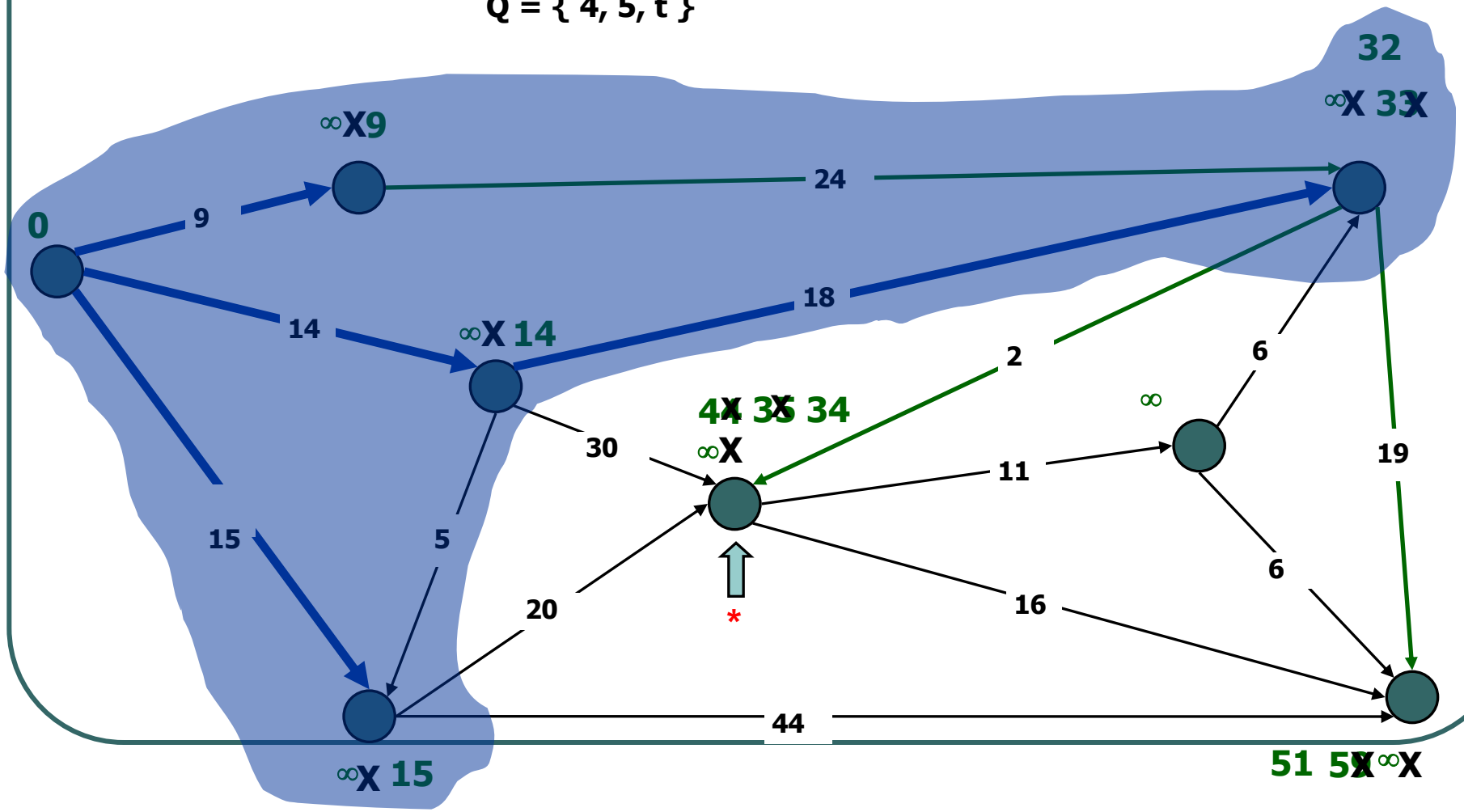
S = { s, 2, 3, 6, 7 }

Q = { 4, 5, t }



Dijkstra's Shortest Path Algorithm

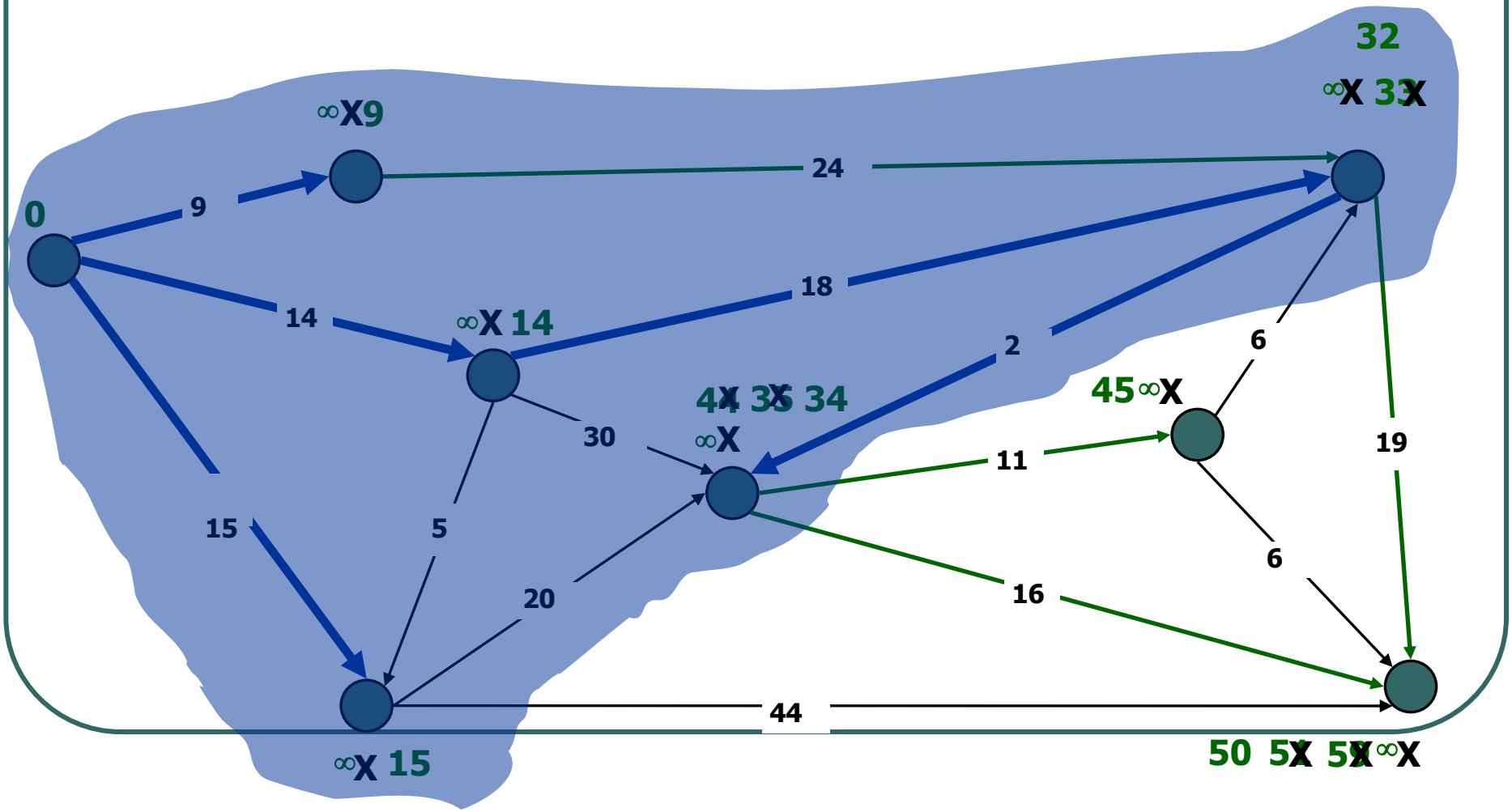
S = { s, 2, 3, 6, 7 }
Q = { 4, 5, t }



Dijkstra's Shortest Path Algorithm

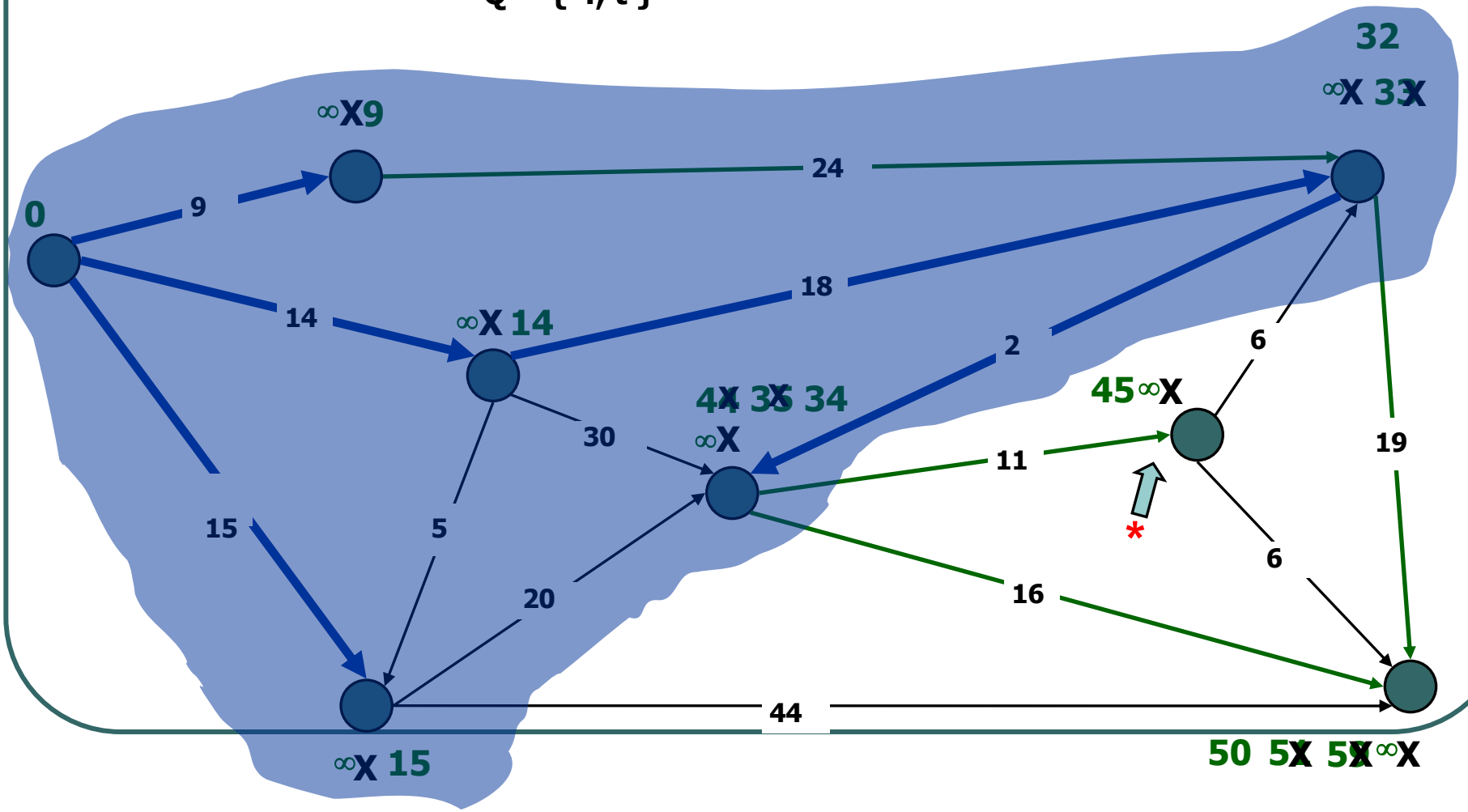
S = { s, 2, 3, 5, 6, 7 }

Q = { 4, t }



Dijkstra's Shortest Path Algorithm

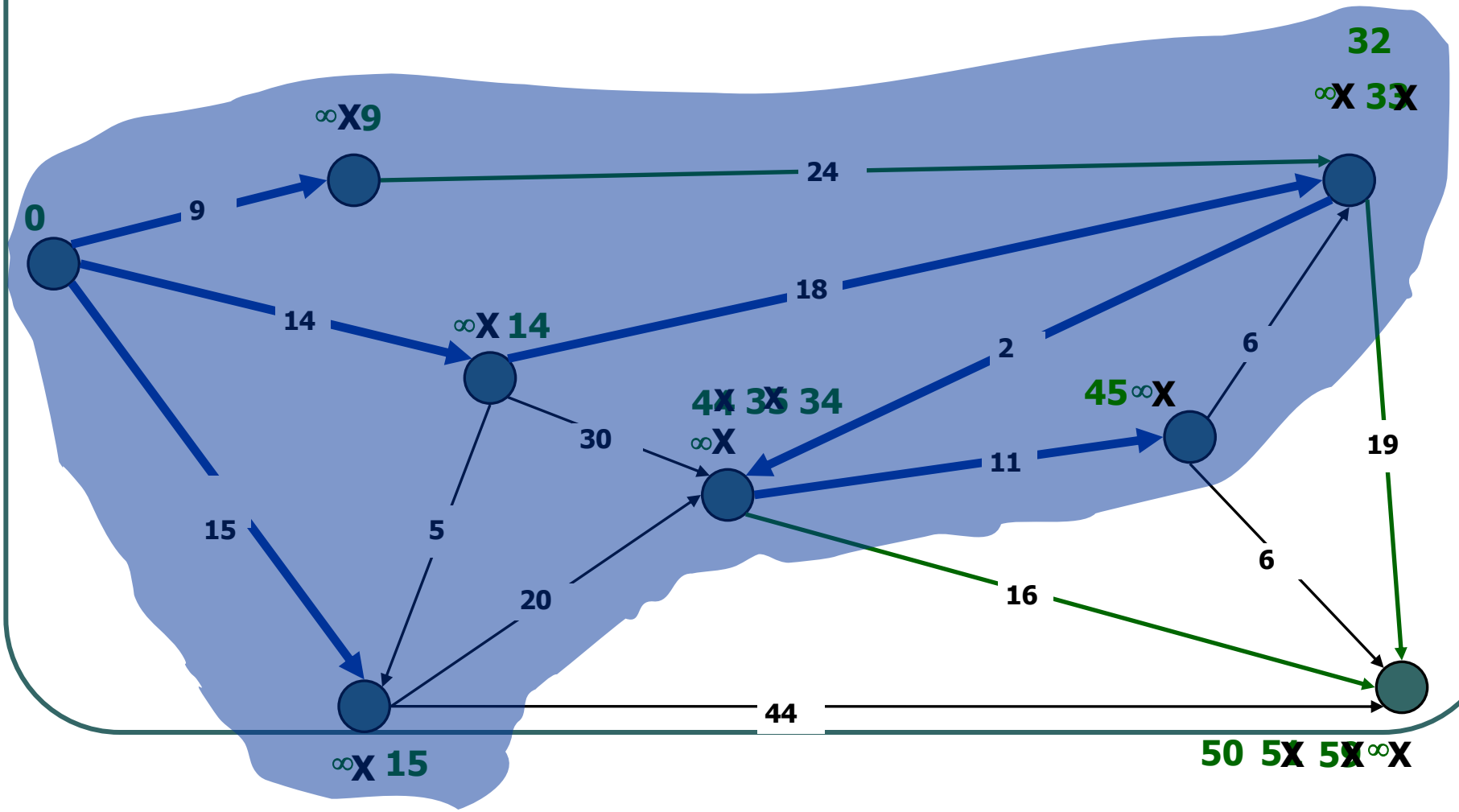
S = { s, 2, 3, 5, 6, 7 }
Q = { 4, t }



Dijkstra's Shortest Path Algorithm

S = { s, 2, 3, 4, 5, 6, 7 }

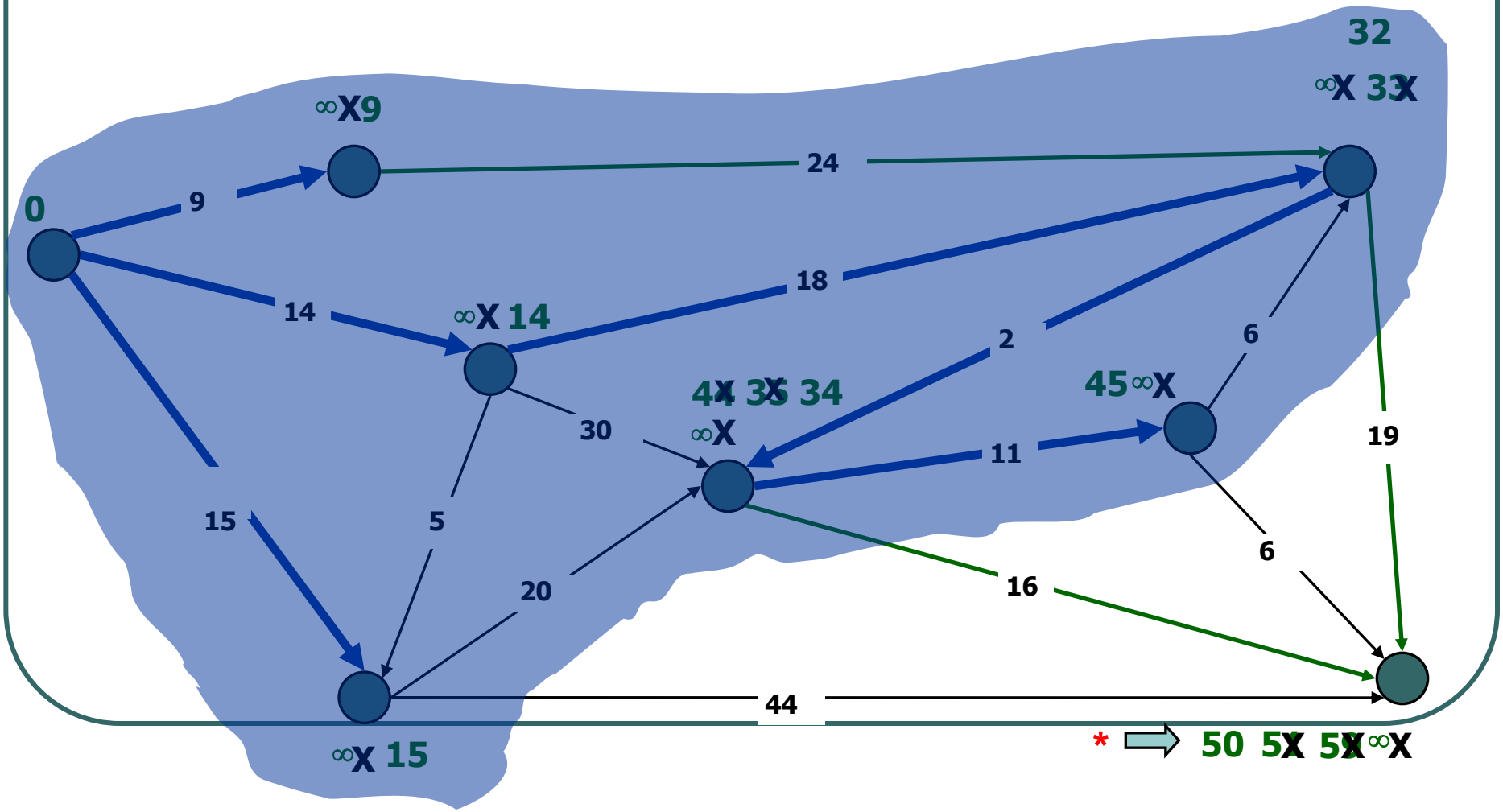
Q = { t }



Dijkstra's Shortest Path Algorithm

S = { s, 2, 3, 4, 5, 6, 7 }

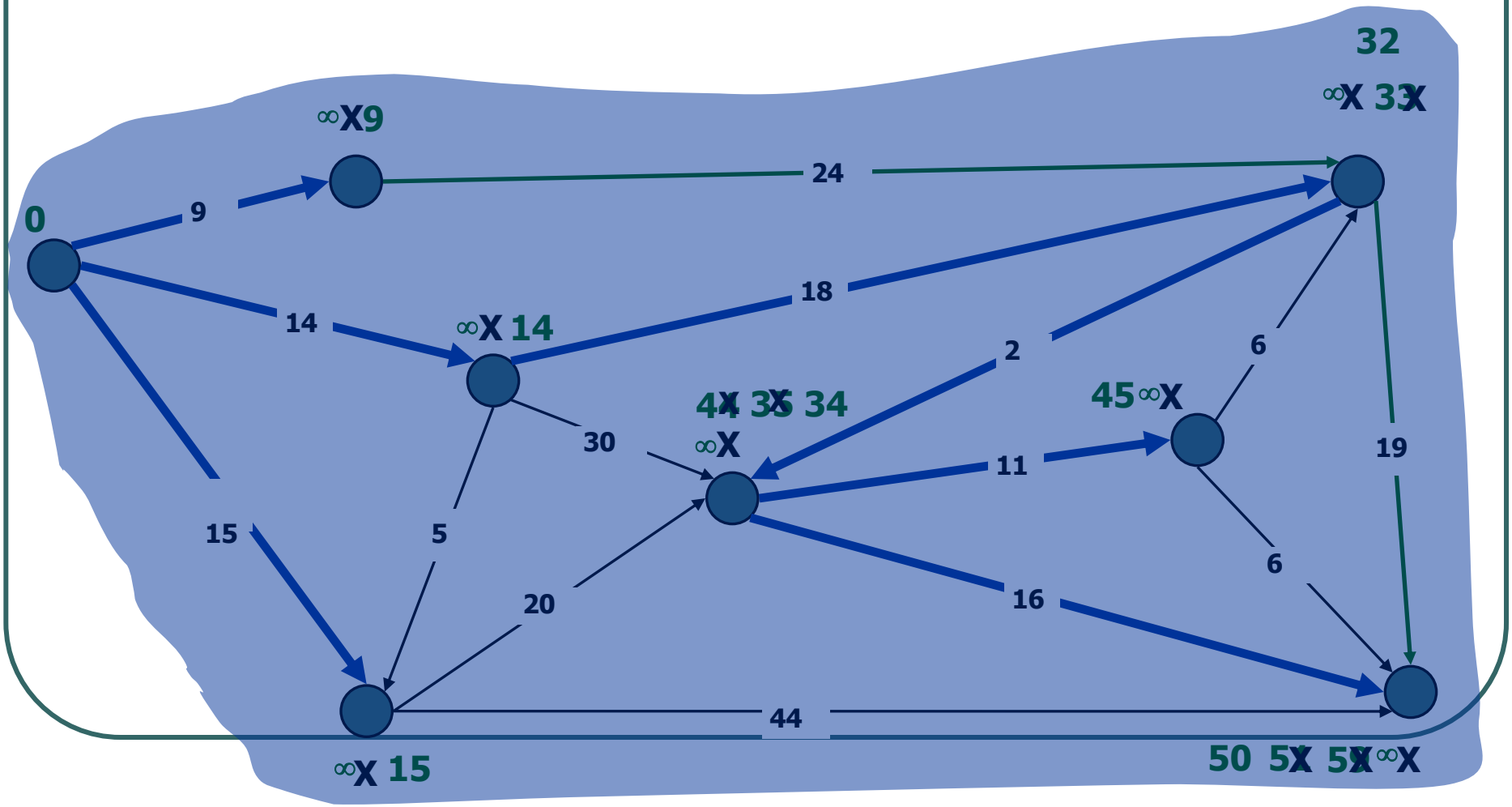
Q = { t }



Dijkstra's Shortest Path Algorithm

S = { s, 2, 3, 4, 5, 6, 7, t }

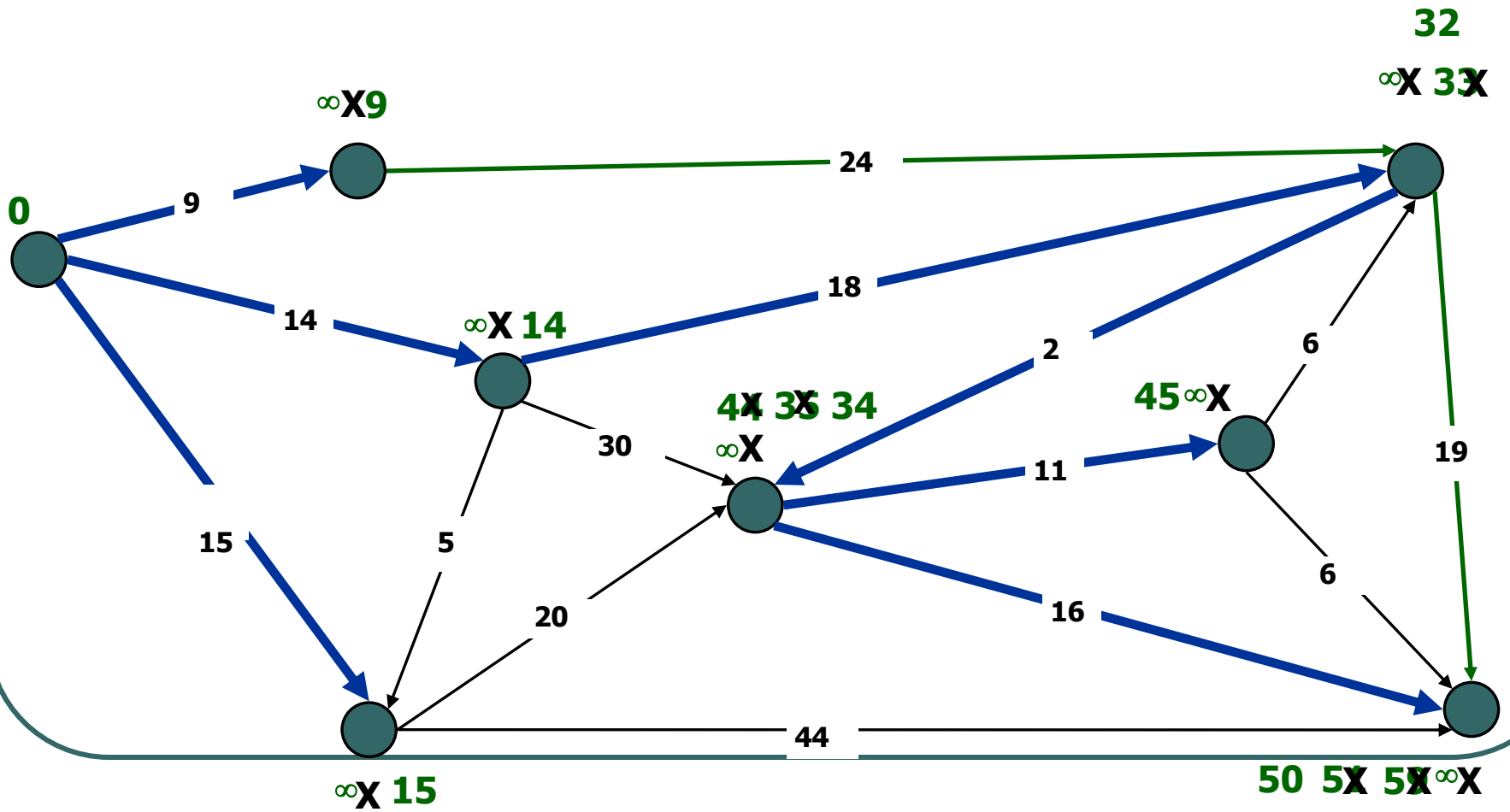
Q = { }



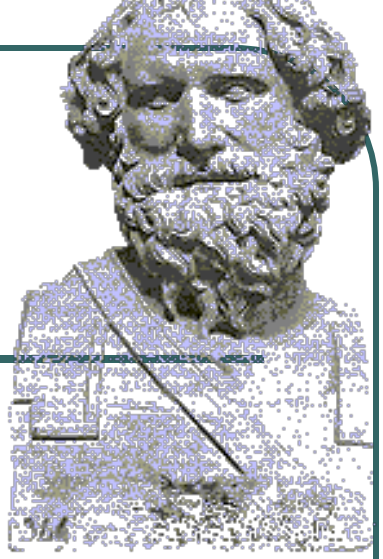
Dijkstra's Shortest Path Algorithm

S = { s, 2, 3, 4, 5, 6, 7, t }

Q = { }



מה הוא פירוש של מלה ***היוריסטי***?



Home Task 1

1.1. חוות דעת של המדענים המובילים על העתיד של AI

1.2 דעתך על העתיד של AI

1.3 השוואה של PRM ו-Dijkstra

נתראה בקרוב!