Department of
Aeronautical and Aviation Engineering
航空及民航工程學系

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

AAE1001 Introduction to Artificial Intelligence and Data Analytics in Aerospace and Aviation Engineering

Week 8 (Project Tasks)

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Necessary Information

- Course Repository (project download) link:
- https://github.com/IPNL-POLYU/PolyU_AAE1001_Github_Project

- TA Information & Contact:

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Group 8-10: Mr Chin Lok TSANG - chin-lok.tsang@connect.polyu.hk

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Project Compulsory Tasks

Project Tasks for Flight Path Planning

1. Find an appropriate aircraft model that achieve the minimum cost for the challenge assigned to your group.
2. Design a new cost area that can reduce the cost of the route.
3. Design a new aircraft model within the constrains to achieve minimum cost for your group challenge.
4. Additional Tasks (see different slide)

The assessment of path planning part is based on the completion and the performance of 1, 2, 3 **(compulsory)** and 4 (additional), according to your: codes, answers on your report, and presentation

Task 1

Find an appropriate aircraft model that achieve minimum cost for each scenario for the challenge assigned to your group.

Aircraft Models

Many types of aircrafts nowadays
(Airbus, Boeing, Bombardier and more)

Each aircraft has different properties
-Capacity (Passenger and cargo) / **COST!**

- Costs of operating an aircraft might include:
  - **Crew cost**
  - **Fuel cost**
  - **Other operational costs**
  - **To keep it simple, costs can be approximated by:**

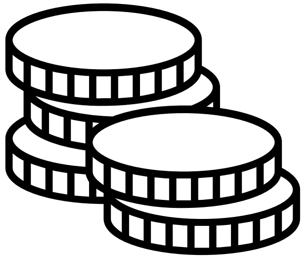
$$\boxed{C = C_F \cdot \Delta F \cdot T_{best} + C_T \cdot T_{best} + C_c}$$

C_F=cost of fuel per kg
ΔF=trip fuel

C_T=time related cost per minute of flight
ΔT=trip time

C_c=fixed cost independent of time

Task 1



Three scenarios with different requirements

Find the **shortest route** from the departure point to the arrival point, then **determine the aircraft type** for each scenario to achieve **minimum cost** while satisfying **passenger needs**

3 main factors affecting the total cost in this project:

- **Shortest distance**
- **Cost intensive area**
- **Aircraft fuel and time costs from different model**

Check out the example to understand this task better!

Task 1

Restrictions and rules:

- Only consider cruise time
- All aircrafts take 1 minute between nearby nodes ($\sqrt{2}$ minute on diagonal movement)
- Each group must use their own obstacle set
- 30% and 15% additional flight time for cost intensive area for Time and Fuel (e.g., 1min -> 1.3min)
- **You must calculate the travelling time for the fastest path by using and modifying the program**
- Only consider one type (from provided three) of aircraft in each scenario
- Time cost stays the same regardless of any vacancy in an aircraft
- Trip cost can be calculated manually, or automatically in program (bonus)

Cost Specification

	A321neo	A330-900neo	A350-900
Fuel Consumption rate (kg/min)	54	84	90
Passenger Capacity	200	300	350
Time cost (Low) ($/min)	10	15	20
Time cost (Medium) ($/min)	15	21	27
Time cost (High) ($/min)	20	27	34
Fixed Cost (C_c) ($)	1800	2000	2500
Source: https://www.airlines-inform.com/			

$$C = C_F \cdot \Delta F \cdot T_{best} + C_T \cdot T_{best} + C_c$$

C_F=cost of fuel per kg
C_T=time related cost per minute of flight
C_c=fixed cost independent of time
ΔF=trip fuel
ΔT=trip time

Task 1 - Example to Accomplish this Task

Scenario:

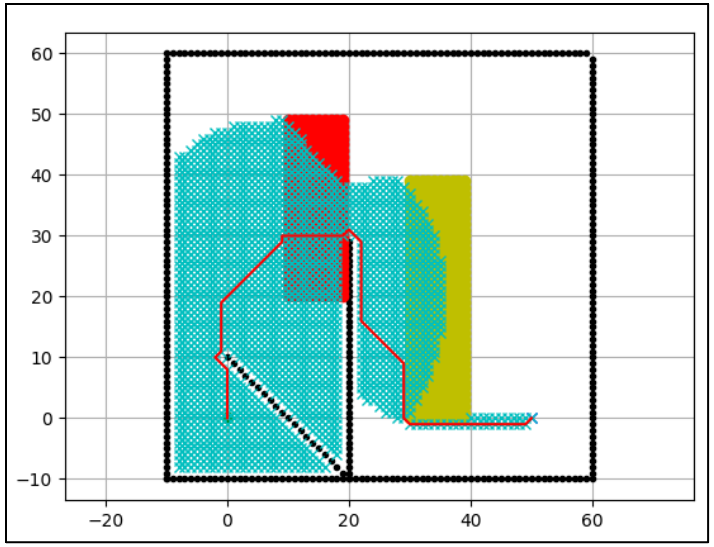
1. 2000 passengers travel from start to destination this week
2. 10 flights maximum for one week
3. Time cost = low, Fuel cost = 0.8 $/kg

First step: Find the shortest path for your obstacle set

1. Set up your obstacles and cost intensive areas using the path planning programme

2. Modify the program so it will calculate the time travelled, hence finds the fastest path (remember to modify cost intensive areas!)

**In this example, the shortest path is planned to be 100 minutes. Considering the cost intensive areas, the fastest path is 120 minutes*



What the working program should look like

*Task 1 tutorial video: https://youtu.be/hmlWX5OEs5U

Task 1 - Example to Accomplish this Task

Second step: Consider the cost factors

1. Count number of flights for aircraft models

Maximum 10 flights for 2000 passengers:
ten A321 flights, seven A330 flights or six A350 flights

2. Calculate trip cost from available numbers:

A321: (0.8\$/kg x 54 kg/min x 120min + 10 \$/min x 120 min + 1800) x 10 flights = \$81840
A330: (0.8\$/kg x 84 kg/min x 120min + 15 \$/min x 120 min + 2000) x 7 flights = \$83048
A350: (0.8\$/kg x 90 kg/min x 120min + 20 \$/min x 120 min + 2500) x 6 flights = \$81240

(can be done inside programme, bonus)

3. As the total cost of operating A350 is the lowest, the answer for this example is **6 flights of A350**!

Cost Specification

	A321neo	A330-900neo	A350-900
Fuel Consumption rate (kg/min)	54	84	90
Passenger Capacity	200	300	350
Time cost (Low) (\$/min)	10	15	20
Time cost (Medium) (\$/min)	15	21	27
Time cost (High) (\$/min)	20	27	34
Fixed Cost (C_c) (\$)	1800	2000	2500
Source: https://www.airlines-inform.com/			

$$C = C_F \cdot \Delta F \cdot T_{best} + C_T \cdot T_{best} + C_c$$

C_F=cost of fuel per kg
C_T=time related cost per minute of flight
C_c=fixed cost independent of time
ΔF=trip fuel
ΔT=trip time

Task 1 - Scenarios

Scenario 1

1. 3000 Passengers need to travel within this week from the start to the destination
2. 12 flights maximum for one week
3. Time cost = medium and Fuel cost = 0.76 $/kg

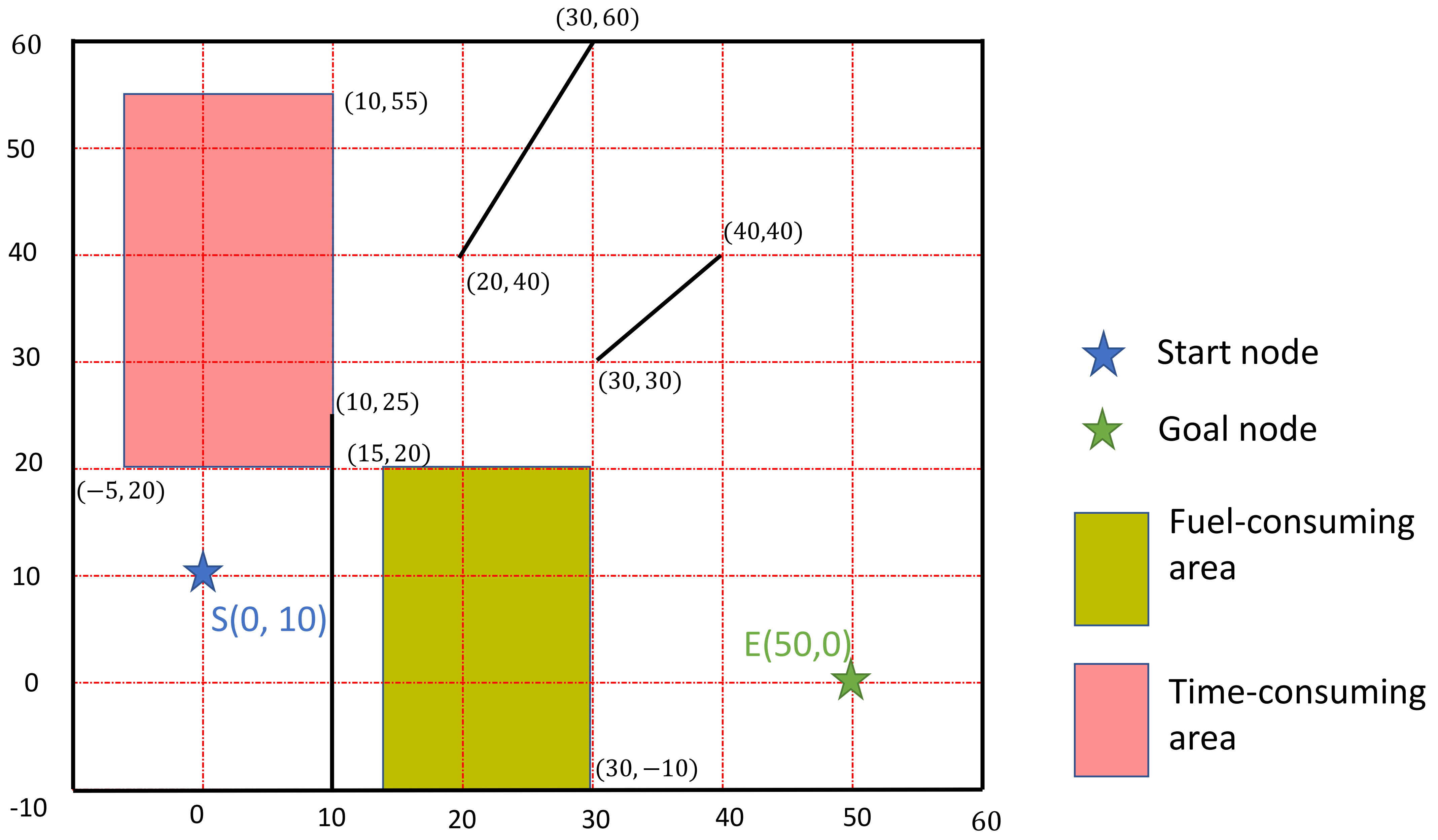
Scenario 2

1. 1250 Passengers need to travel within this month from the start to the destination
2. 5 flights maximum for one week
3. Time cost = high and Fuel cost = 0.88 $/kg

Scenario 3

1. 2500 Passengers need to travel within this week from the start to the destination
2. 25 flights maximum for one week
3. Time cost = low and Fuel cost = 0.95 $/kg

Group 1



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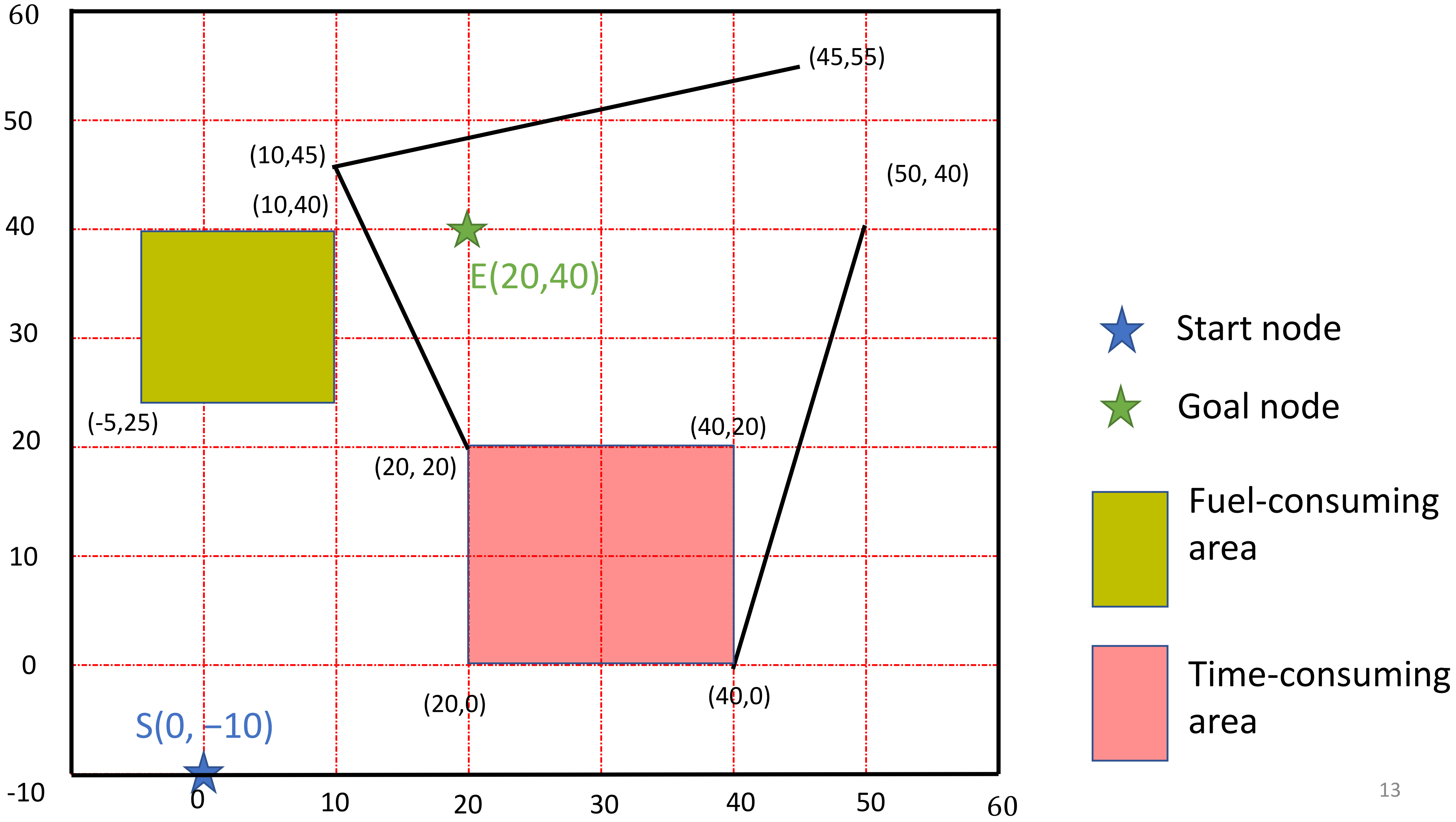
Fuel-consuming area
Time-consuming area

Group 2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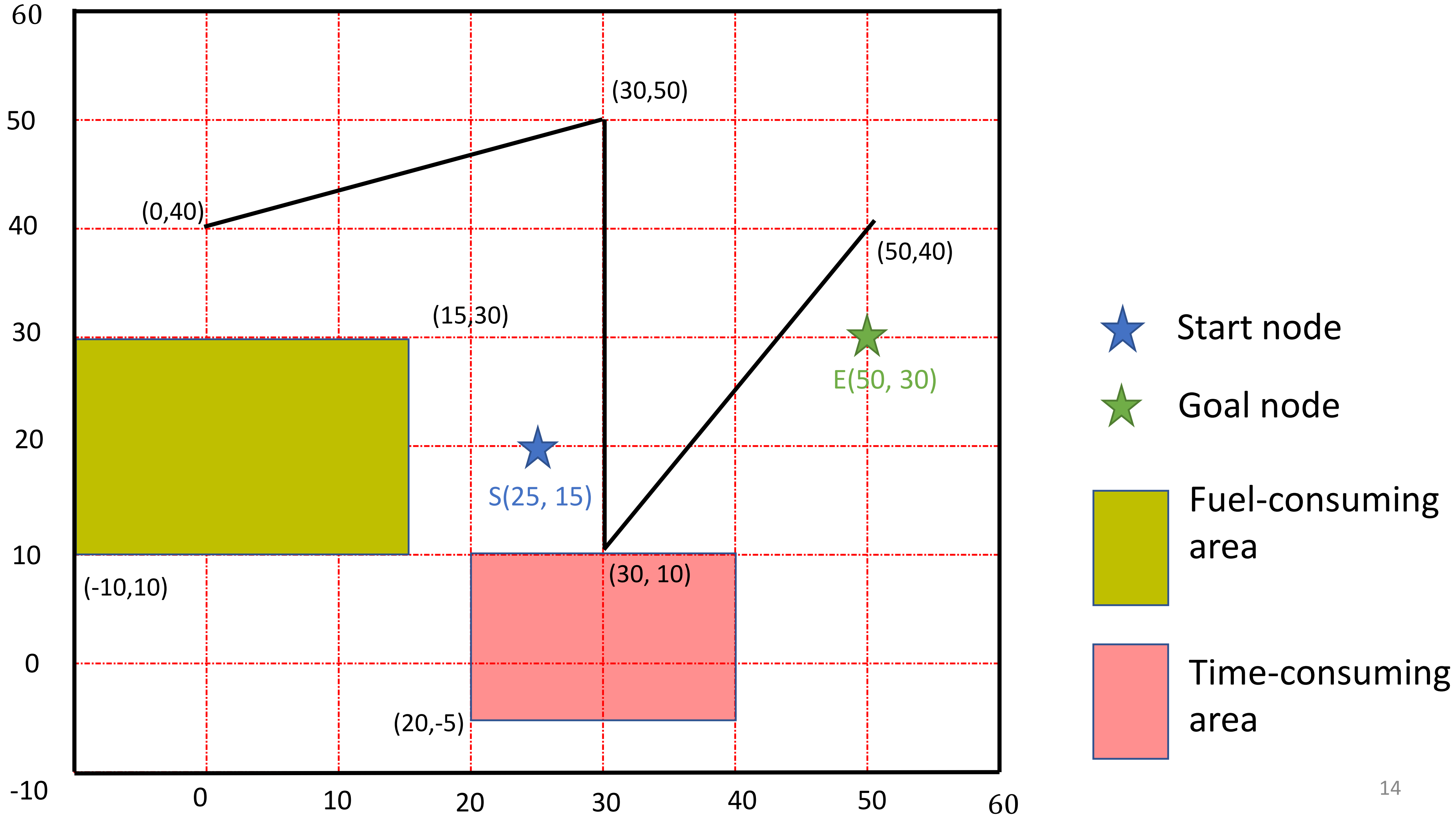
Start node
Goal node
Fuel-consuming area
Time-consuming area

Group 3



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Start node
Goal node
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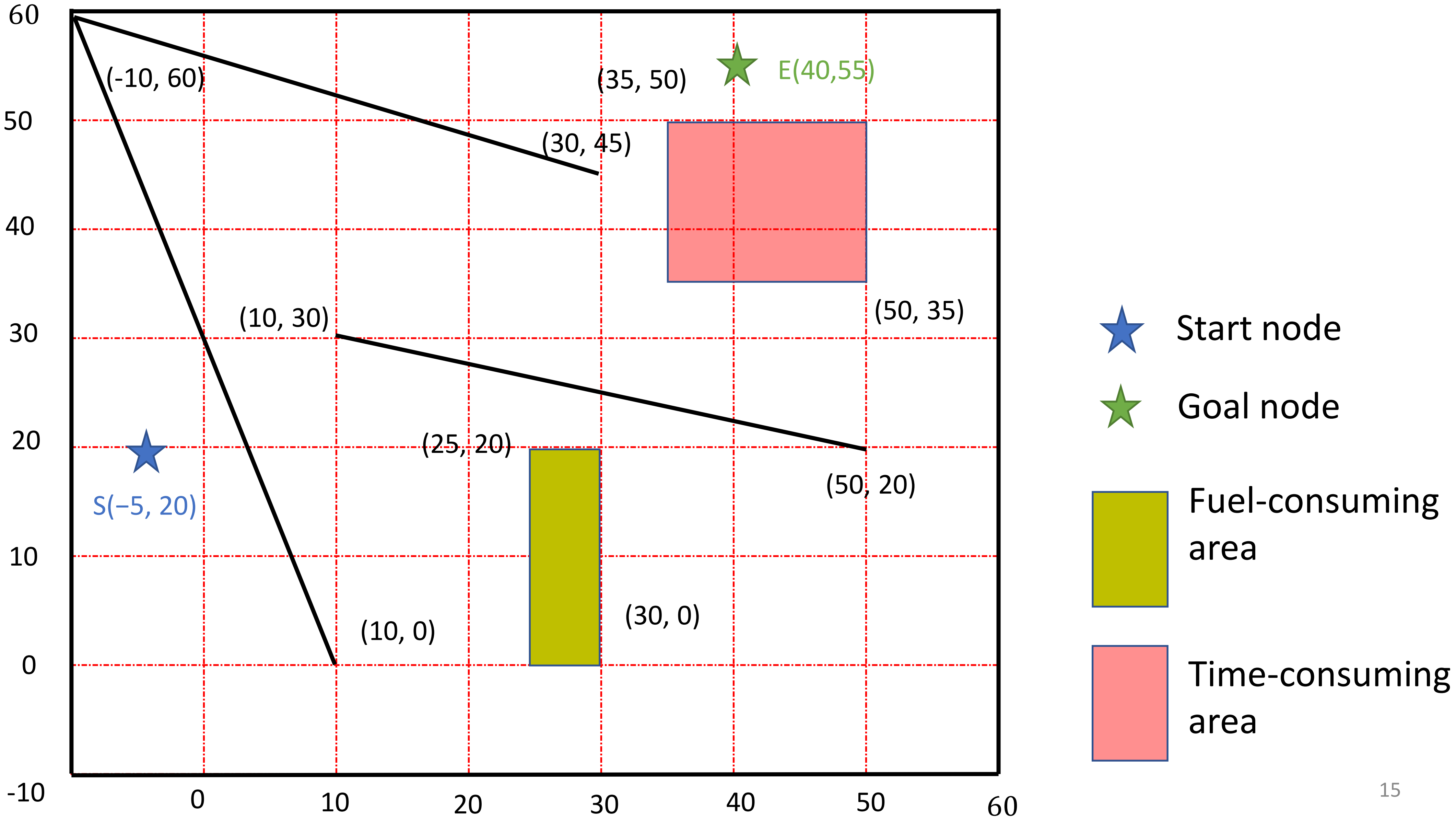
Time-consuming area

Group 4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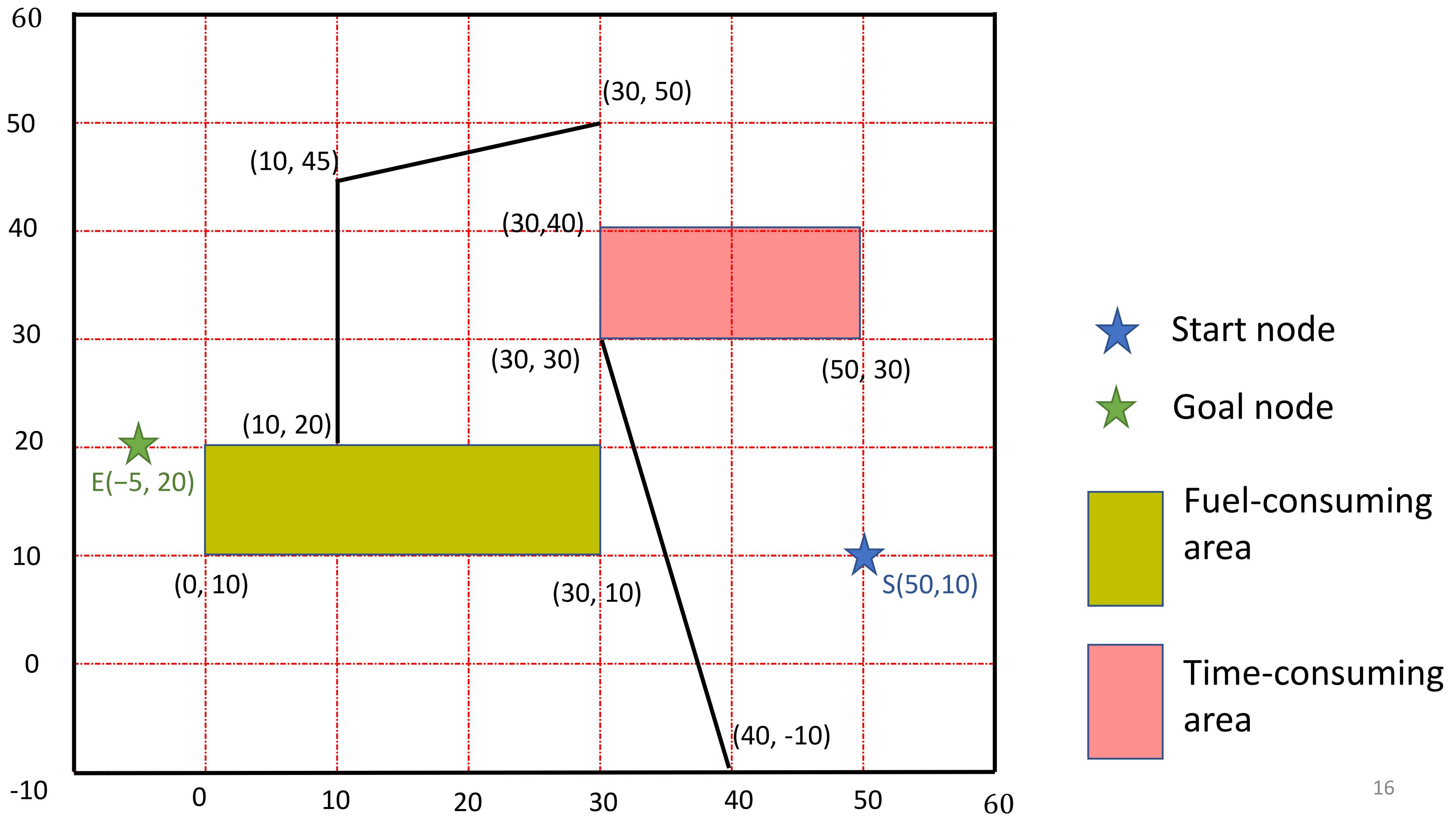
Start node
Goal node
Fuel-consuming area
Time-consuming area

Group 5



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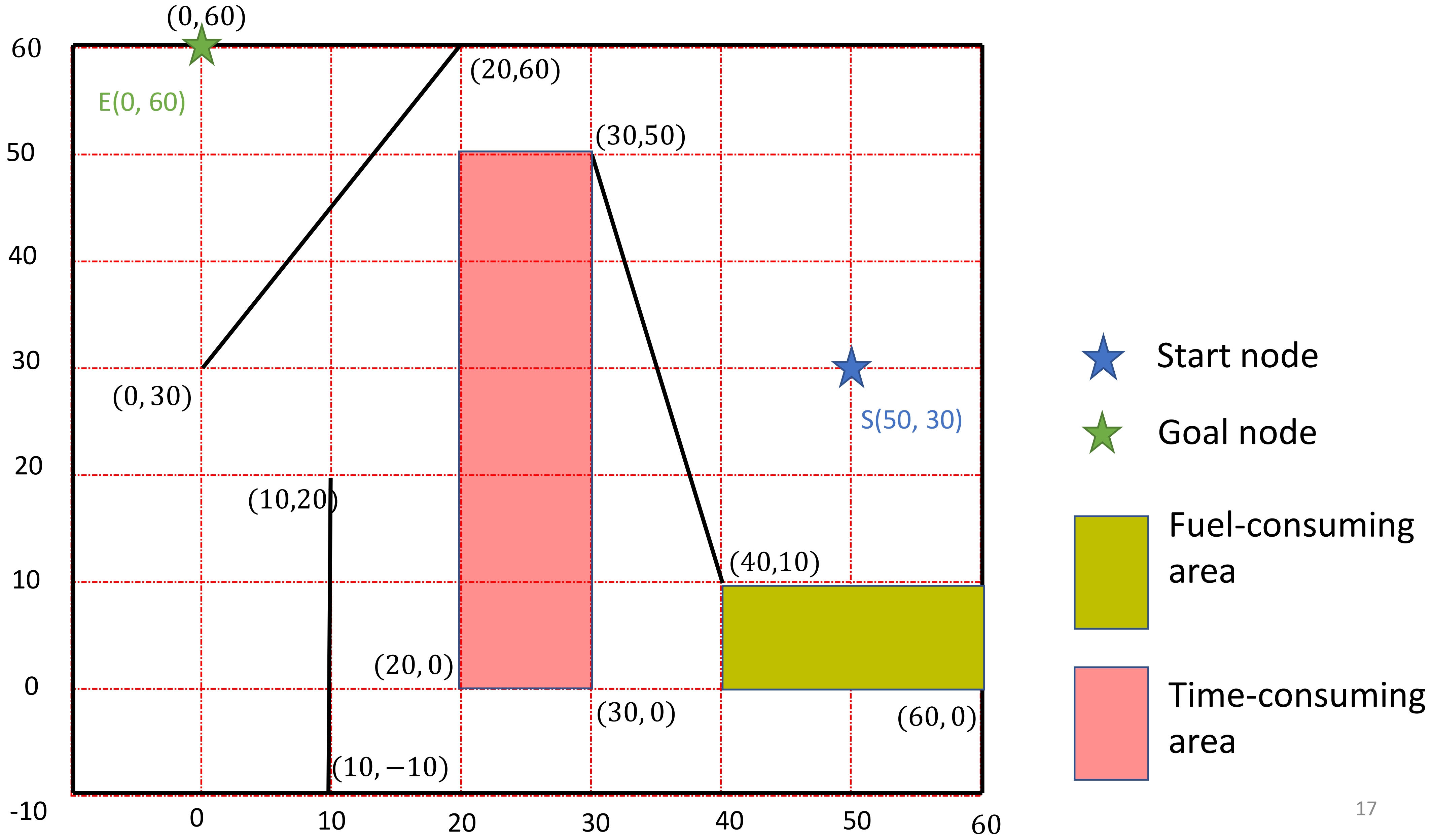
Time-consuming area

Group 6



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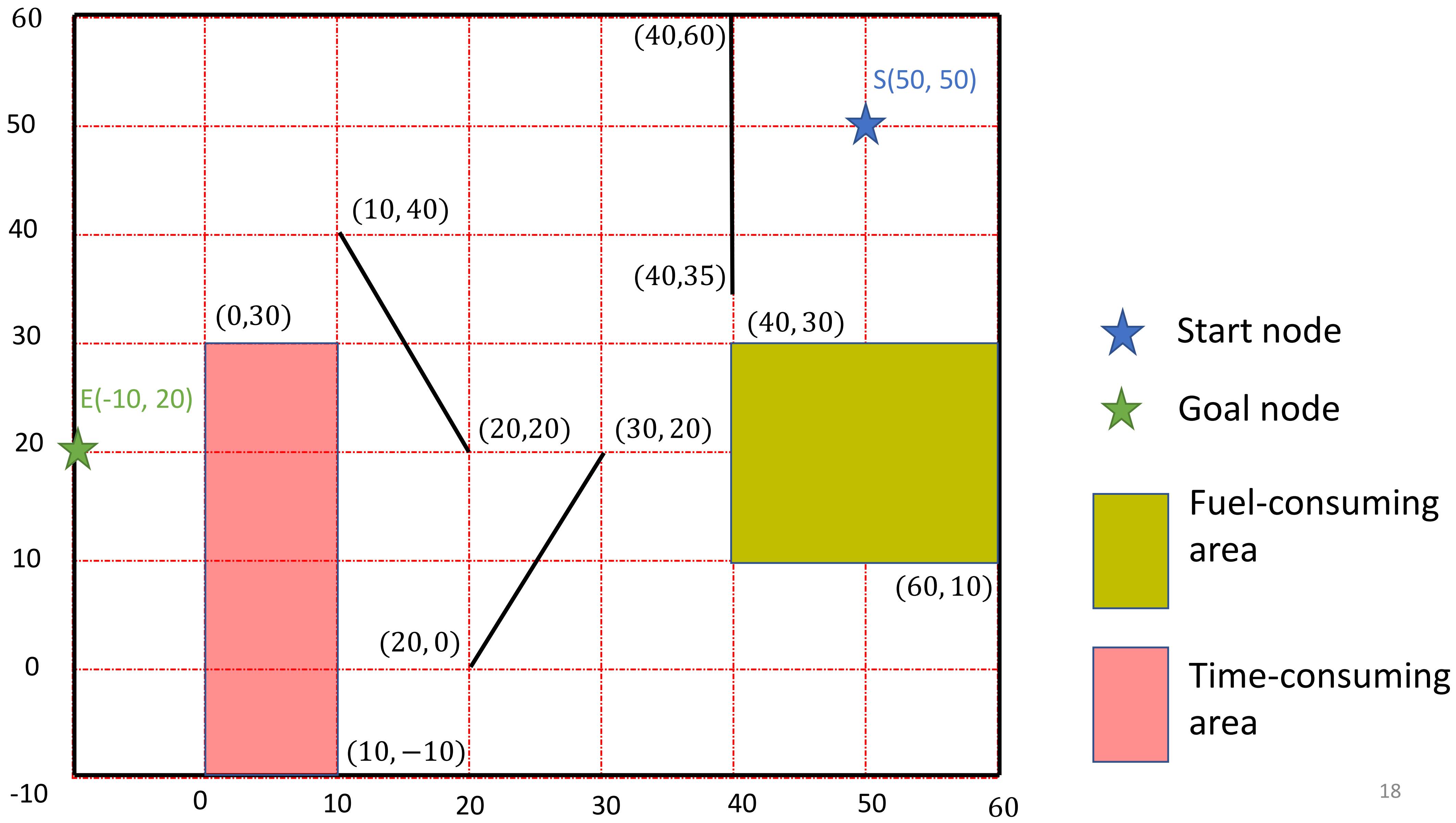
Fuel-consuming area
Time-consuming area

Group 7



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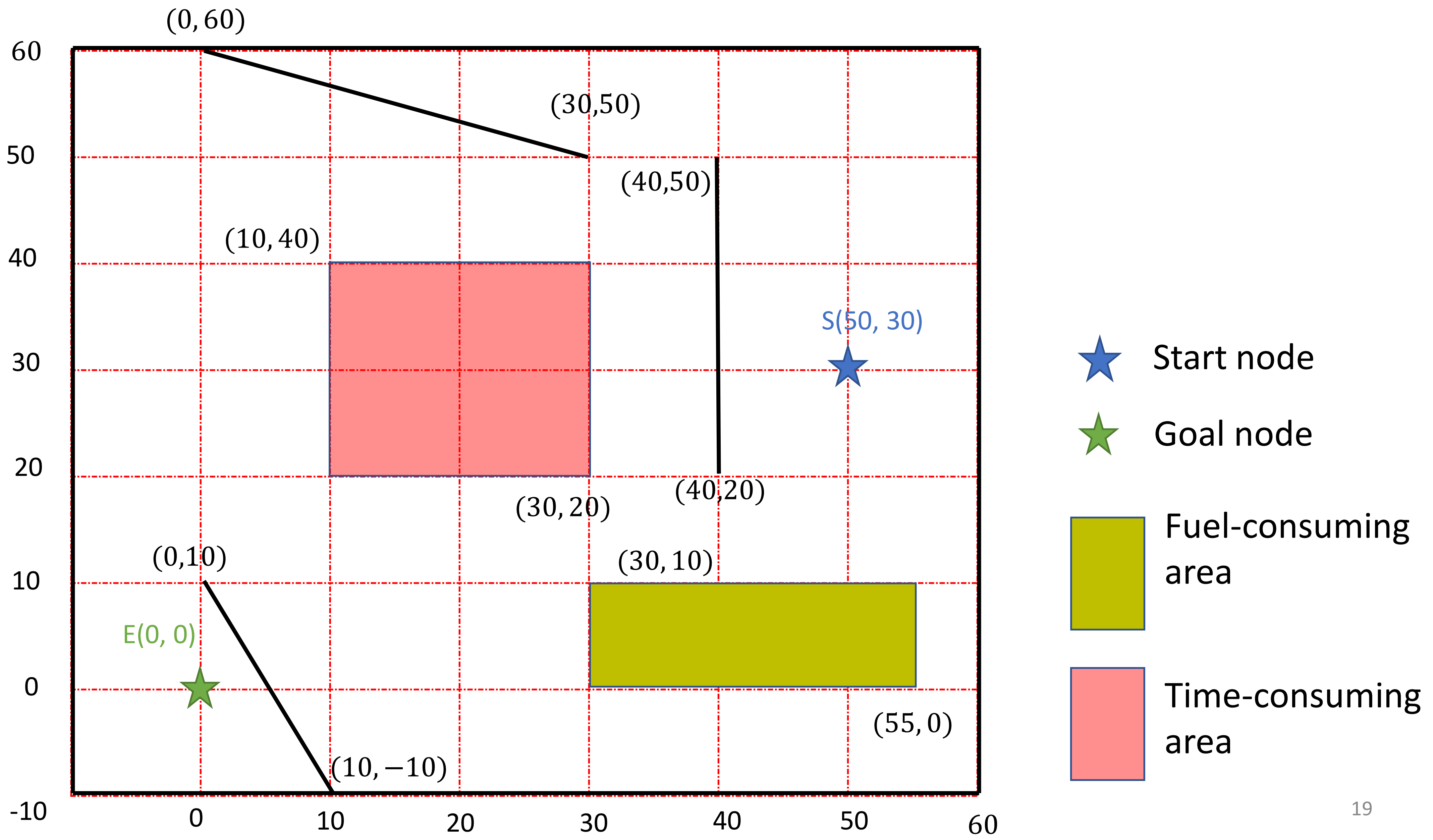
Goal node
Fuel-consuming area
Time-consuming area

Group 8



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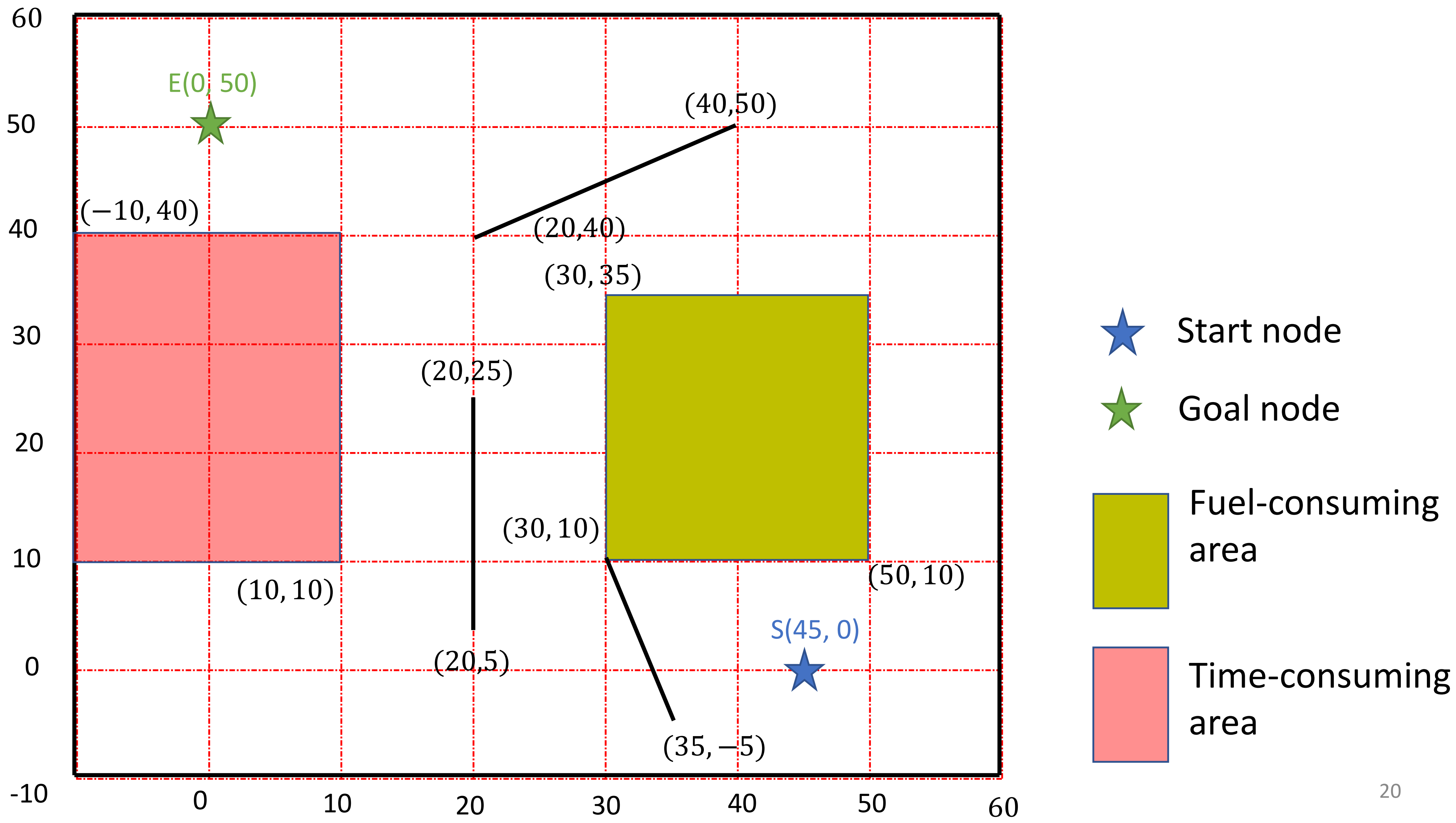
Start node
Goal node
Fuel-consuming area
Time-consuming area

Group 9



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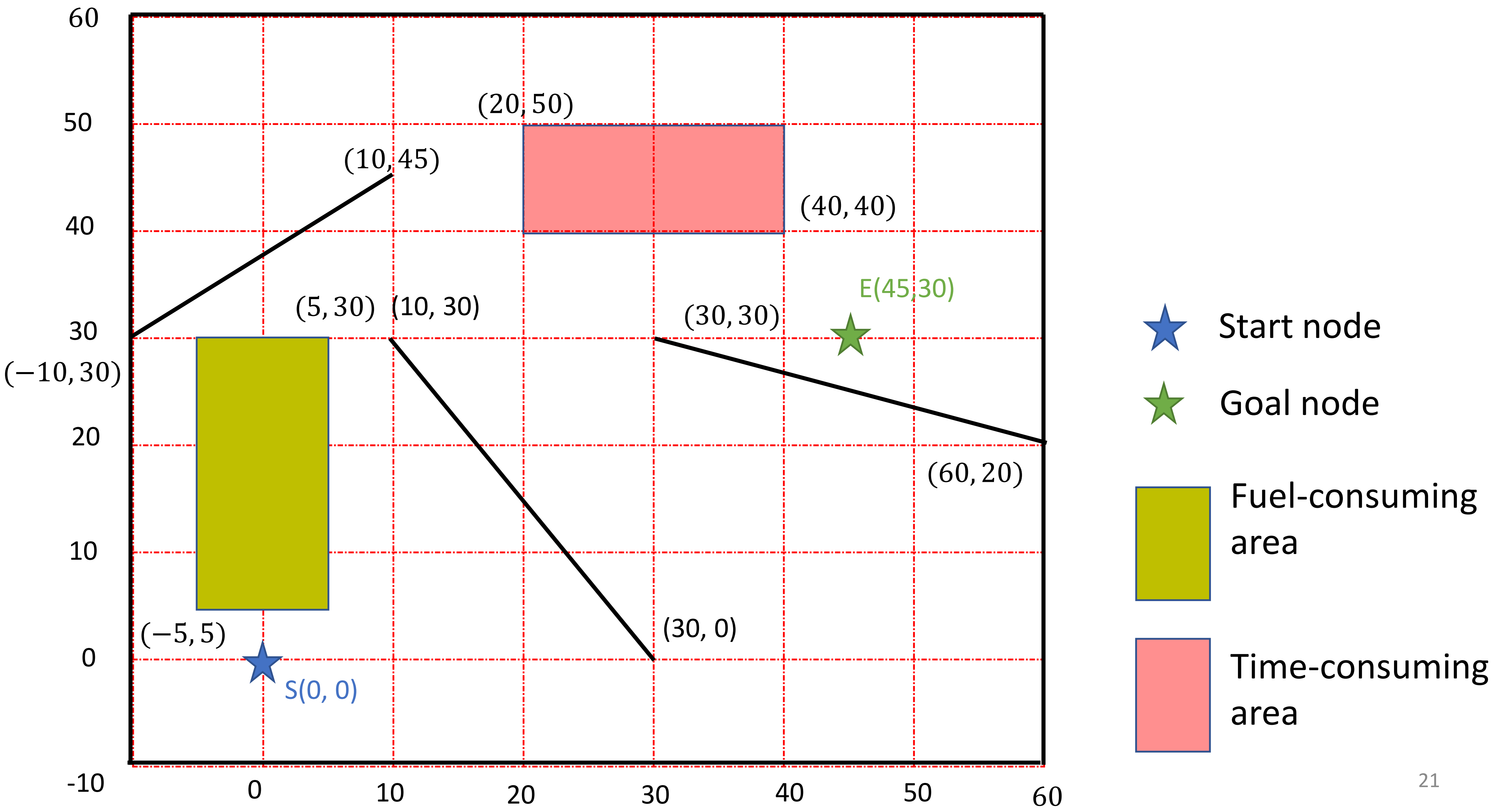
Goal node
Fuel-consuming area
Time-consuming area

Group 10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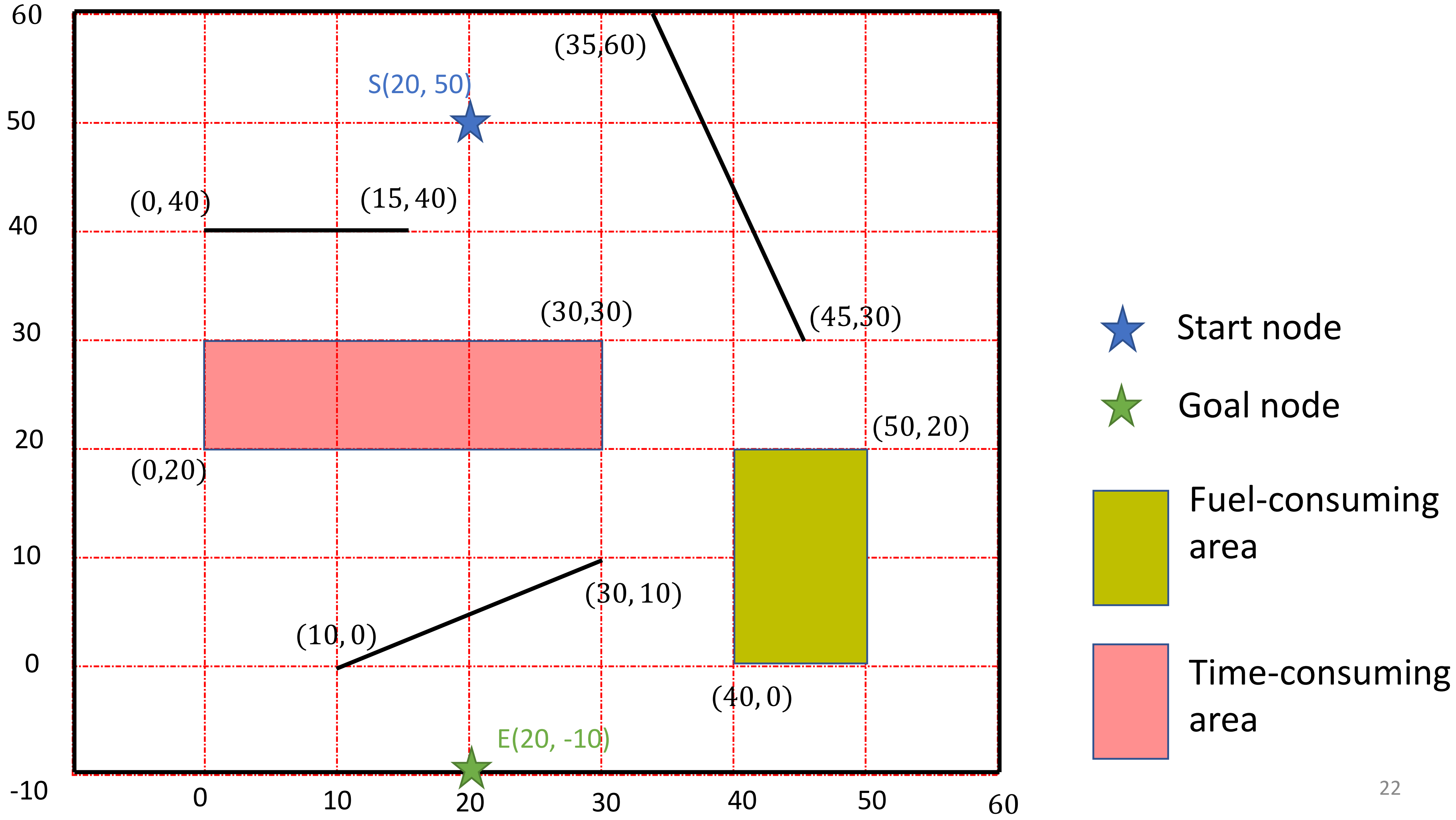
Fuel-consuming area
Time-consuming area

Group 11



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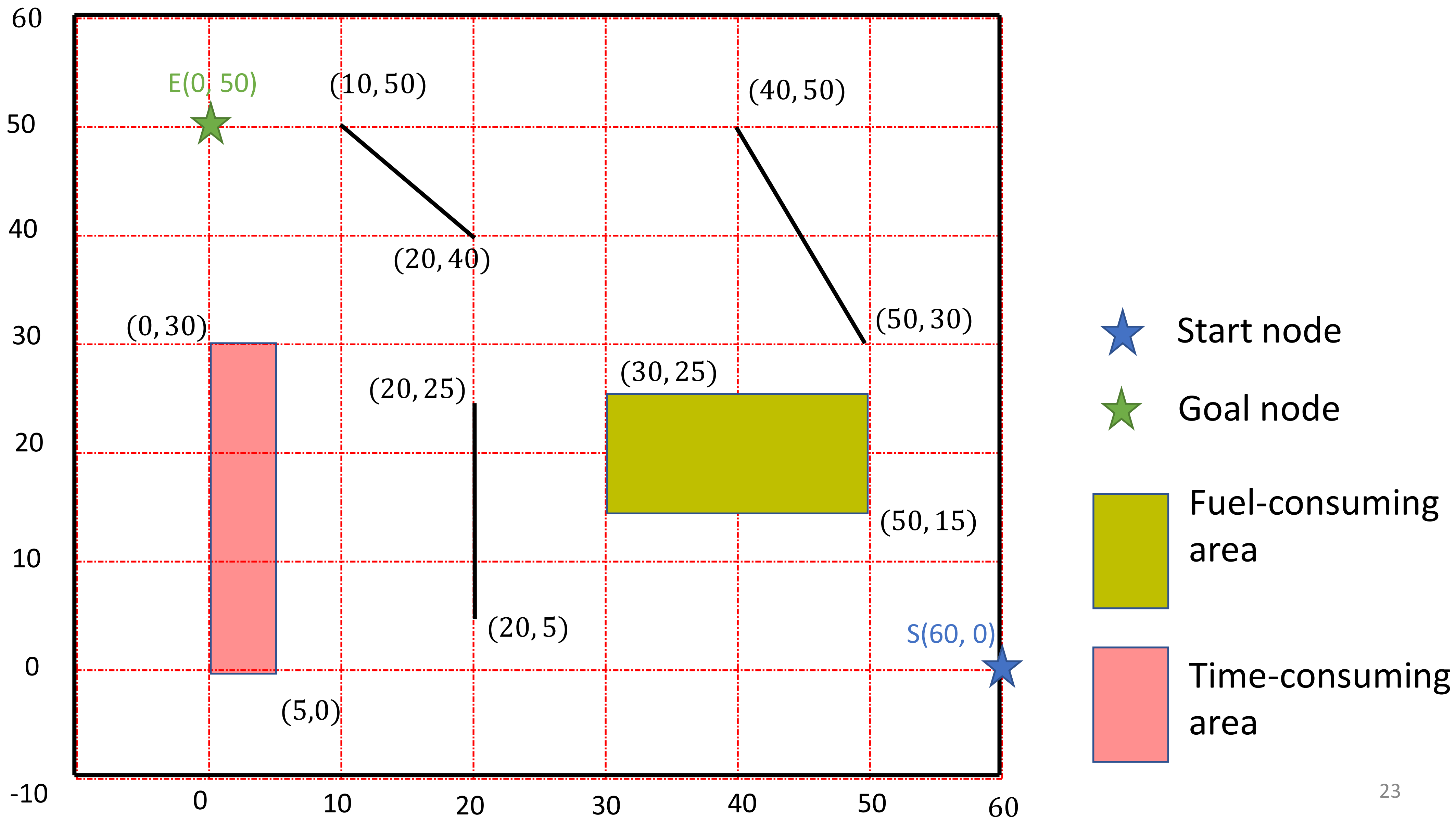
Fuel-consuming area
Time-consuming area

Group 12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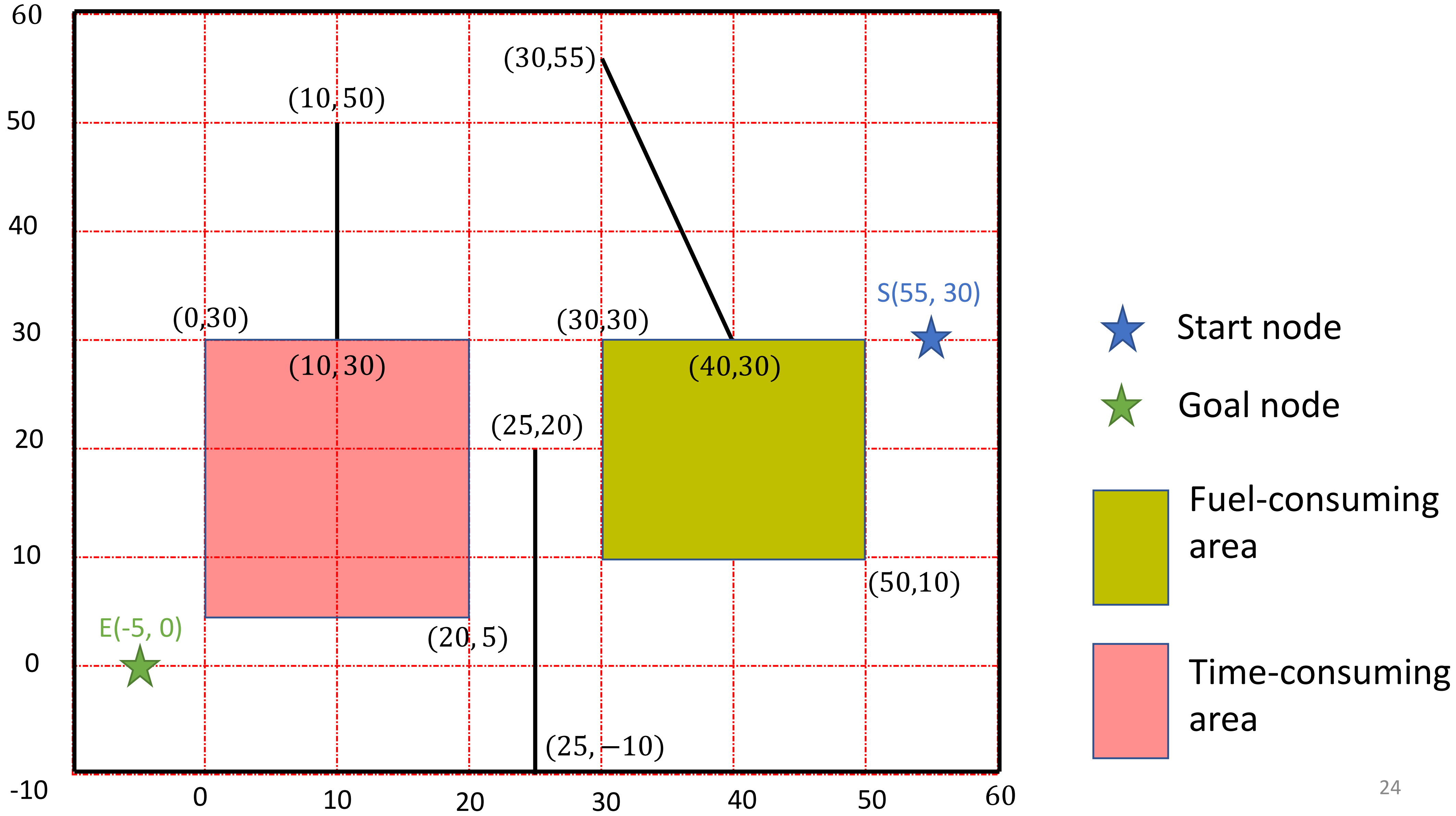
Goal node
Fuel-consuming area
Time-consuming area

Group 13



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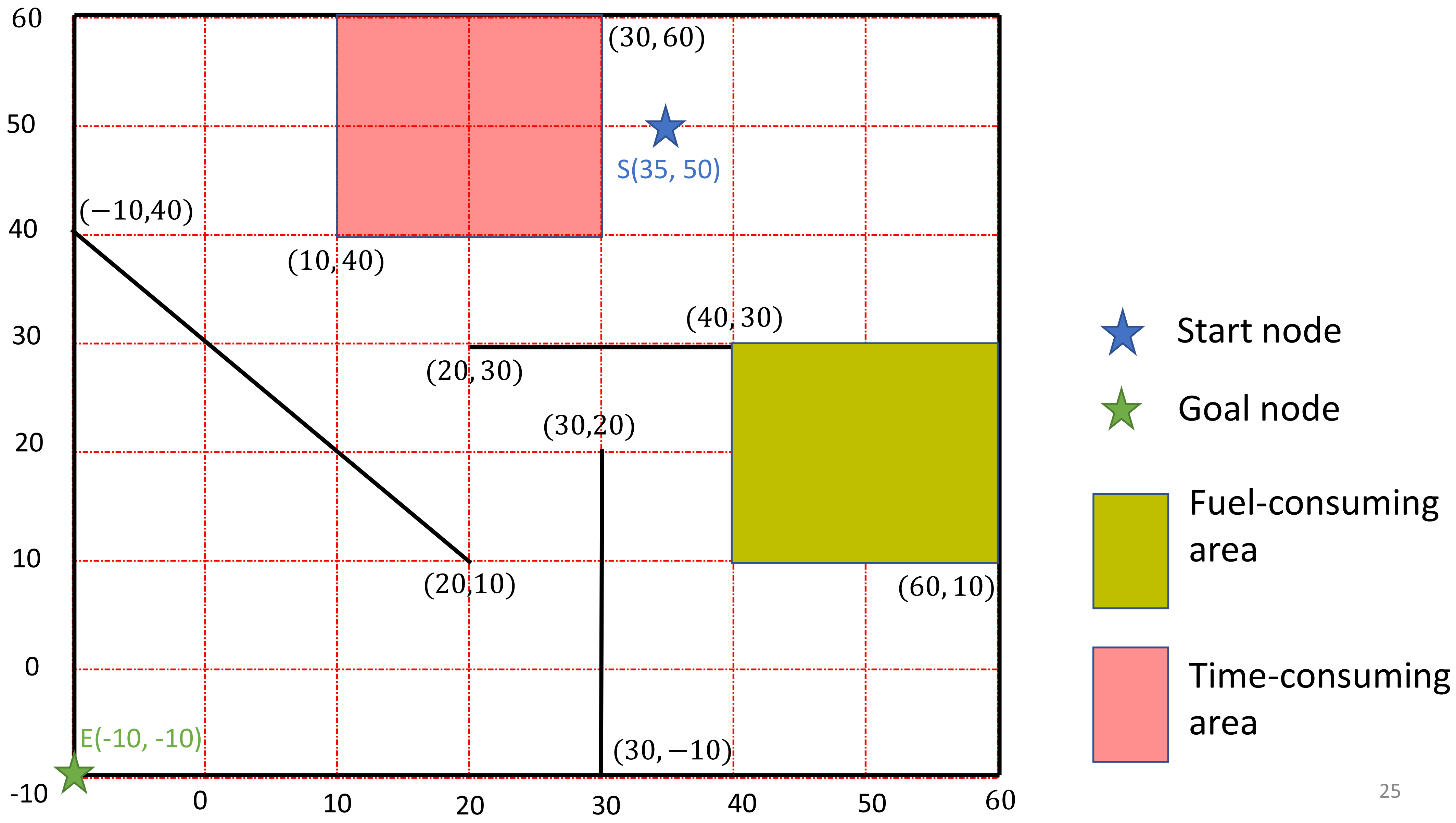
Group 14



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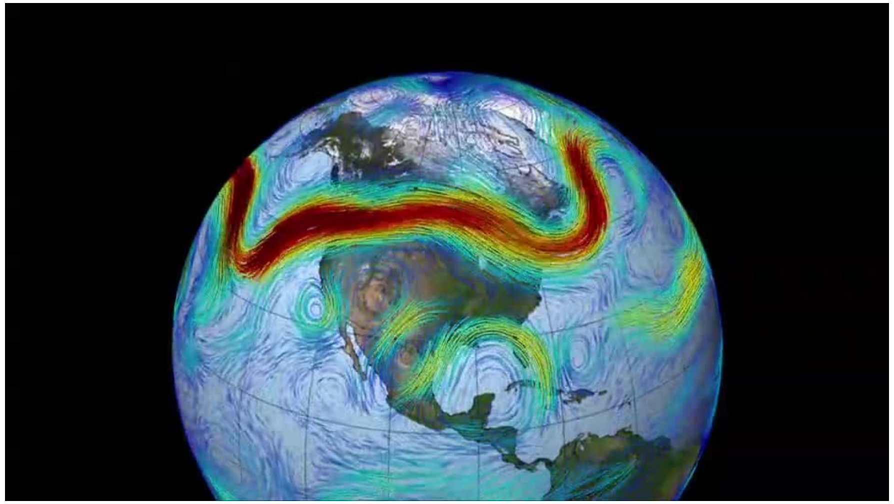
(60, 10)
E(-10, -10)
(30, −10)
Start node
Goal node
Fuel-consuming area
Time-consuming area

Task 2

Design a new cost area that can reduce the cost of the route.

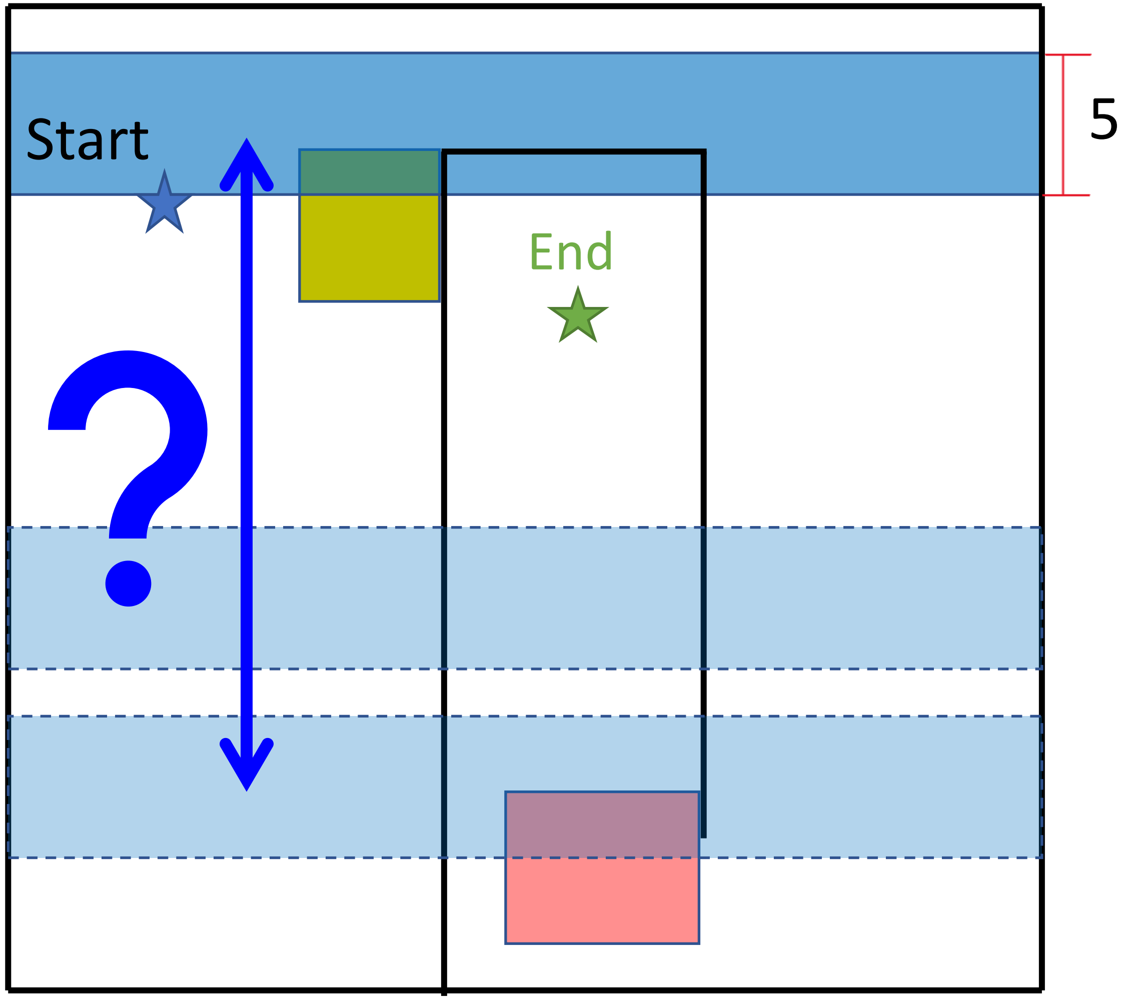
Task 2

- There are certain areas where aircrafts could consume relatively less fuel (Jet stream)
- On the other hand, there are cost intensive areas (like the ones you create in task 1)
- Recreate a jet stream that could benefit your flight route the most



Task 2 - Jet stream example (you decide the location)

- Use Scenario 1 of task 1 as the background
- Find the best place to set your minus-cost-area (jet stream) in your group challenge.
- Cost along the jet stream is reduced by 5% [1]
- The area of the jet stream must span across the map laterally and span **5-unit** length vertically (e.g., blue area)
- Again, using the program to do the calculation would grant you more bonus marks!



[1] https://www.theengineer.co.uk/jet-stream-commercial-airlines-reading-university-emissions/

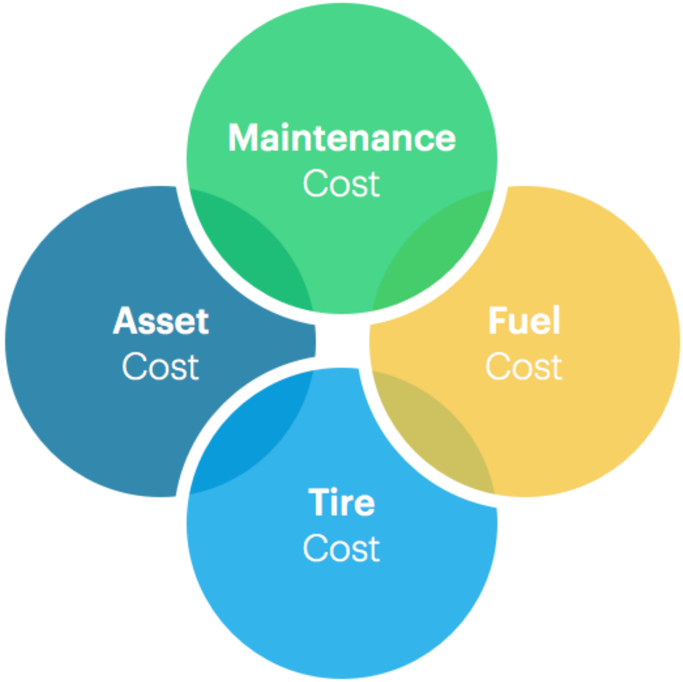
Task 3

Design a new Aircraft Model that achieve minimum cost for the challenge assigned to your group.

(Path planning programme not necessary in this task)

Designing an Aircraft

- In real life, aircrafts are designed based on industry needs:
- A380 for large global transport hubs
- Design a new aircraft by finding out its parameters based on the restrictions



Task 3

Rules and Restrictions:

- Design a new aircraft to best fit Scenario 1 in task 1
- Only consider cruise time of the flight
- Also design the passenger capacity of the aircraft, for each 50 passenger (min 100 to max 450) increase time cost by 2 $/min (Base C_T = 12 $/min)
- The base design is a twin-engine aircraft, if capacity >= 300, you must switch to a 4-engine aircraft
- C_c= 2000 for twin-engine aircrafts, 2500 for 4-engine aircrafts
- Each engine consumes fuel at 20kg/min
- Follow the trip cost equation and materials on the next slides to design your aircraft:

Task 3 requires:

- A name for your aircraft
- Passenger capacity
- Engine count
- Detailed calculation of all operating costs (Follow the equation)
- Bonus: Carefully study the rules and restrictions, try and explain the reason / evidence behind them (Open ended)

$$C = C_F \cdot \Delta F \cdot T_{best} + C_T \cdot T_{best} + C_c$$

C_F=cost of fuel per kg
C_T=time related cost per minute of flight
C_c=fixed cost independent of time
ΔF=trip fuel
ΔT=trip time

Fuel Cost

Fuel Price Analysis [2]

The jet fuel price ended last week up 5.7% at $111.7/bbl:

4 February 2022	Share in World Index	cts/gal	$/bbl (barrels)	$/mt	Index Value 2000 = 100	vs. 1 week ago	vs. 1 month ago	vs.1 yr ago
Jet Fuel Price	100%	266.02	111.73	882.30	305.42	5.7%	14.7%	73.7%
Asia & Oceania	22%	251.62	105.68	834.89	301.96	3.5%	14.8%	67.2%
Europe & CIS	28%	266.20	111.80	882.13	301.23	4.8%	14.2%	75.2%
Middle East & Africa	7%	254.67	106.96	844.55	319.42	4.0%	15.4%	71.5%
North America	39%	275.14	115.56	912.90	307.21	7.7%	14.7%	76.4%
Latin & Central America	4%	274.91	115.46	912.17	319.85	7.2%	16.3%	75.5%

[2] https://www.iata.org/en/publications/economics/fuel-monitor/

Have fun with your tasks ☺