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# Introduction

## Optimal Search Strategies for Journey Planning from Big City to Benin

Four travelers embark on a unique journey, each with distinct information to guide them. **Person 1** seeks to hide in another city for 3 months, while **Persons 2, 3, and 4** aim to travel from **Big City** to **Benin**. Their information varies:

* **Person 1**: No information (no map, no distances).
* **Person 2**: Heuristic (estimated) distances via communication.
* **Person 3**: Actual distances via a city map.
* **Person 4**: Both heuristic and actual distances.

This document presents the best search strategies for each traveler, leveraging a graph of cities with actual and heuristic distances, to ensure efficient and effective journey planning.

# Graph and Data

The journey is modeled as a graph with **14 cities** and their connections:

**Cities**

* Big City, Benghazi, Petra, Kinshasa, Giza, Lagos, Varanasi, Larnaca, Luxor, Cadiz, Cairo, Ife, Benin, Addis Ababa

## Connections (Actual Distances)

|  |  |  |
| --- | --- | --- |
| From | To | Distance |
| Big City | Benghazi | 100 |
| Big City | Petra | 140 |
| Big City | Kinshasa | 90 |
| Big City | Giza | 330 |
| Big City | Lagos | 98 |
| Big City | Varanasi | 670 |
| Benghazi | Larnaca | 60 |
| Benghazi | Luxor | 420 |
| Petra | Luxor | 210 |
| Petra | Cadiz | 200 |
| Kinshasa | Giza | 320 |
| Kinshasa | Cairo | 420 |
| Giza | Ife | 360 |
| Giza | Benin | 90 |
| Lagos | Addis Ababa | 120 |
| Cairo | Ife | 90 |
| Ife | Benin | 90 |
| Addis Ababa | Benin | 110 |

## Heuristic Values (Estimated Distances to Benin)

* Big City: 500
* Benghazi: 600
* Petra: 600
* Kinshasa: 400
* Giza: 200
* Lagos: 400
* Varanasi: 1000
* Larnaca: 900
* Luxor: 700
* Cadiz: 800
* Cairo: 600
* Ife: 400
* Benin: 0
* Addis Ababa: 200

**Start**: Big City  
**Goal for Persons 2, 3, 4**: Benin  
**Goal for Person 1**: Hide in another city for 3 months

# Search Strategies and Results

## Person 1: Hiding Strategy

* **Information**: None (no map, no distances, no heuristics).
* **Goal**: Hide in another city for 3 months.
* **Strategy**: Random selection or blind search (Breadth-First Search [BFS] or Depth-First Search [DFS]).
* **Recommendation**: Travel to a nearby city like **Kinshasa (90 units)** or **Lagos (98 units)** to hide. No goal-directed search is needed.
* **Analysis**: Without information, a simple move to a nearby city minimizes travel exposure. The provided BFS/DFS solution (Big City → Giza → Benin, cost 420, BFS: 15 nodes, DFS: 13 nodes) incorrectly assumes a goal of reaching Benin.
  + **BFS**:
    - Expanded nodes: Big City(0), Benghazi(100), Petra(140), Kinshasa(90), Giza(330), Lagos(98), Varanasi(670), Larnaca(160), Luxor(520), Luxor(350), Cadiz(340), Cairo(510), Giza(410), Ife(690), Benin(420), Addis Ababa(218)
    - Path: Big City → Giza → Benin, cost 420
    - Nodes expanded: 15
  + **DFS**:
    - Expanded nodes: Big City(0), Benghazi(100), Larnaca(160), Luxor(520), Petra(140), Luxor(350), Cadiz(340), Kinshasa(90), Cairo(510), Ife(510), Giza(410), Giza(330), Benin(420)
    - Path: Big City → Giza → Benin, cost 420
    - Nodes expanded: 13
* **Conclusion**: Random selection of a nearby city is sufficient for hiding using **BFS**.

## Person 2: Greedy Best-First Search

* **Information**: Heuristic distances only.
* **Goal**: Reach Benin from Big City.
* **Strategy**: Greedy Best-First Search (selects node with lowest heuristic value, h(n)).
* **Result**: Path **Big City → Giza → Benin**, cost **420** (330 + 90), **3 nodes expanded**.
  + **Steps**:
    - Node tested 0, expanded 0:
      * Expanded node: Big City(500)
      * Open list: Big City(500)
    - Node tested 1, expanded 1:
      * Expanded node: Big City(500)
      * Open list: Giza(200), Kinshasa(400), Lagos(400), Benghazi(600), Petra(600), Varanasi(1000)
    - Node tested 2, expanded 2:
      * Expanded node: Big City(500), Giza(200)
      * Open list: Benin(0), Ife(400), Kinshasa(400), Lagos(400), Benghazi(600), Petra(600), Varanasi(1000)
    - Node tested 3, expanded 2:
      * Expanded node: Big City(500), Giza(200), Benin(0)
      * Open list: Ife(400), Kinshasa(400), Lagos(400), Benghazi(600), Petra(600), Varanasi(1000)
* **Analysis**: Fast but suboptimal, as the optimal path is Big City → Lagos → Addis Ababa → Benin (cost 328).
* **Recommendation**: Use Greedy search for quick results when only heuristic data is available.

## Person 3: Uniform Cost Search (UCS)

* **Information**: Actual distances only.
* **Goal**: Reach Benin from Big City.
* **Strategy**: UCS (expands node with lowest cumulative path cost, g(n)).
* **Result**: Path **Big City → Lagos → Addis Ababa → Benin**, cost **328** (98 + 120 + 110), **8 nodes expanded**.
  + **Steps**:
    - Expanded node: Big City(0)
      * Node list: Kinshasa(90), Lagos(98), Benghazi(100), Petra(140), Giza(330), Varanasi(670)
    - Expanded node: Kinshasa(90)
      * Node list: Lagos(98), Benghazi(100), Petra(140), Giza(330), Giza(410), Cairo(510), Varanasi(670)
    - Expanded node: Lagos(98)
      * Node list: Benghazi(100), Petra(140), Addis Ababa(218), Giza(330), Giza(410), Cairo(510), Varanasi(670)
    - Expanded node: Benghazi(100)
      * Node list: Petra(140), Larnaca(160), Addis Ababa(218), Giza(330), Giza(410), Cairo(510), Luxor(520), Varanasi(670)
    - Expanded node: Petra(140)
      * Node list: Larnaca(160), Addis Ababa(218), Giza(330), Luxor(350), Luxor(340), Cadiz(340), Giza(410), Cairo(510), Luxor(520), Varanasi(670)
    - Expanded node: Larnaca(160)
      * Node list: Addis Ababa(218), Giza(330), Luxor(350), Luxor(340), Cadiz(340), Giza(410), Cairo(510), Luxor(520), Varanasi(670)
    - Expanded node: Addis Ababa(218)
      * Node list: Benin(328), Giza(330), Luxor(350), Luxor(340), Cadiz(340), Giza(410), Cairo(510), Luxor(520), Varanasi(670)
    - Expanded node: Benin(328)
      * Node list: Giza(330), Luxor(350), Luxor(340), Cadiz(340), Giza(410), Cairo(510), Luxor(520), Varanasi(670)
* **Analysis**: Guarantees the shortest path by prioritizing actual costs.
* **Recommendation**: Use UCS for optimal results with actual distances.

## Person 4: A\* Search

* **Information**: Both heuristic and actual distances.
* **Goal**: Reach Benin from Big City.
* **Strategy**: A\* Search (minimizes f(n) = g(n) + h(n), where g(n) is actual cost and h(n) is heuristic estimate).
* **Result**: Path **Big City → Lagos → Addis Ababa → Benin**, cost **328**, **5 nodes expanded**.
  + **Steps**:
    - Expanded node: Big City(500)
      * Node list: Kinshasa(490), Lagos(498), Giza(530), Benghazi(700), Petra(740), Varanasi(1670)
    - Expanded node: Kinshasa(490)
      * Node list: Lagos(498), Giza(530), Giza(610), Benghazi(700), Petra(740), Cairo(1110), Varanasi(1670)
    - Expanded node: Lagos(498)
      * Node list: Addis Ababa(418), Giza(530), Giza(610), Benghazi(700), Petra(740), Cairo(1110), Varanasi(1670)
    - Expanded node: Addis Ababa(418)
      * Node list: Benin(328), Giza(530), Giza(610), Benghazi(700), Petra(740), Cairo(1110), Varanasi(1670)
    - Expanded node: Benin(328)
      * Node list: Giza(530), Giza(610), Benghazi(700), Petra(740), Cairo(1110), Varanasi(1670)
* A Table\*:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| City | g(n) | h(n) | f(n) = g(n) + h(n) | h\*(n) |
| Big City | 0 | 500 | 500 | 328 |
| Benghazi | 100 | 600 | 700 | 428 |
| Petra | 140 | 600 | 740 | 388 |
| Kinshasa | 90 | 400 | 490 | 410 |
| Giza | 330 / 410 | 200 | 530 / 610 | 170 |
| Lagos | 98 | 400 | 498 | 402 |
| Varanasi | 670 | 1000 | 1670 | 0 |
| Larnaca | 160 | 900 | 1060 | 168 |
| Luxor | 520 / 350 | 700 | 1220 / 1050 | 148 |
| Cadiz | 340 | 800 | 1140 | 160 |
| Cairo | 510 | 600 | 1110 | 0 |
| Ife | 510 / 690 | 400 | 910 / 1090 | 0 |
| Benin | 500 / 420 / 328 | 0 | 500 / 420 / 328 | 0 |
| Addis Ababa | 218 | 200 | 418 | 110 |

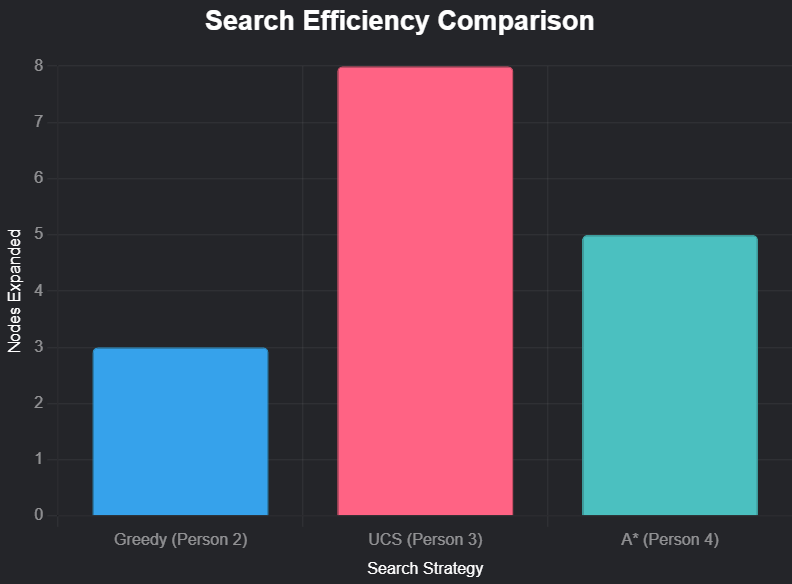
* **Analysis**: Optimal and efficient, expanding fewer nodes than UCS due to heuristic guidance.
* **Recommendation**: Use A\* for the best balance of efficiency and optimality when both data types are available.

# Comparison of Strategies

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Person | Information | Strategy | Path | Cost | Nodes Expanded | Optimal? |
| 1 | None | Random/BFS | Kinshasa or Lagos | 90 or 98 | Varies | N/A (hiding) |
| 2 | Heuristic | Greedy | Big City → Giza → Benin | 420 | 3 | No |
| 3 | Actual | UCS | Big City → Lagos → Addis Ababa → Benin | 328 | 8 | Yes |
| 4 | Both | A\* | Big City → Lagos → Addis Ababa → Benin | 328 | 5 | Yes |

# Search Efficiency Chart

The chart below compares the number of nodes expanded by each search strategy for Persons 2, 3, and 4, highlighting A\*’s efficiency.



# Conclusion

* **Person 1**: Move to **Kinshasa** or **Lagos** for hiding, as no specific destination is required.
* **Person 2**: Greedy search is fast but yields a suboptimal path (cost 420 vs. 328).
* **Person 3**: UCS ensures the optimal path (Big City → Lagos → Addis Ababa → Benin, cost 328).
* **Person 4**: A\* provides the optimal path with fewer nodes expanded, making it the most efficient.

**Key Insight**: A\* is ideal when both heuristic and actual distances are available, while UCS guarantees optimality with only actual distances. For hiding, a nearby city suffices.

# Recommendations

* **For Person 1**: Provide basic distance information to nearby cities to optimize hiding.
* **For Person 2**: Supplement heuristic data with actual distances for better pathfinding.
* **For All**: Use A\* whenever both data types are available for the best balance of efficiency and optimality.