Unveiling the Power of AI

Reasoning Systems and the Future of AI

GU Zhan (Sam)

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GU Zhan (**Sam**) lectures Master of Technology programme in the areas of data science, machine intelligence, soft computing, and applied deep learning. Prior to ...

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As a lecturer and consultant in applied machine intelligence, **Zhan GU** (**Sam**) engages communities and schools to help organizations making sense of their ...

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NUS-ISS offers five graduate programmes which focus on the practical aspects of information technology (IT) and data science.

Graduate Diploma in Systems Analysis

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Master of Technology in Software Engineering

Focuses on building robust, secure and maintainable software systems using innovative software technology

Suspect of depression by overwhelming daily stresses, but shy to consult a doctor?

Empower you to conduct professional assessment DIY, with:

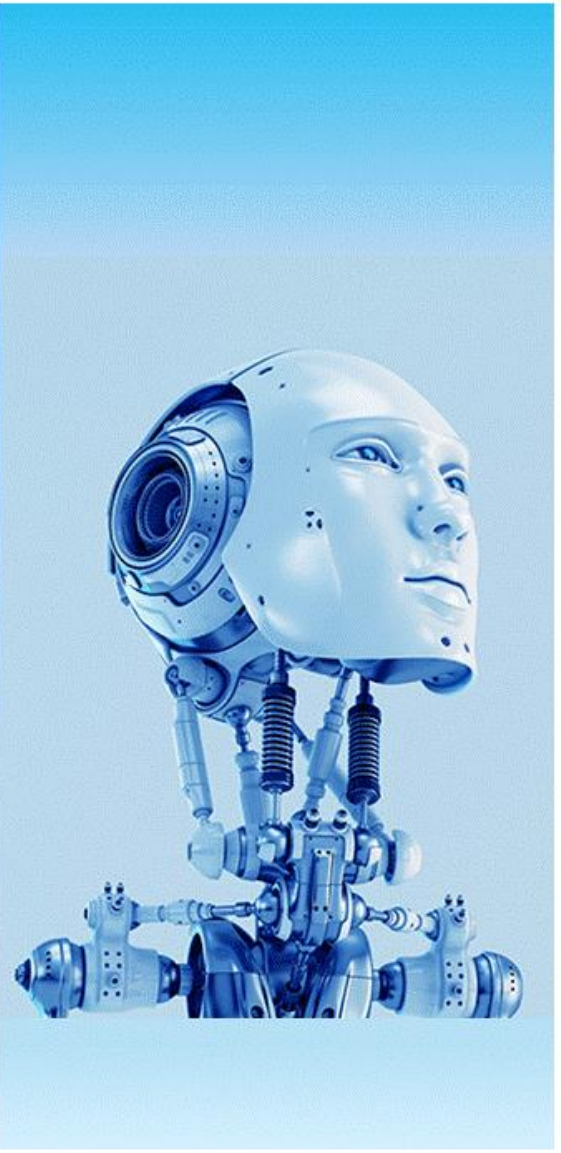
Depression Screener

[Health] Depression Screener

Pepper Project Group

CAO LIANG	A0012884E
GENG LIANGYU	A0195278M
HAN DONGCHOU FRANCIS	A0195414A
ONG BOON PING	A0195172B
TAN CHIN GEE	A0195296M

Depression Screening System



Source: https://github.com/IRS-MR/IRS-MR-2019-01-19-IS1PT-GRP-Pepper-DepressionScreeningSystem

Want to consult a depression specialist, but worried about shy personality, Chinese speaking only, and other concerns... Which doctor to see?

Empower you to meet a doctor suitable to your needs, with:

Patient-Doctor Matcher

[Health] Patient-Doctor Matcher

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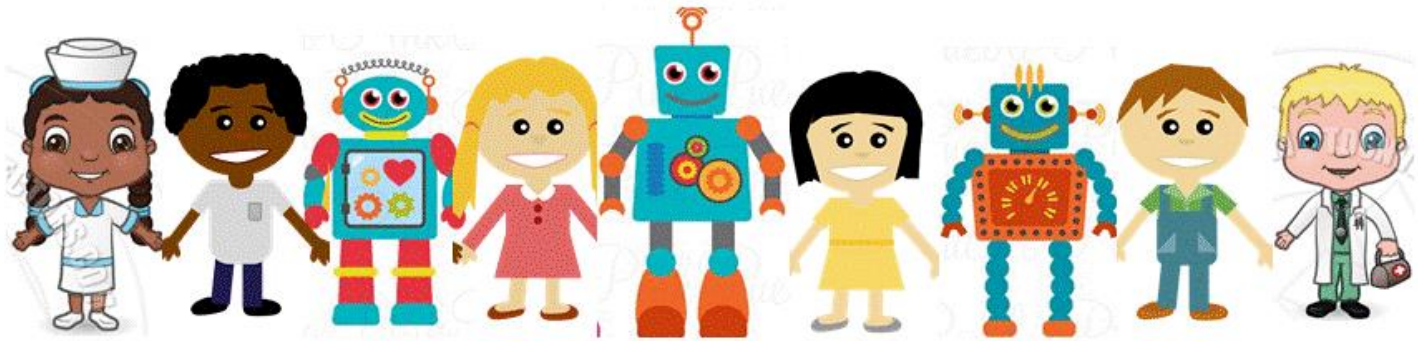
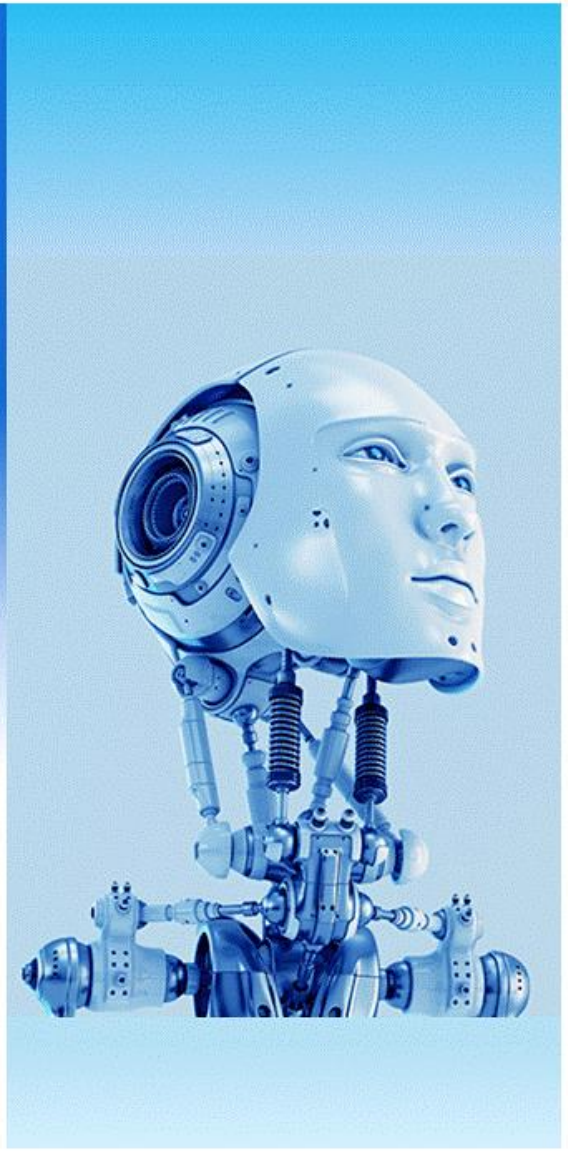
Patient Matching System





Source: https://github.com/IRS-RS/IRS-RS-2019-03-09-IS1PT-GRP-Pepper-PatientMatchingSystem

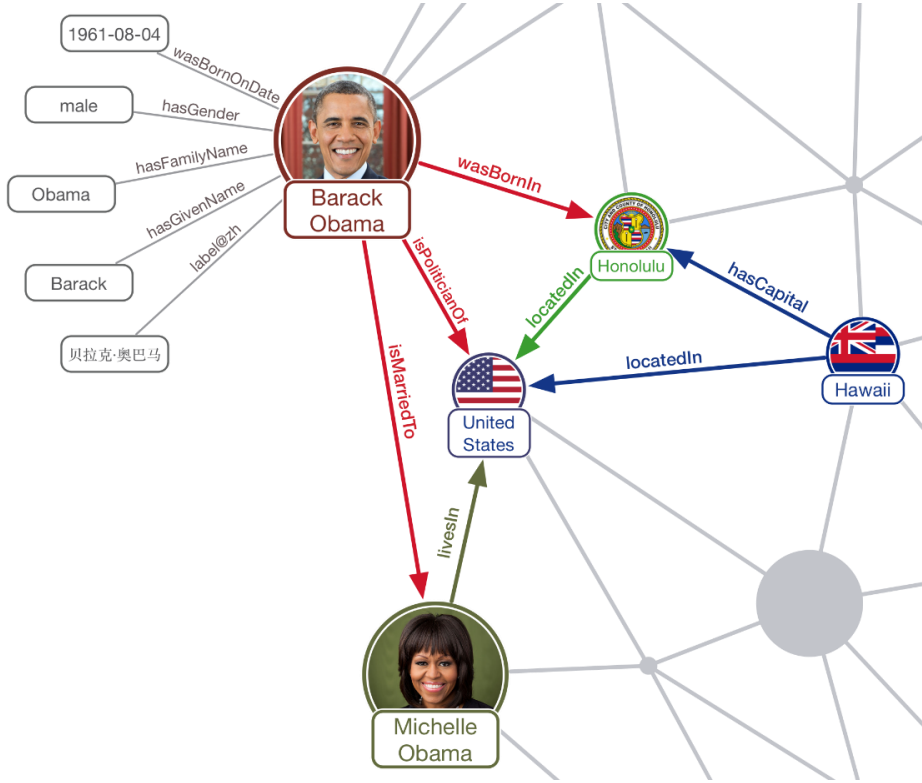
Reasoning Using Uninformed Search:

Graph Search

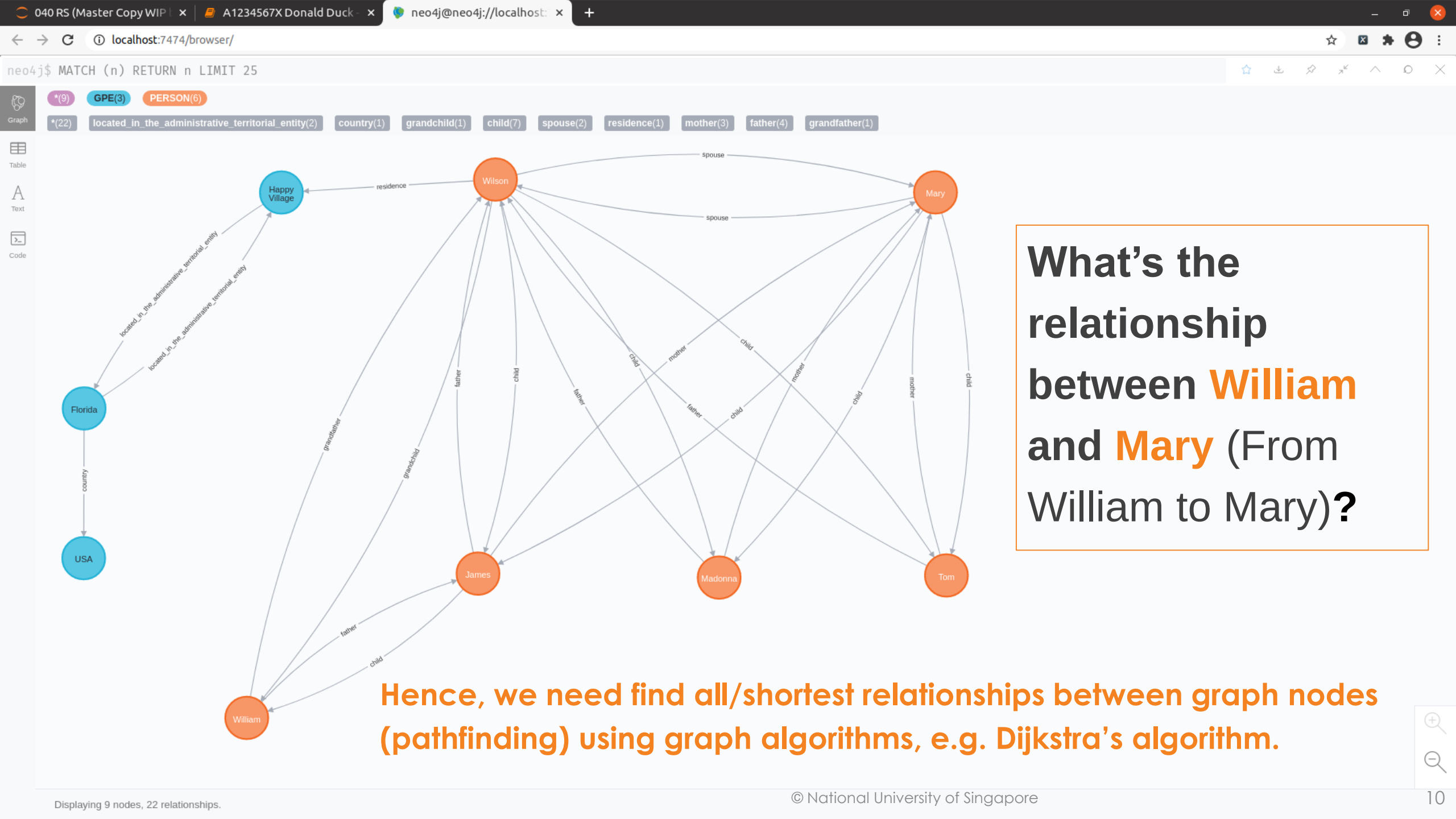
Uninformed Search Techniques (Graph)

Knowledge Graph / Semantic Web / Ontology

- **A model (data structure) for word concepts in human cognition, consisting of nodes, links and labels**
  - **Nodes (vertices)** represent objects, concepts, or situations. They can be instances (individual objects as in Knowledge Graph) or classes (generic objects as in Semantic Web)
  - **Links (edges)** between nodes represent a relationship/predicate
  - **Labels (attributes)**
    - Labels on nodes indicate the name of the object, concept, etc.
    - Labels on links describe the type of relationship between nodes
- **Search objective: Find out the relationship between Barack and Hawaii.**



Source: https://www.ambiverse.com/wp-content/uploads/2017/01/KnowledgeGraph-Relations-cropped2.png



Uninformed Search Techniques (Graph)

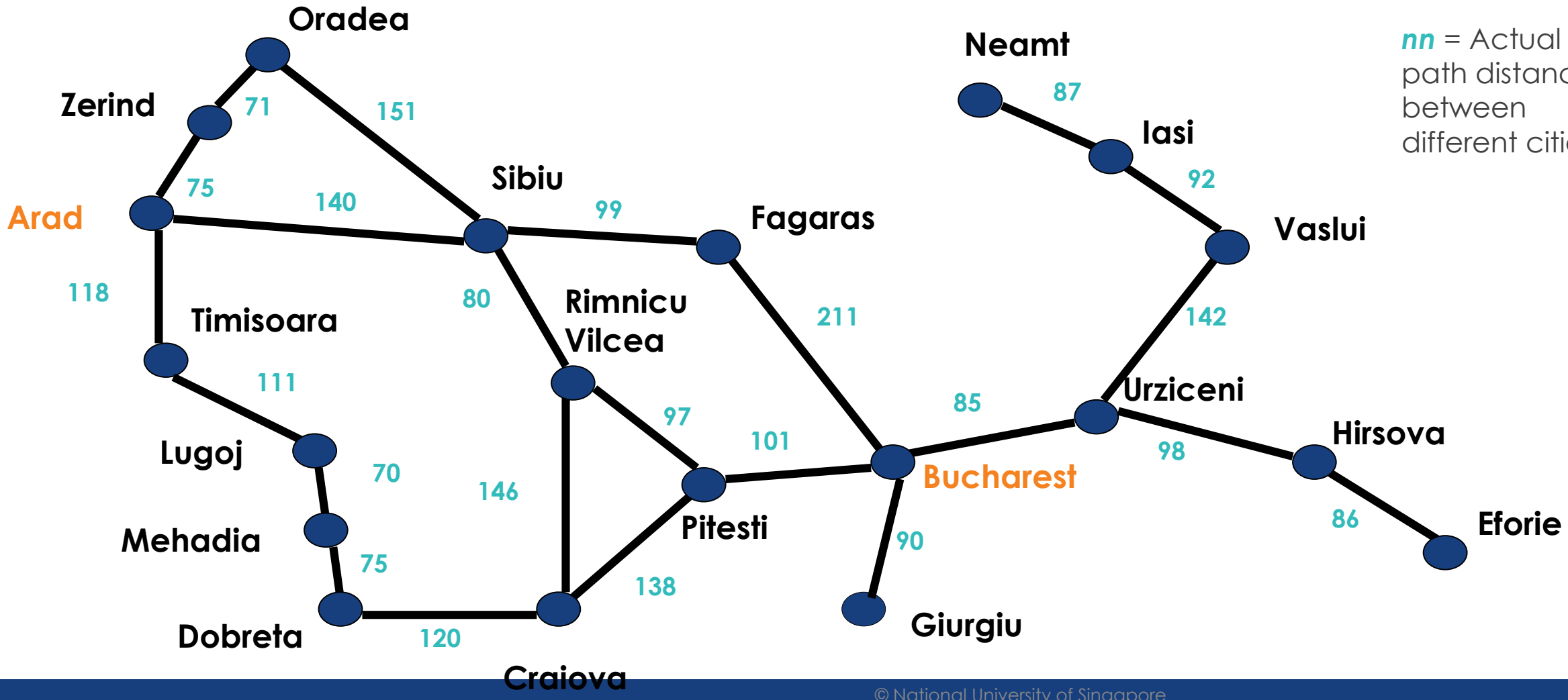
Dijkstra's algorithm conducts a breadth-first search (BFS) with a higher level of analysis (calculation of path cost) in order to find the shortest path between two nodes in a graph. Here's how it works:

1. Pick the **start** and **end nodes** and add the start node to the set of **solved nodes** with a value of **0**. Solved nodes are the set of nodes with the shortest known path from the start node. The start node has a value of 0 because it is 0 path-length away from itself.
2. Traverse breadth-first from the start node to its **nearest neighbors (frontier nodes)** and record/calculate the path length against each neighboring node.
3. Pick the **shortest path to one of these neighbors** and mark that node as solved. In case of a tie, Dijkstra's algorithm picks at random.
4. Visit the nearest neighbors (frontier nodes) to the **set of solved nodes** and record/accumulate the path lengths from the start node against these new neighbors. Don't visit any neighboring nodes that have already been solved, as we already know the shortest paths to them.
5. Repeat steps three and four until the **end/destination node** has been marked as "**solved node**", or a termination criteria is satisfied.

: https://neo4j.com/blog/graph-search-algorithm-basics/

Uninformed Search Techniques (Graph)

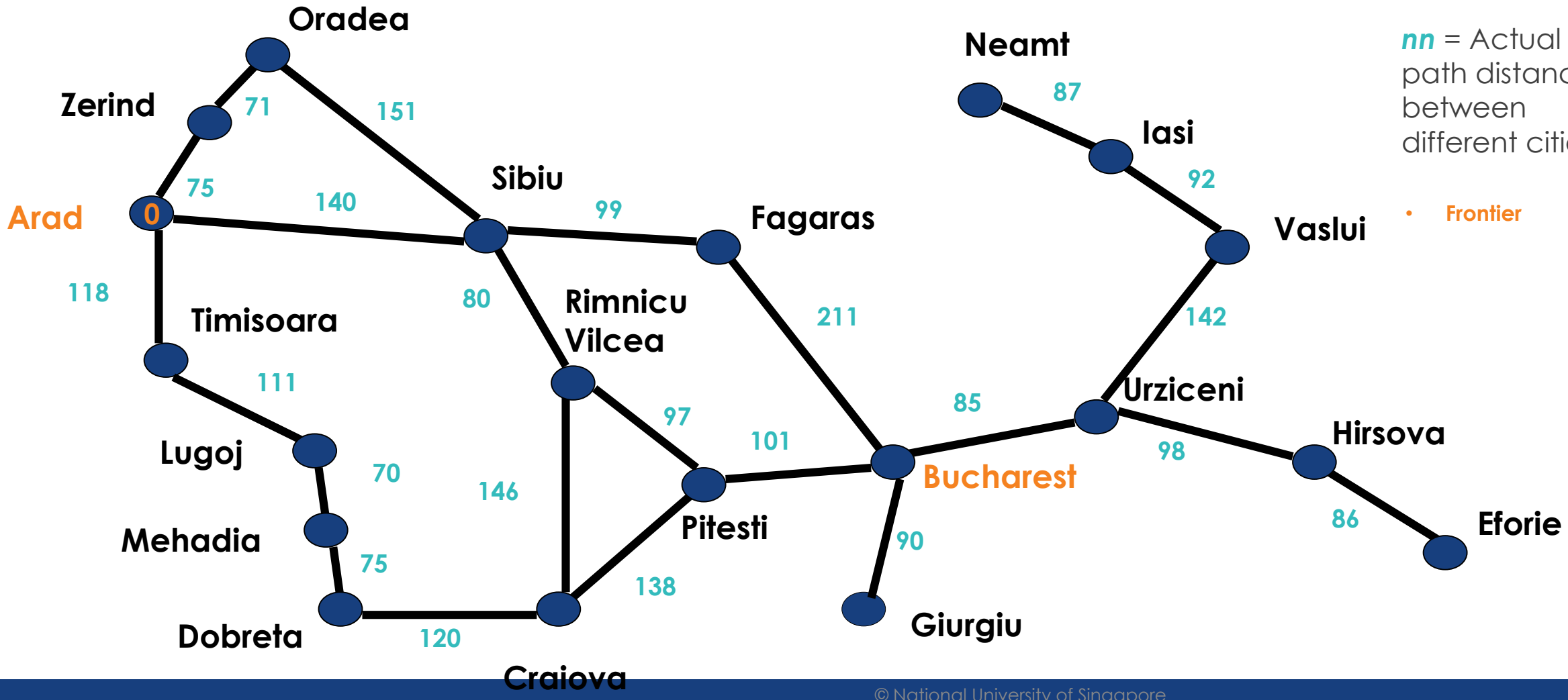
Goal: find shortest path from Arad to Bucharest.



nn = Actual path distance between different cities

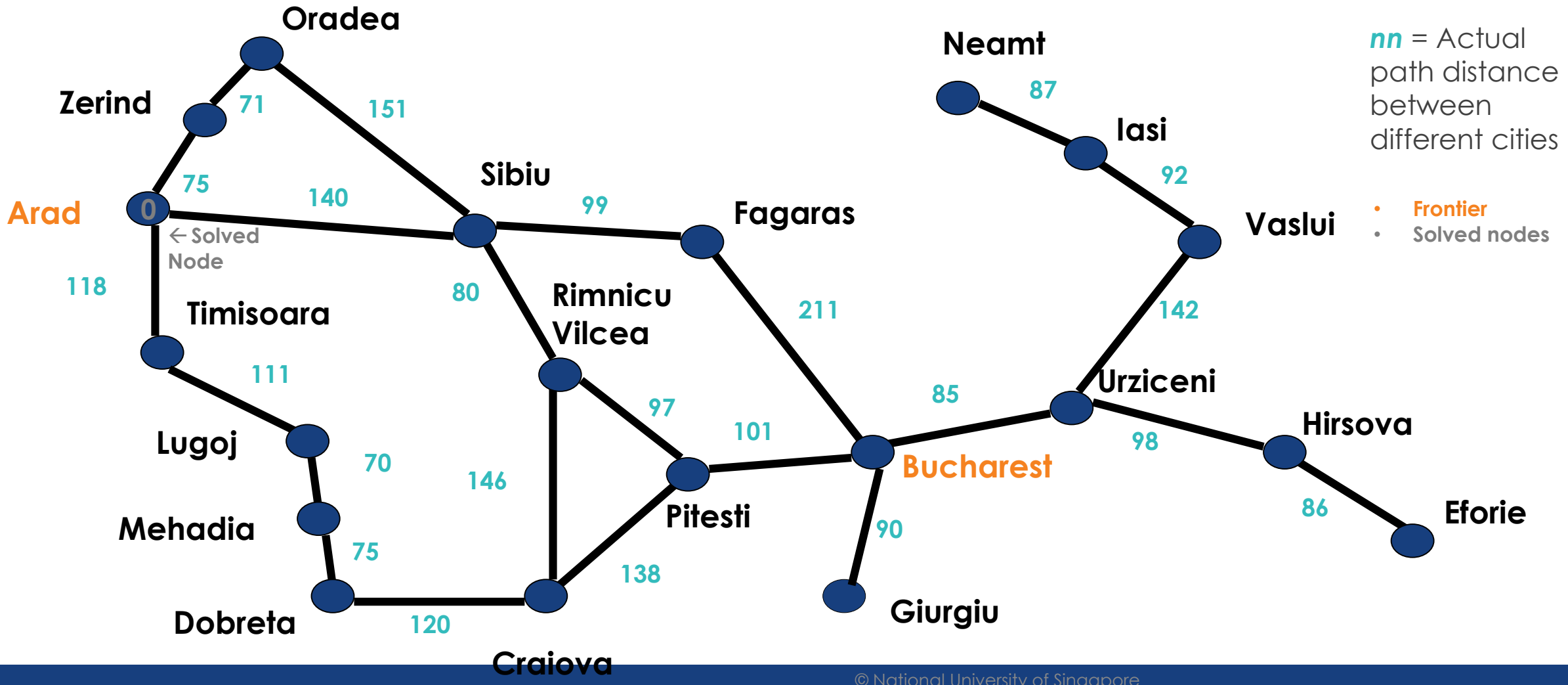
Uninformed Search Techniques (Graph)

Initialize Start Node (Frontier Node**): Arad; Shortest distance: Zero;**



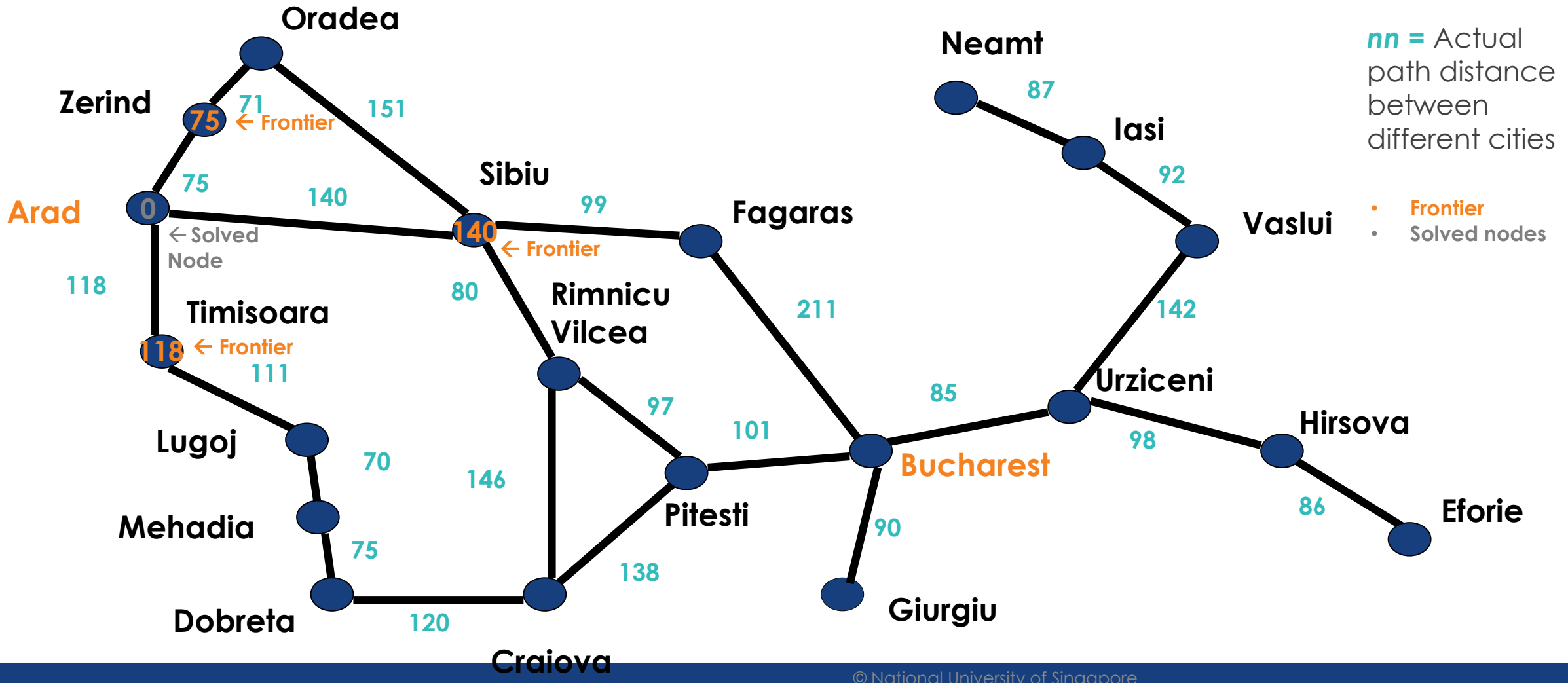
Uninformed Search Techniques (Graph)

Update list of Solved Nodes;



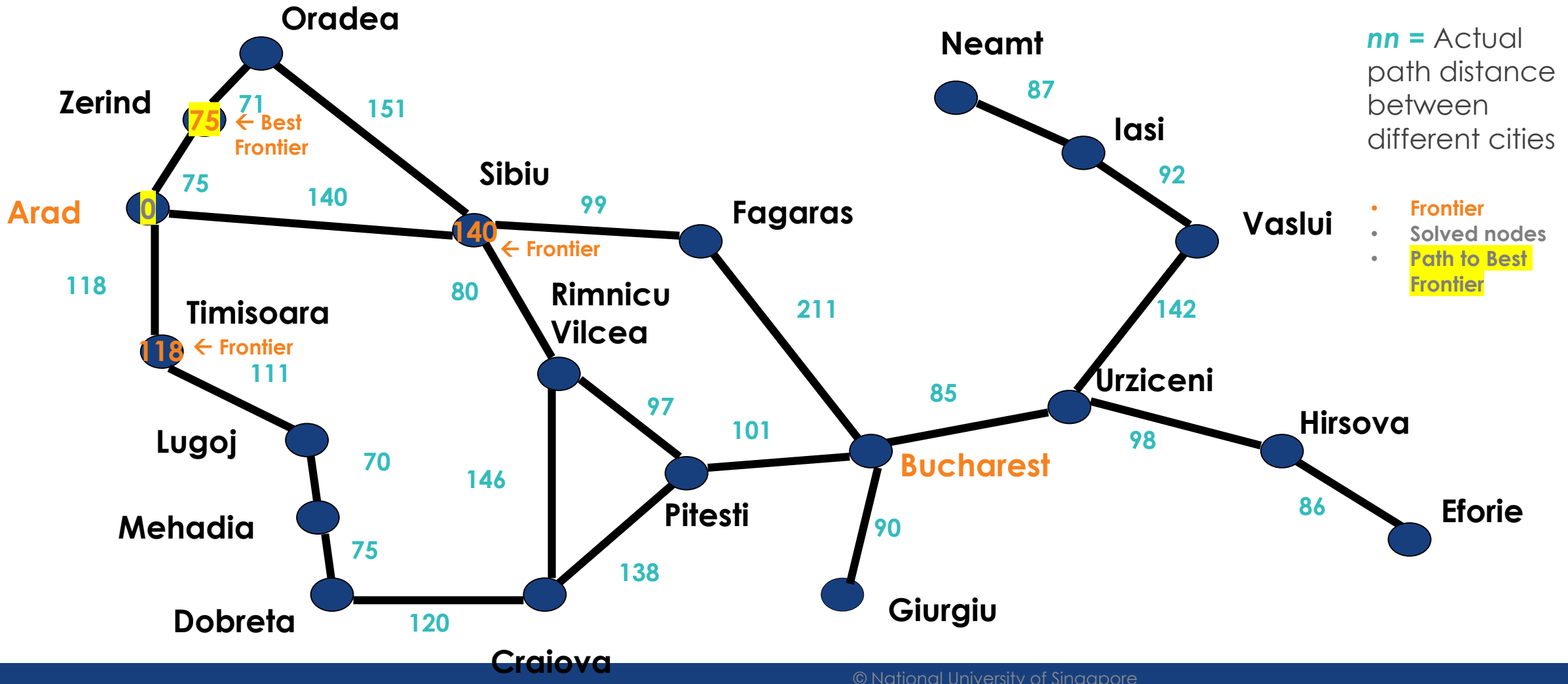
Uninformed Search Techniques (Graph)

Expand and calculate Frontier Nodes;



Uninformed Search Techniques (Graph)

Determine Best Frontier Node;



Uninformed Search Techniques (Graph)

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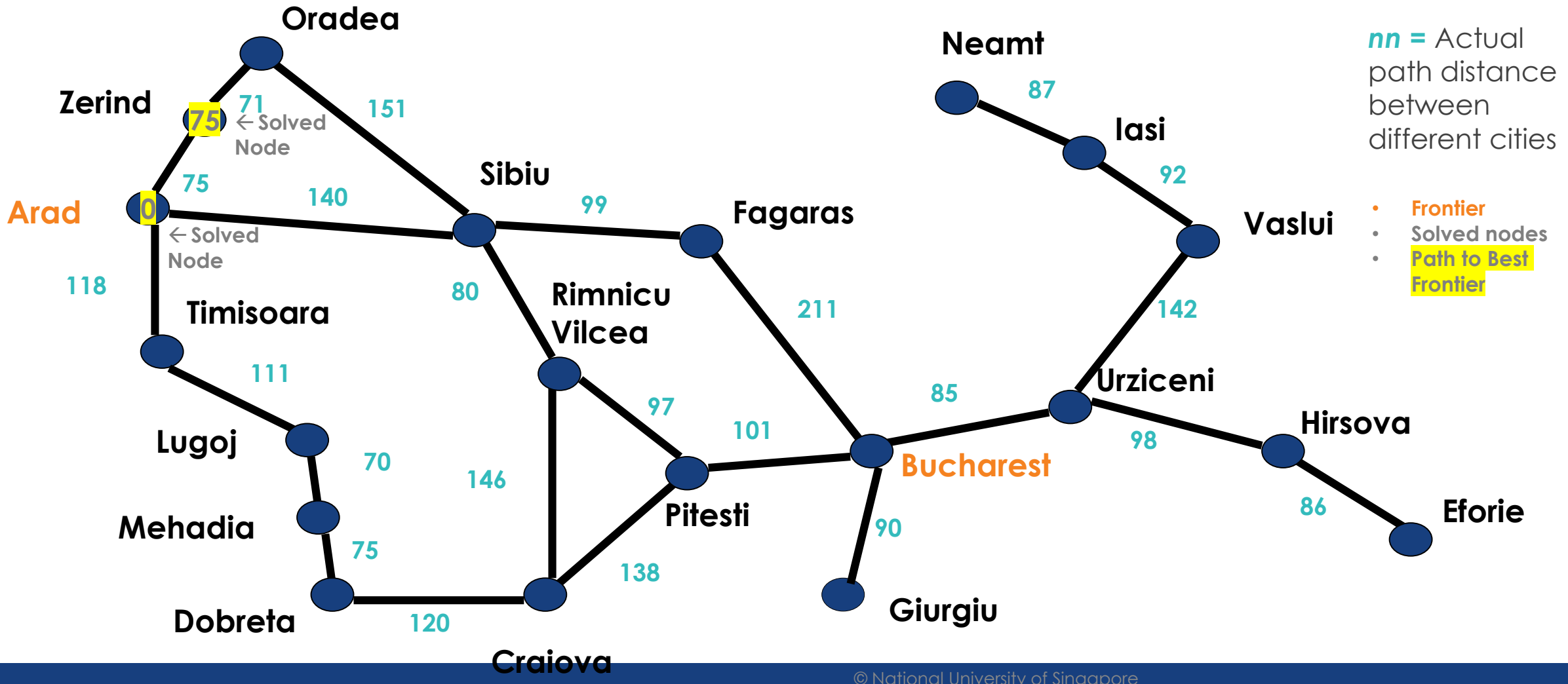
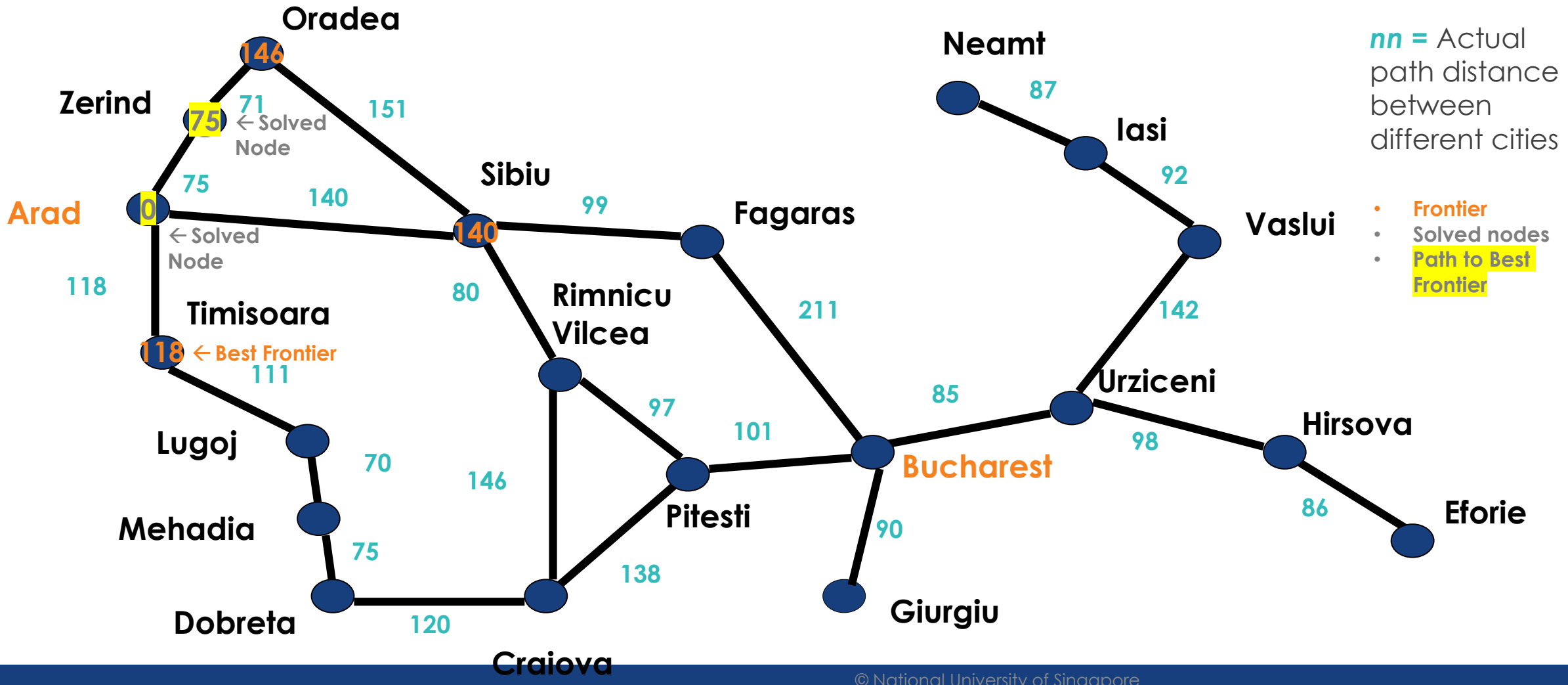


Uninformed Search Techniques (Graph)

Expand and calculate Frontier Nodes; Determine Best Frontier Node;



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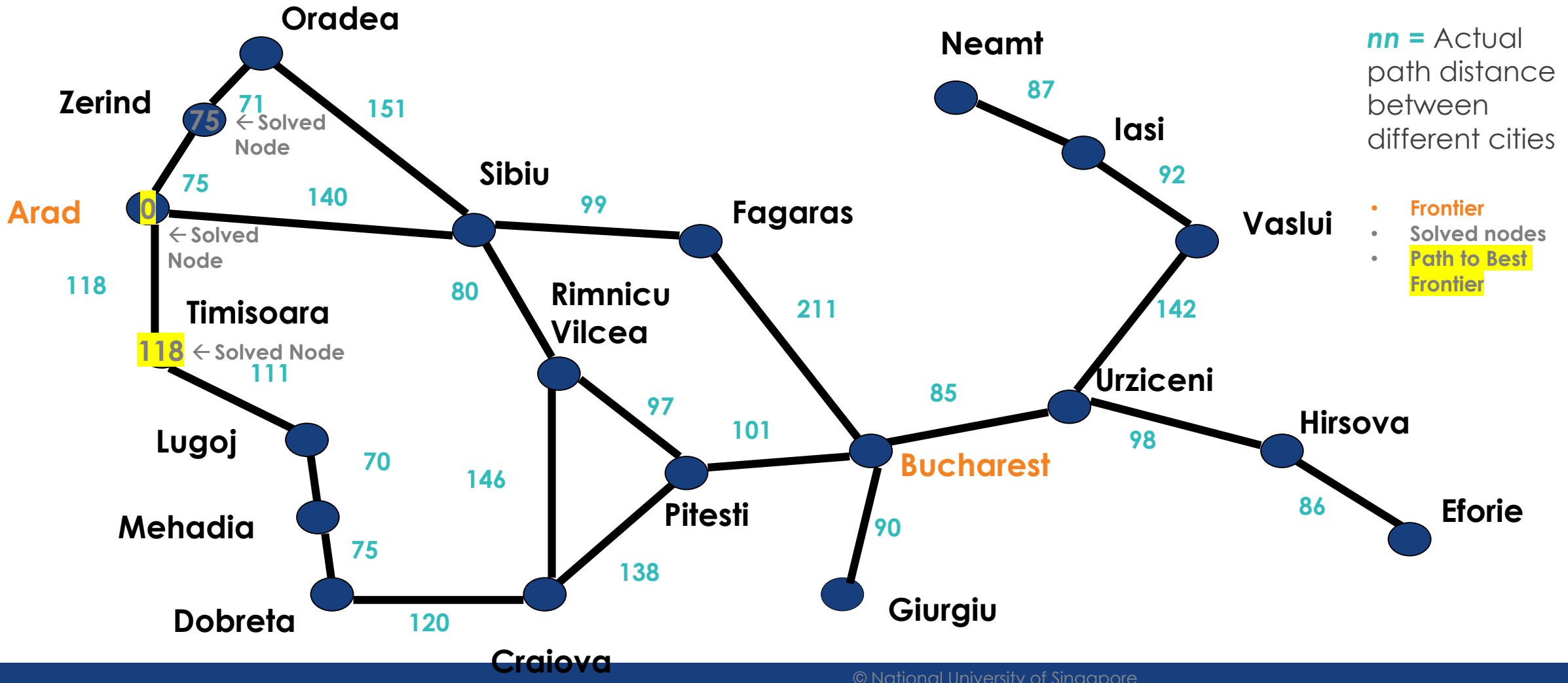

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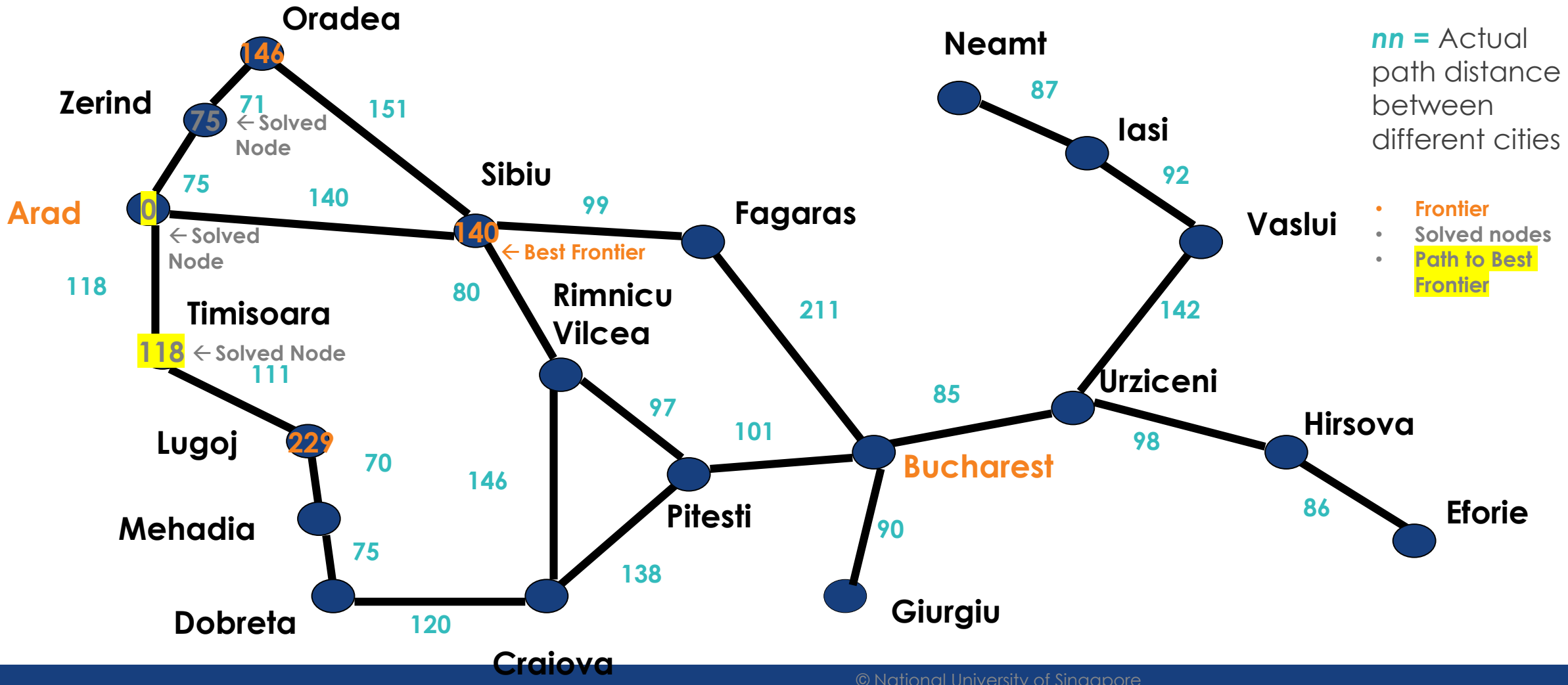

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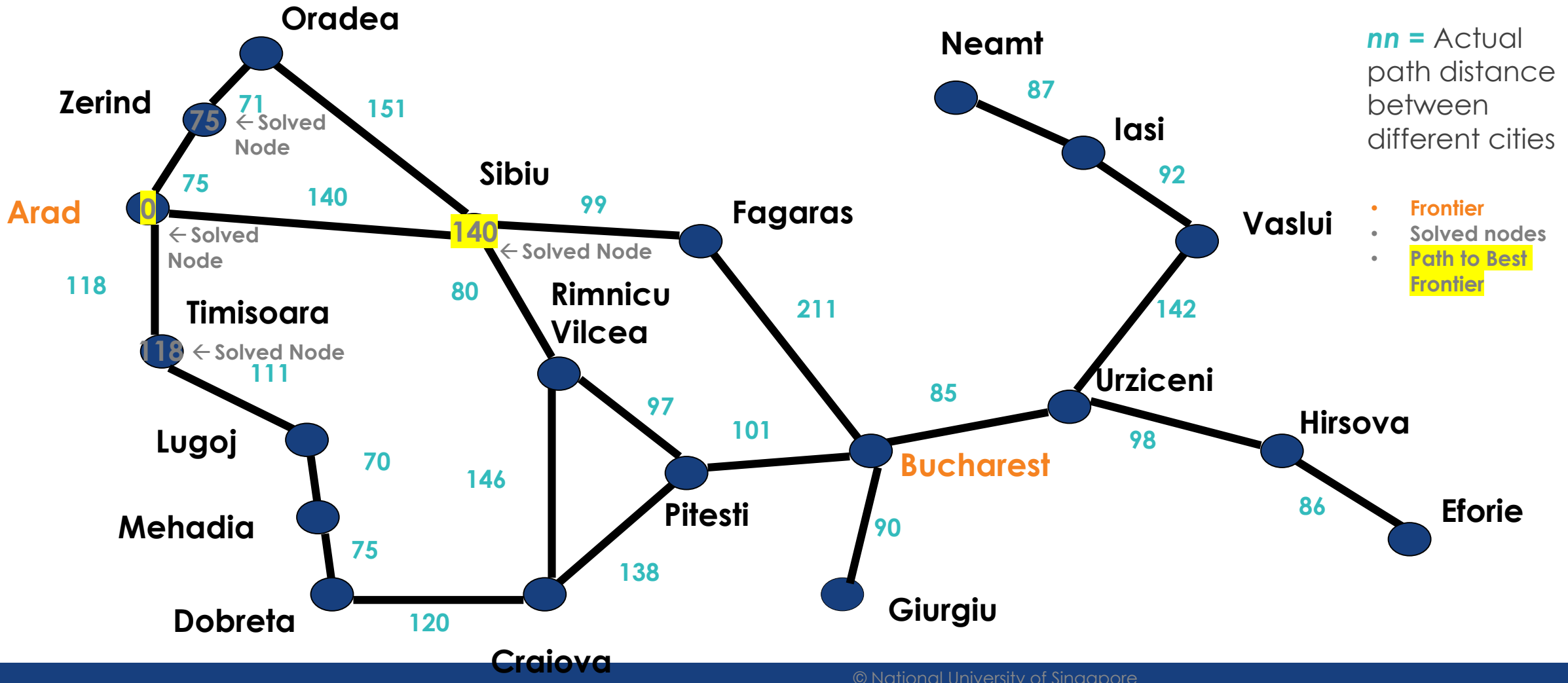

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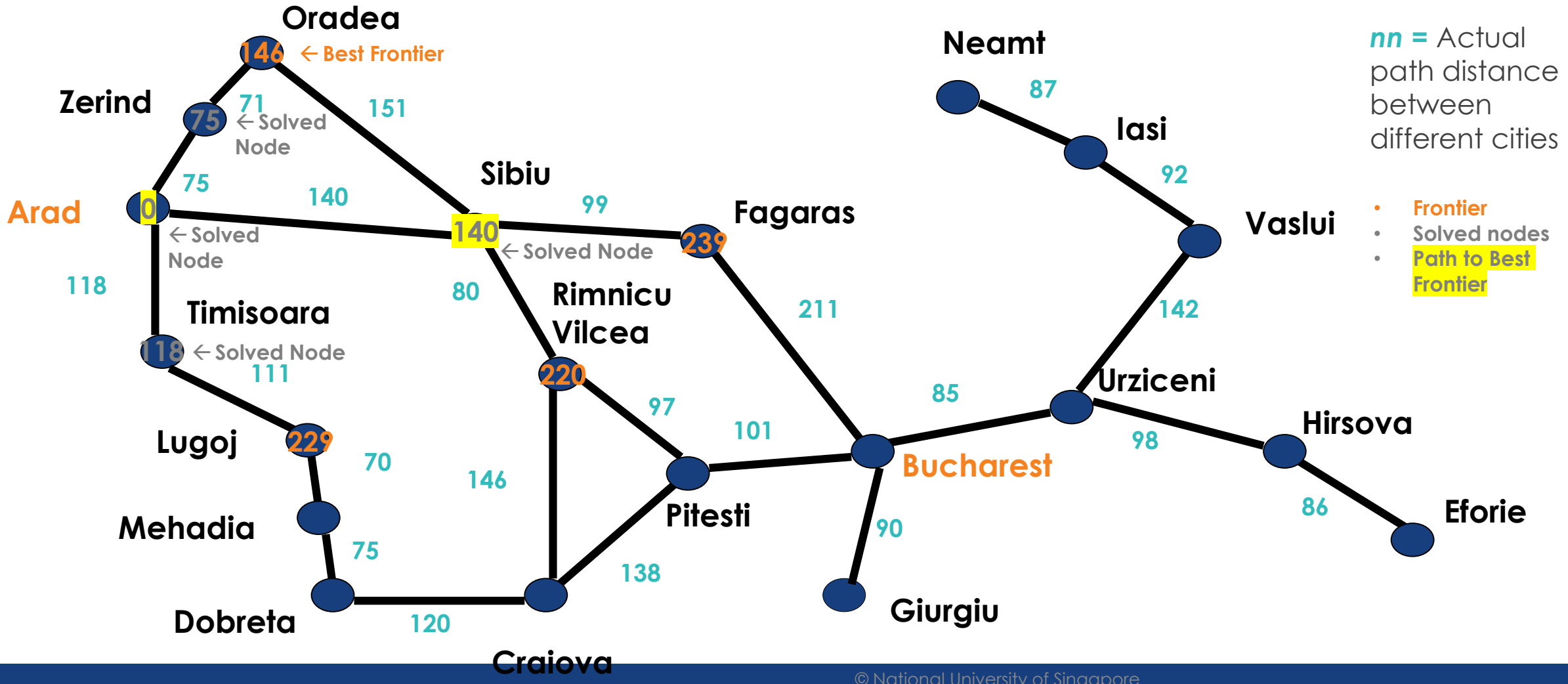

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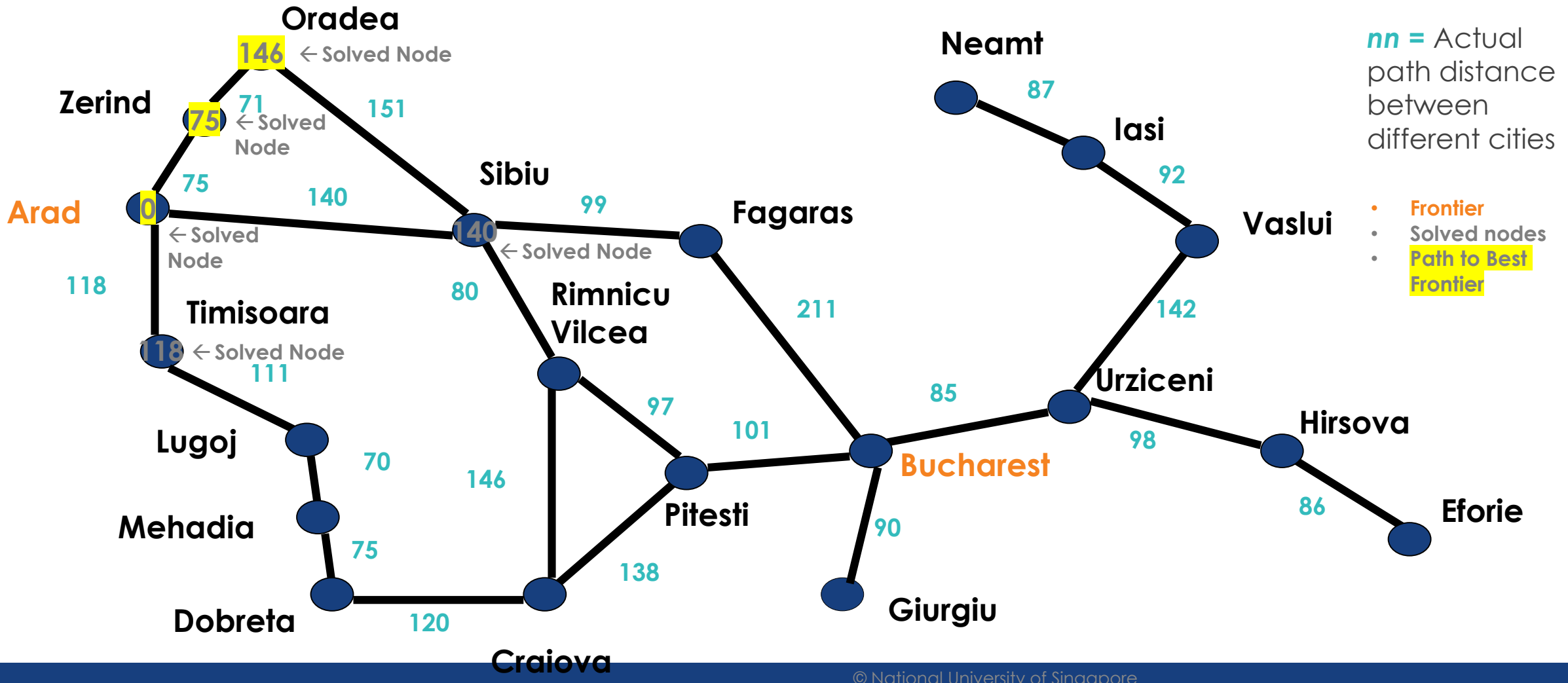

Uninformed Search Techniques (Graph)

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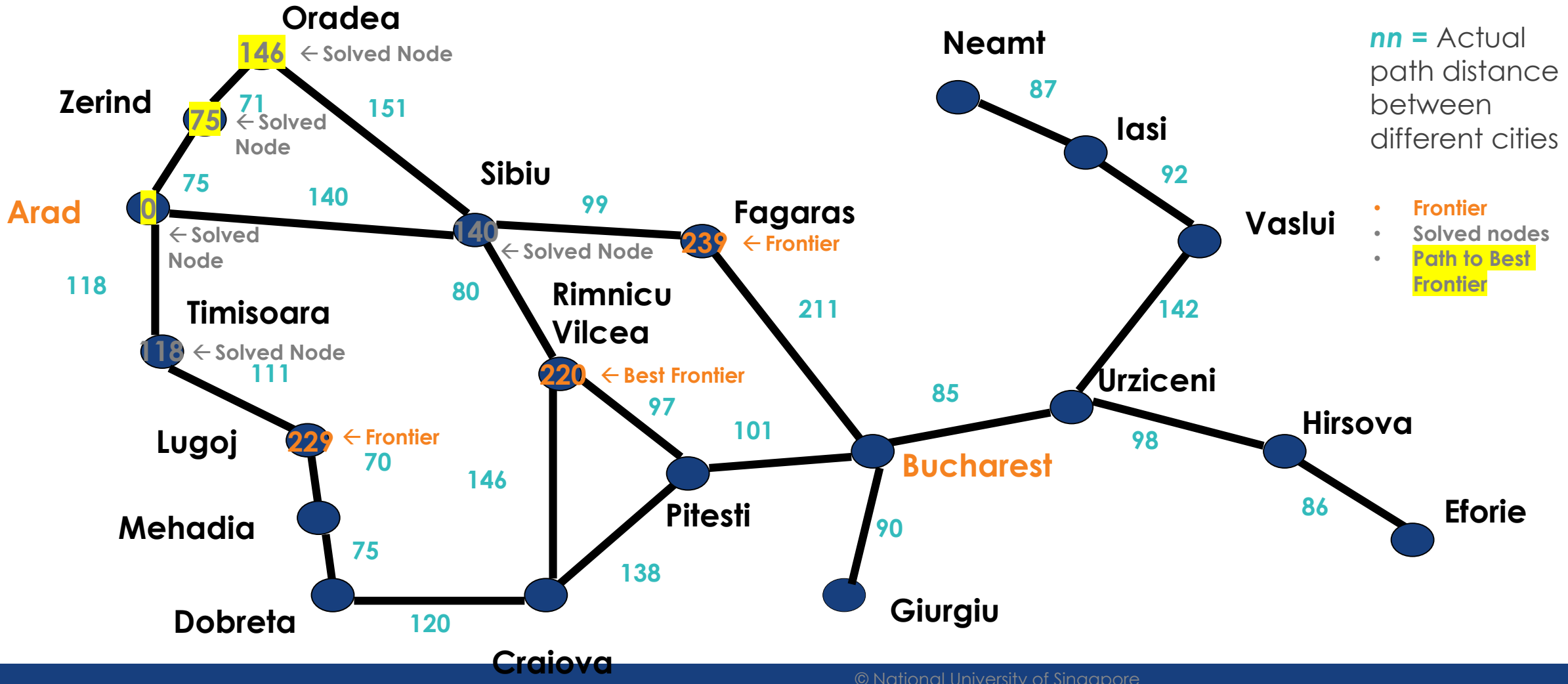

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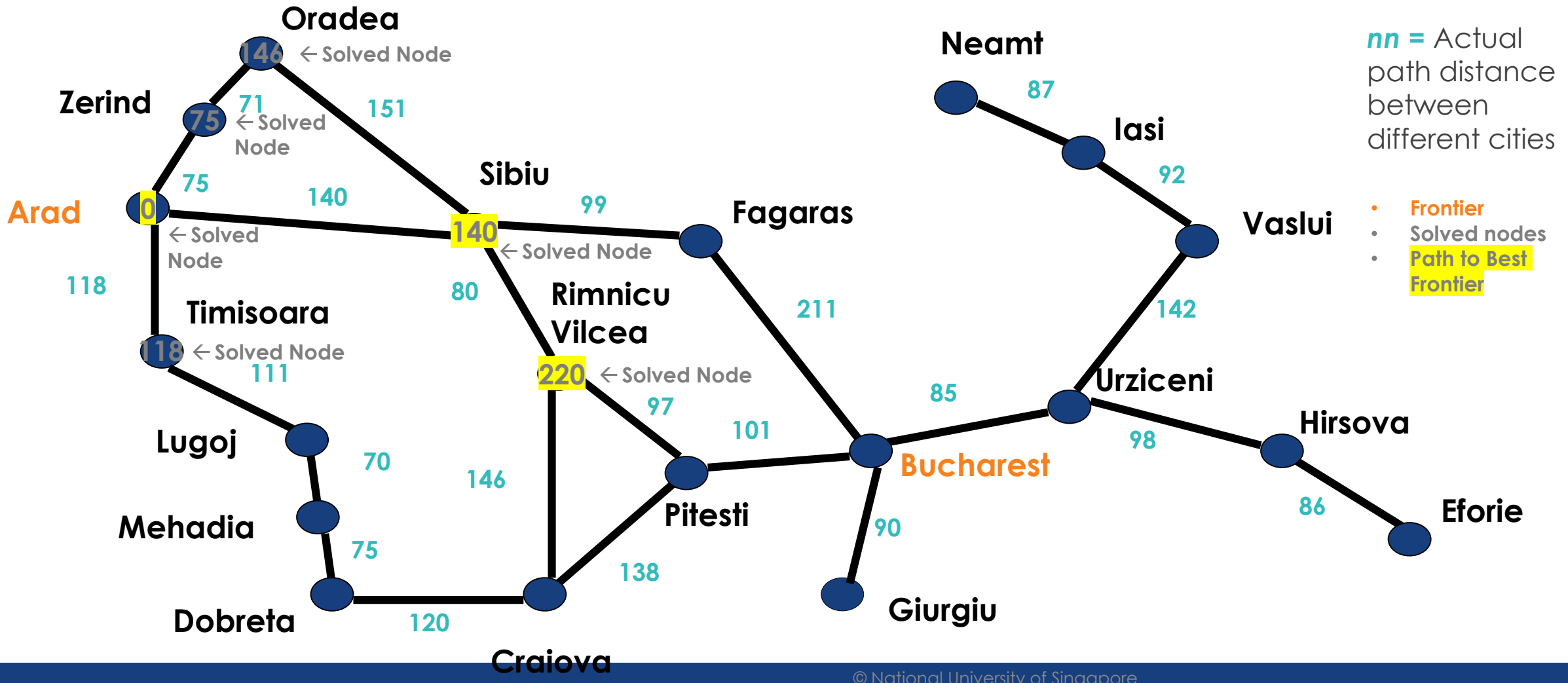

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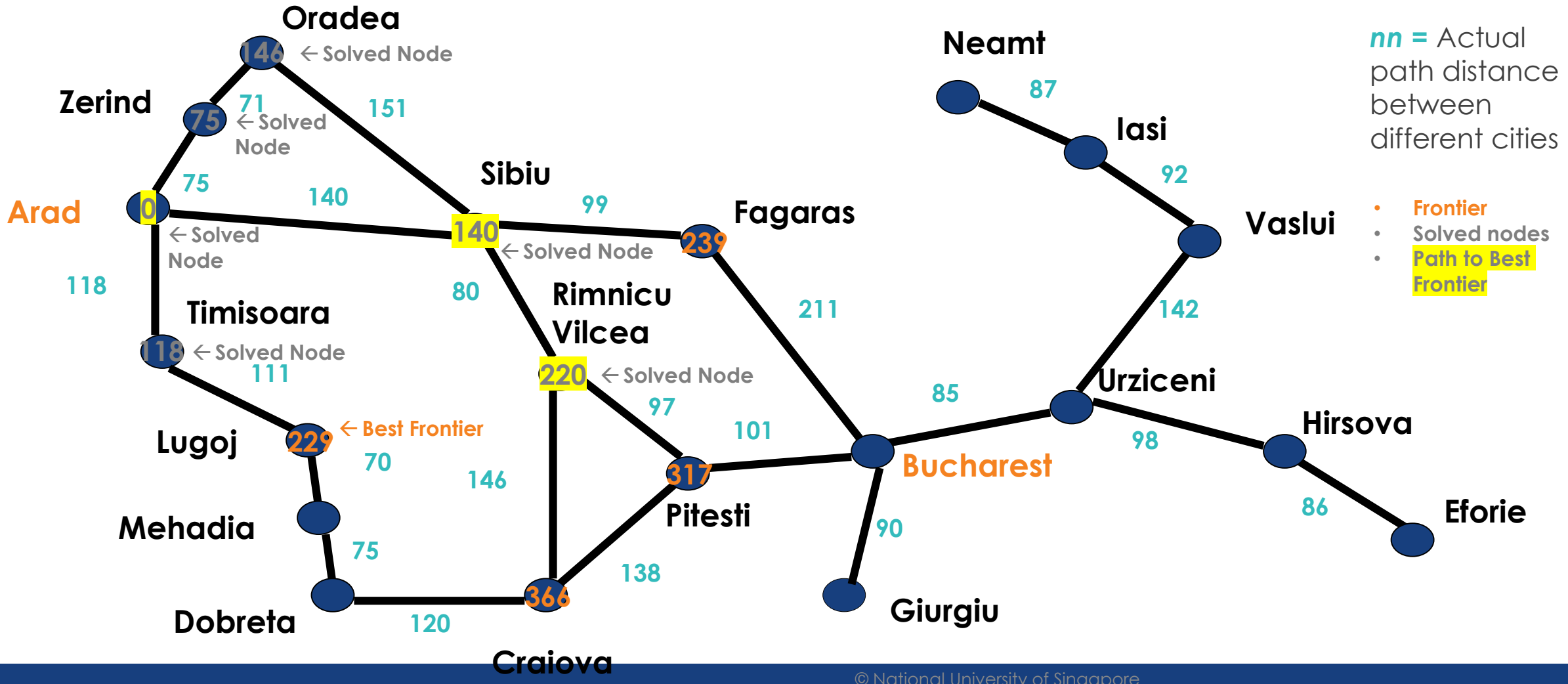

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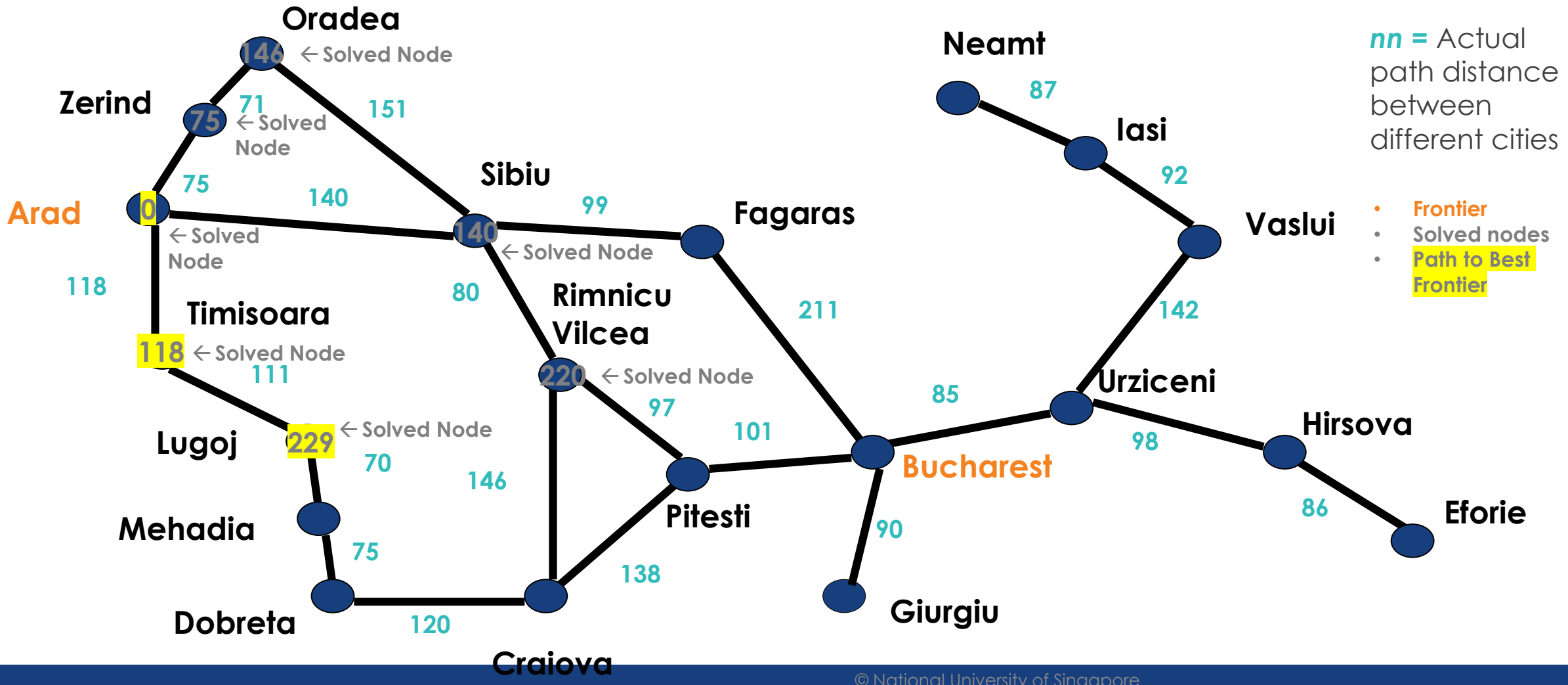

Uninformed Search Techniques (Graph)

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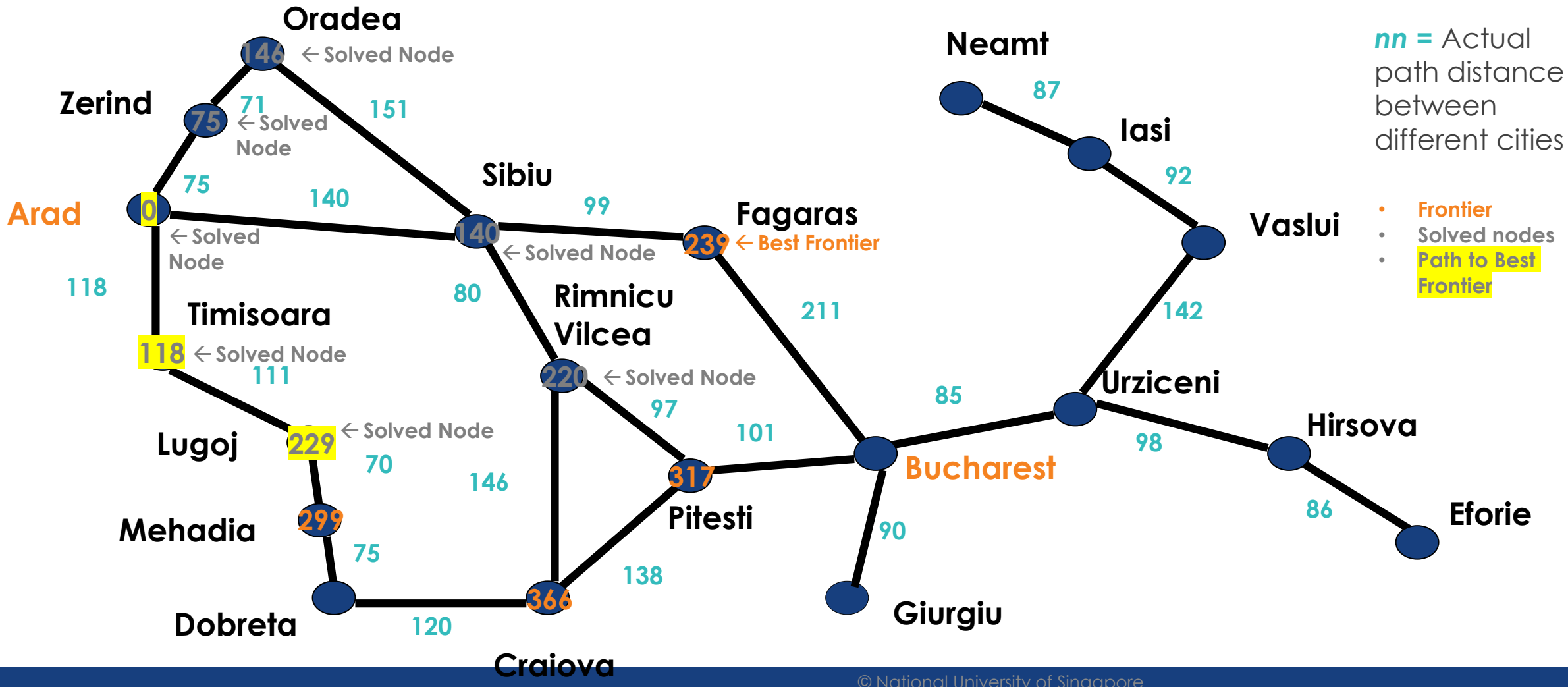

Uninformed Search Techniques (Graph)

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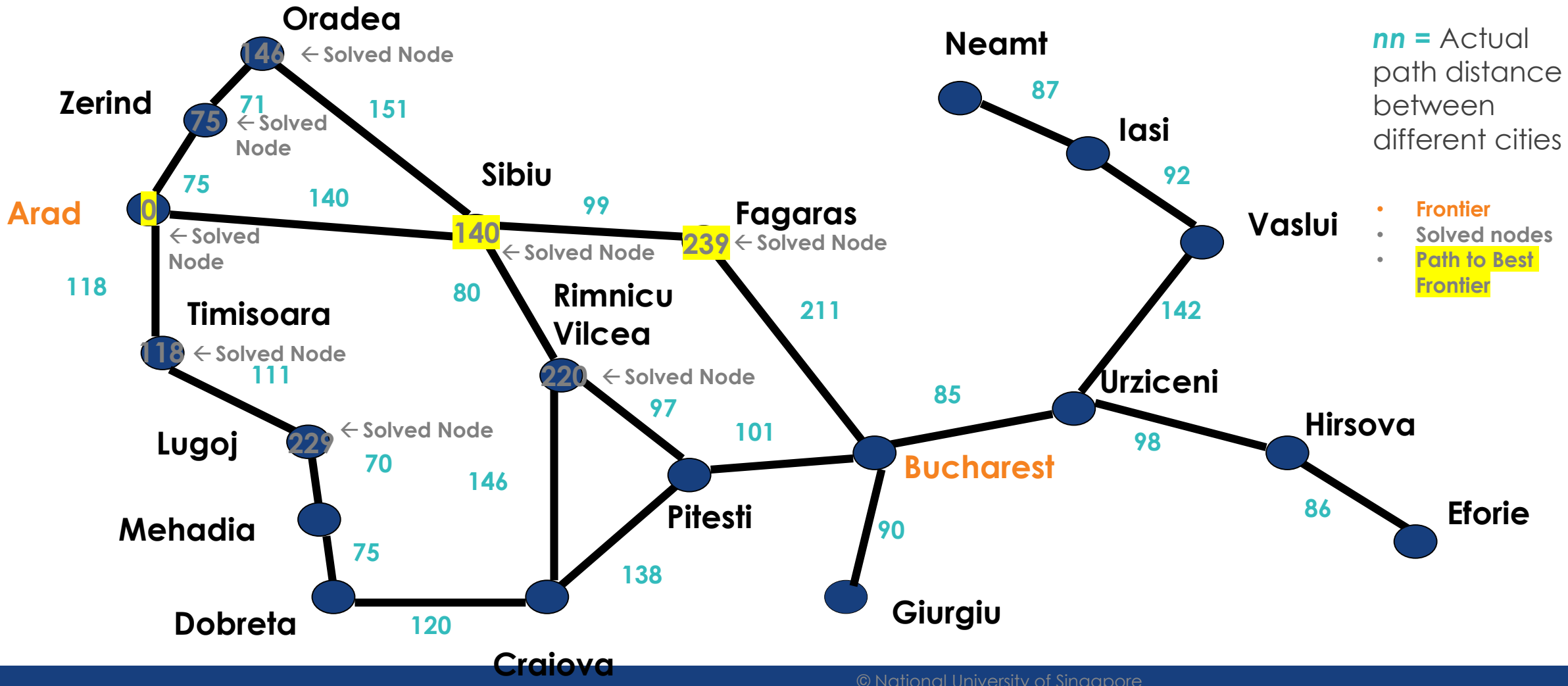

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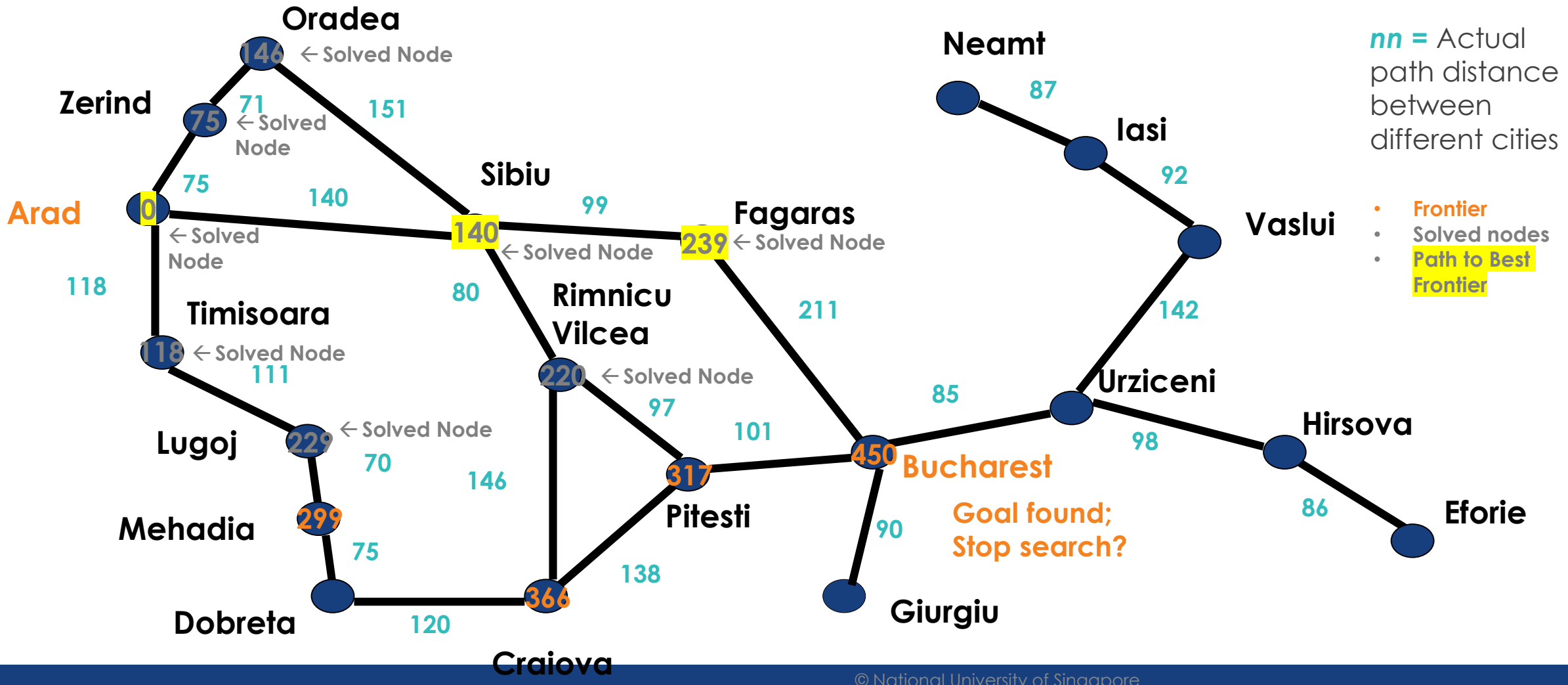
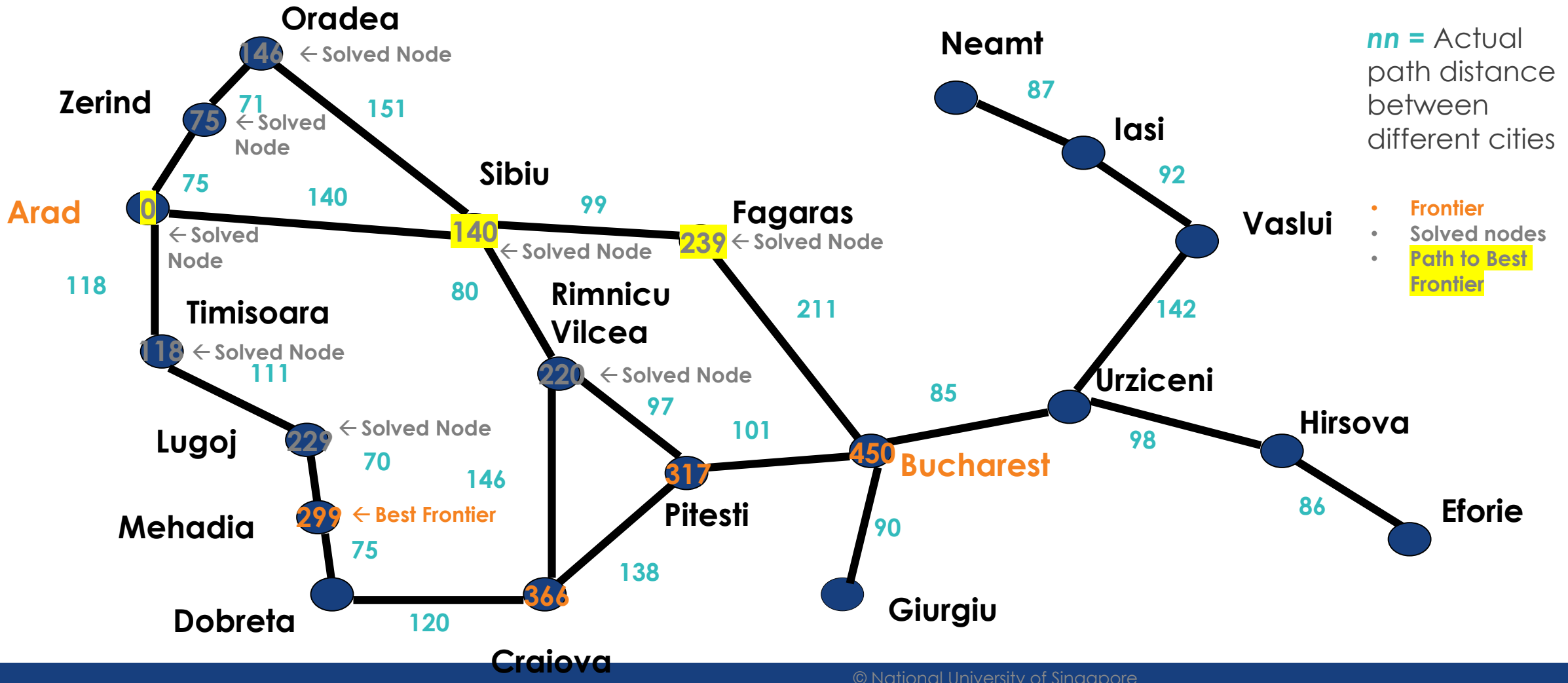


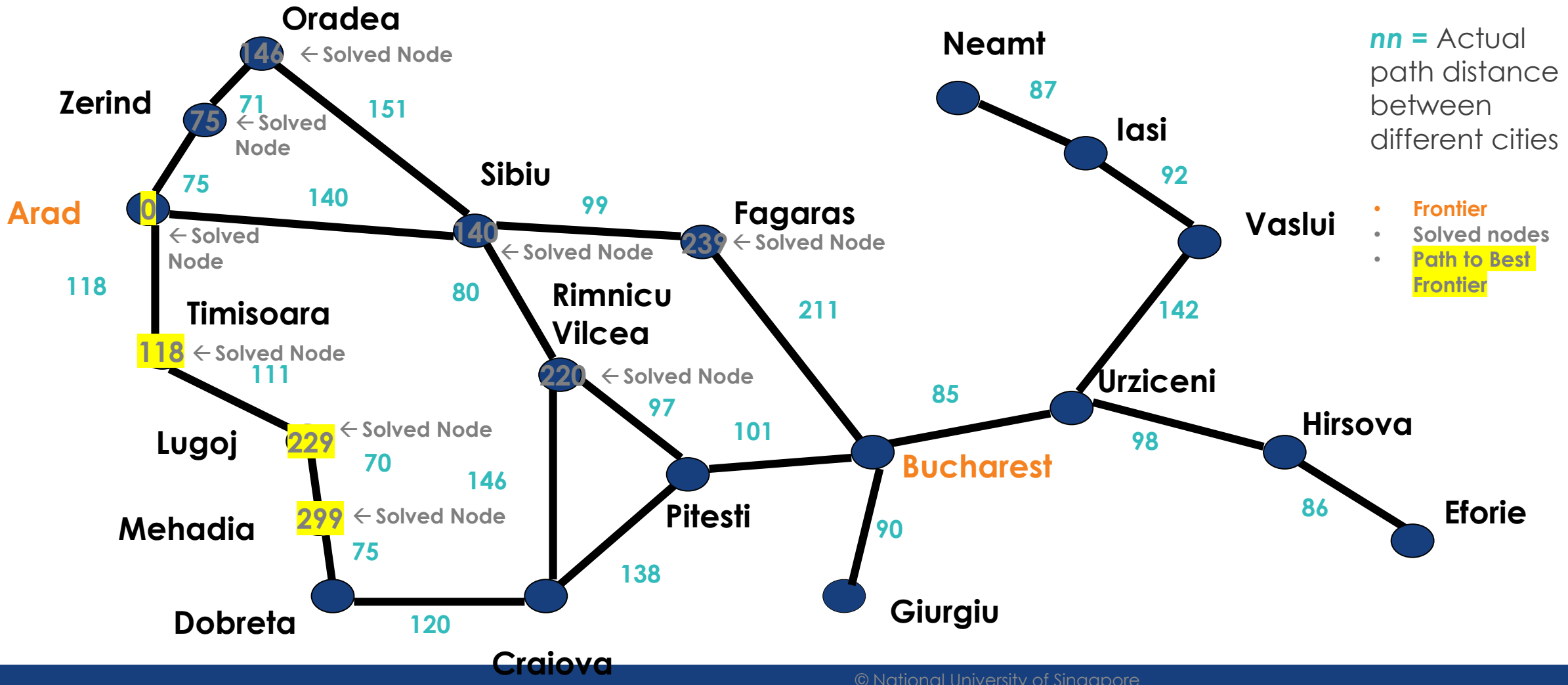
Uninformed Search Techniques (Graph)

Determine Best Frontier Node;



Uninformed Search Techniques (Graph)

Update list of Solved Nodes;



Uninformed Search Techniques (Graph)

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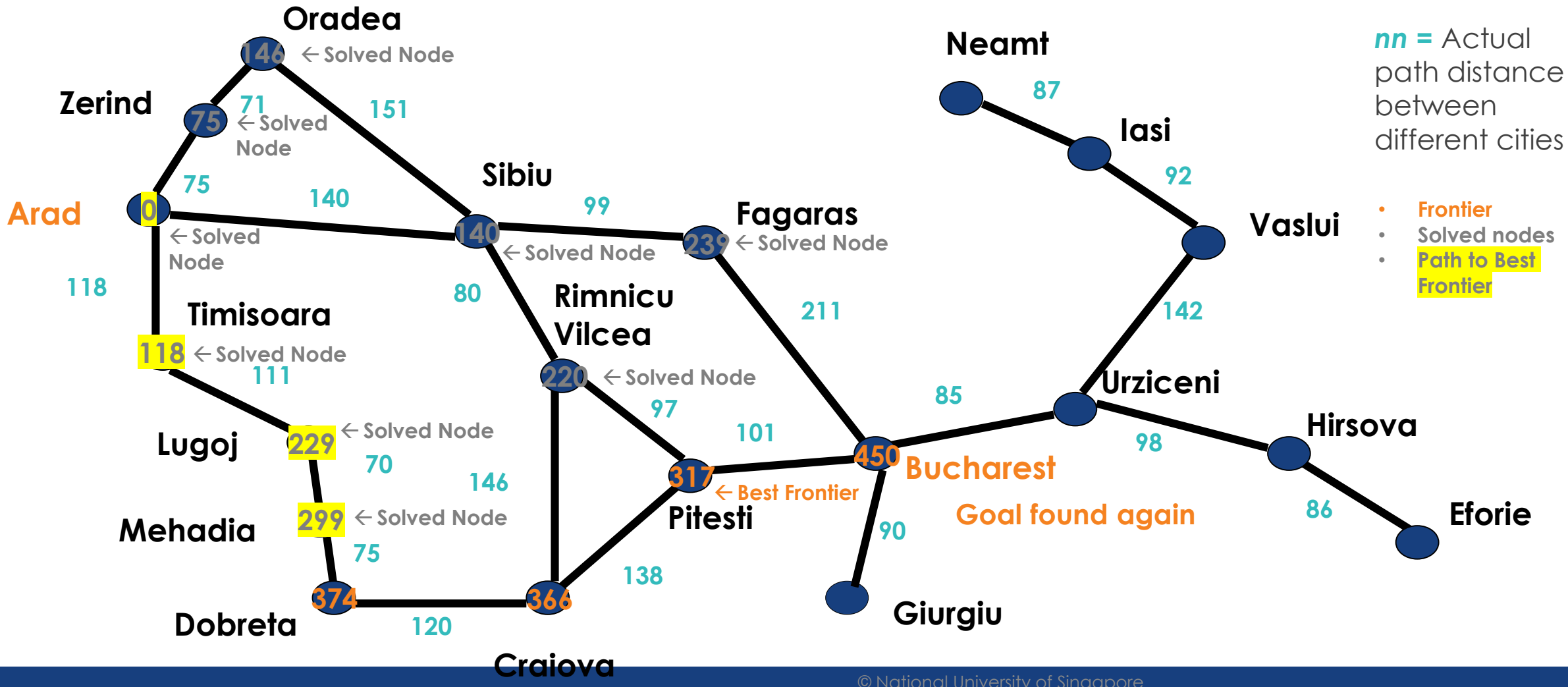
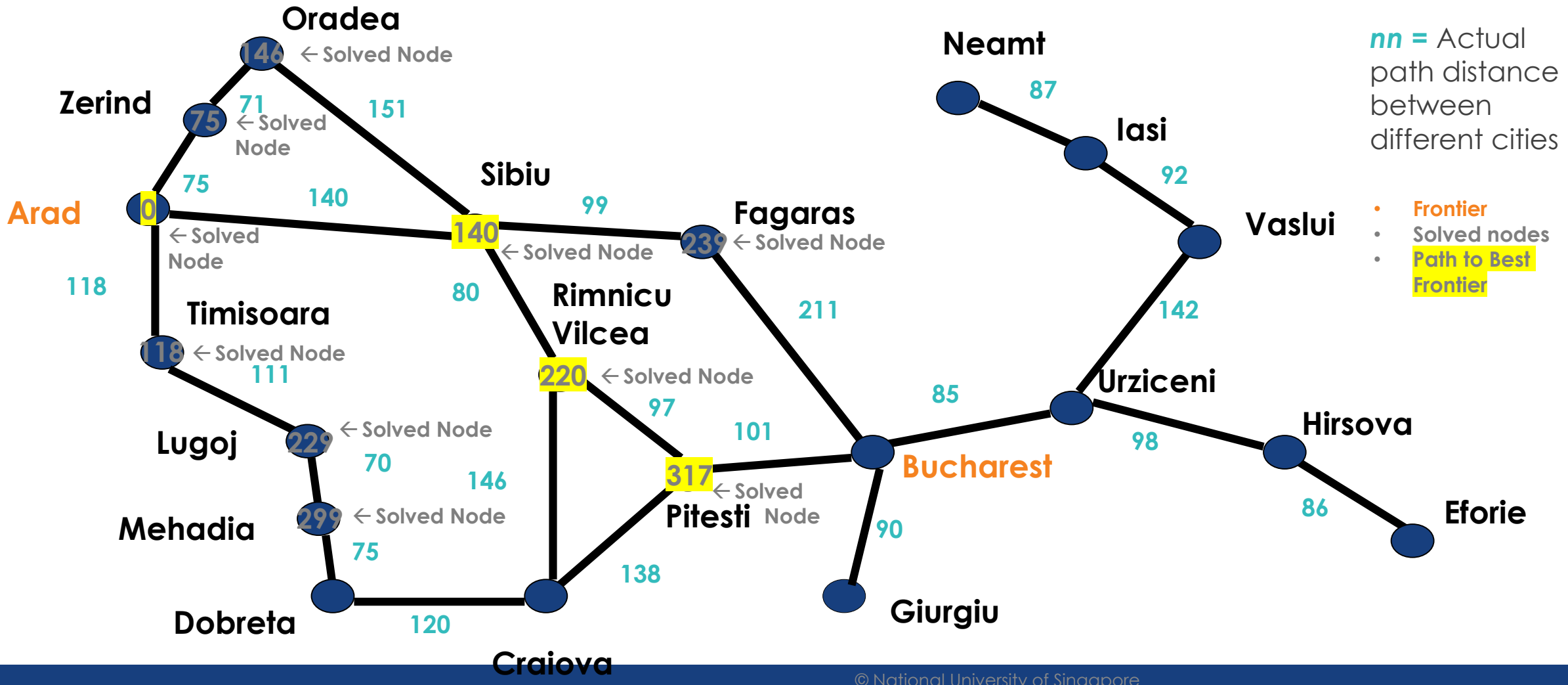


Uninformed Search Techniques (Graph)

Update list of Solved Nodes;



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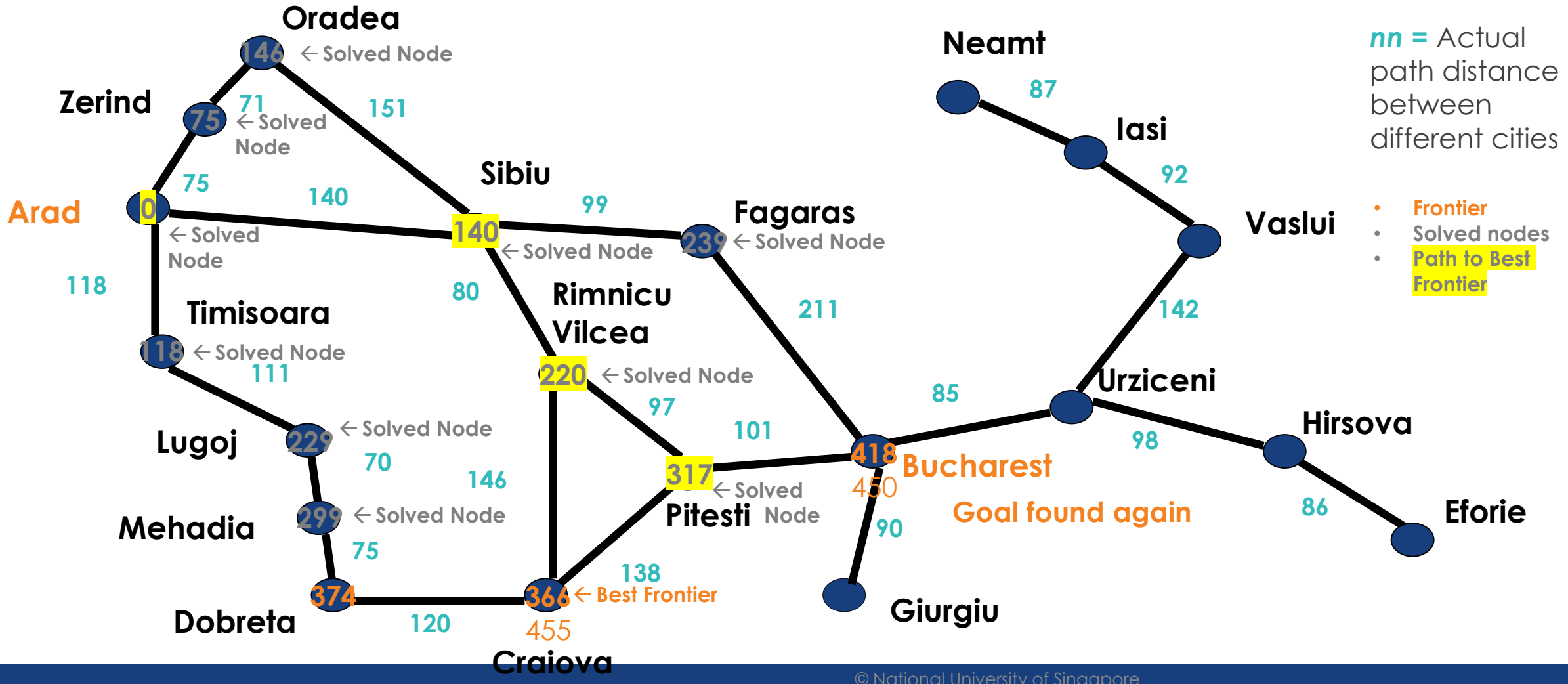

Uninformed Search Techniques (Graph)

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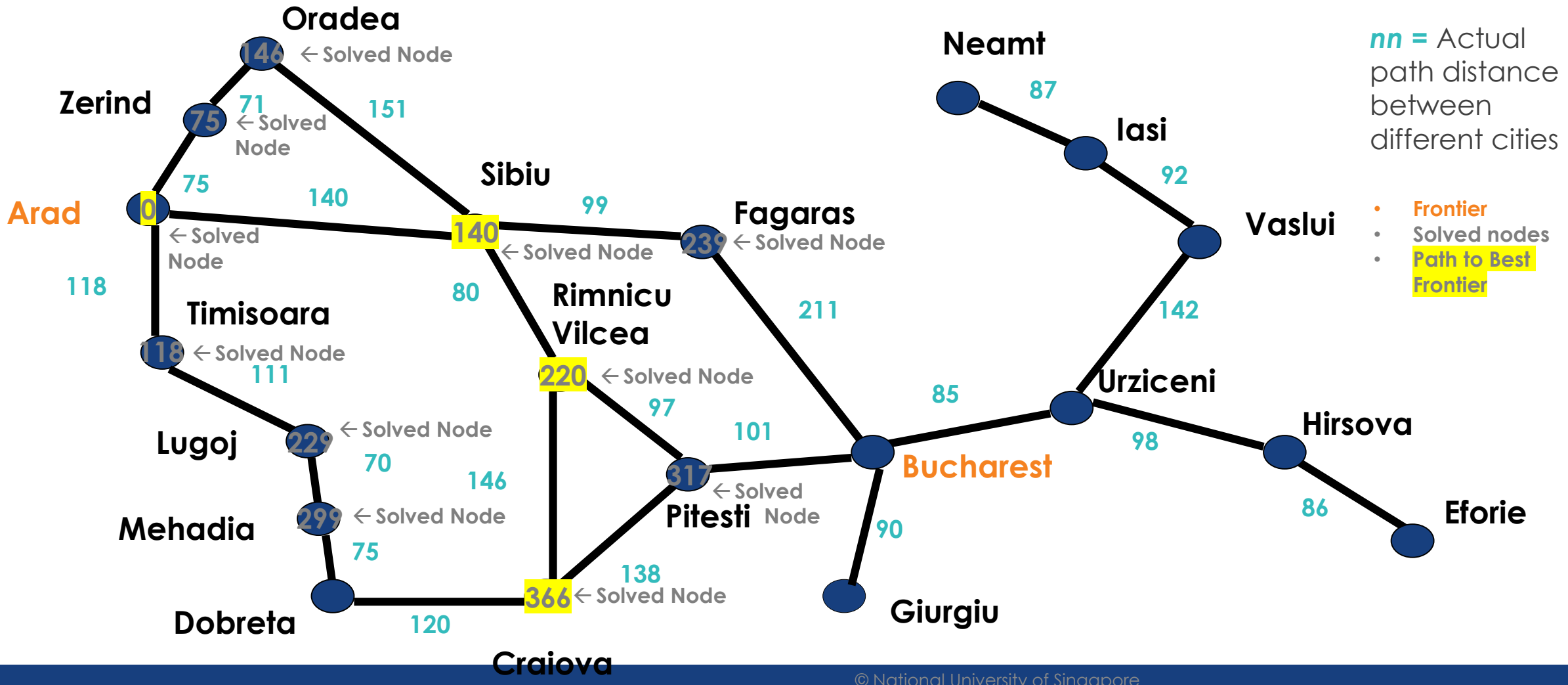

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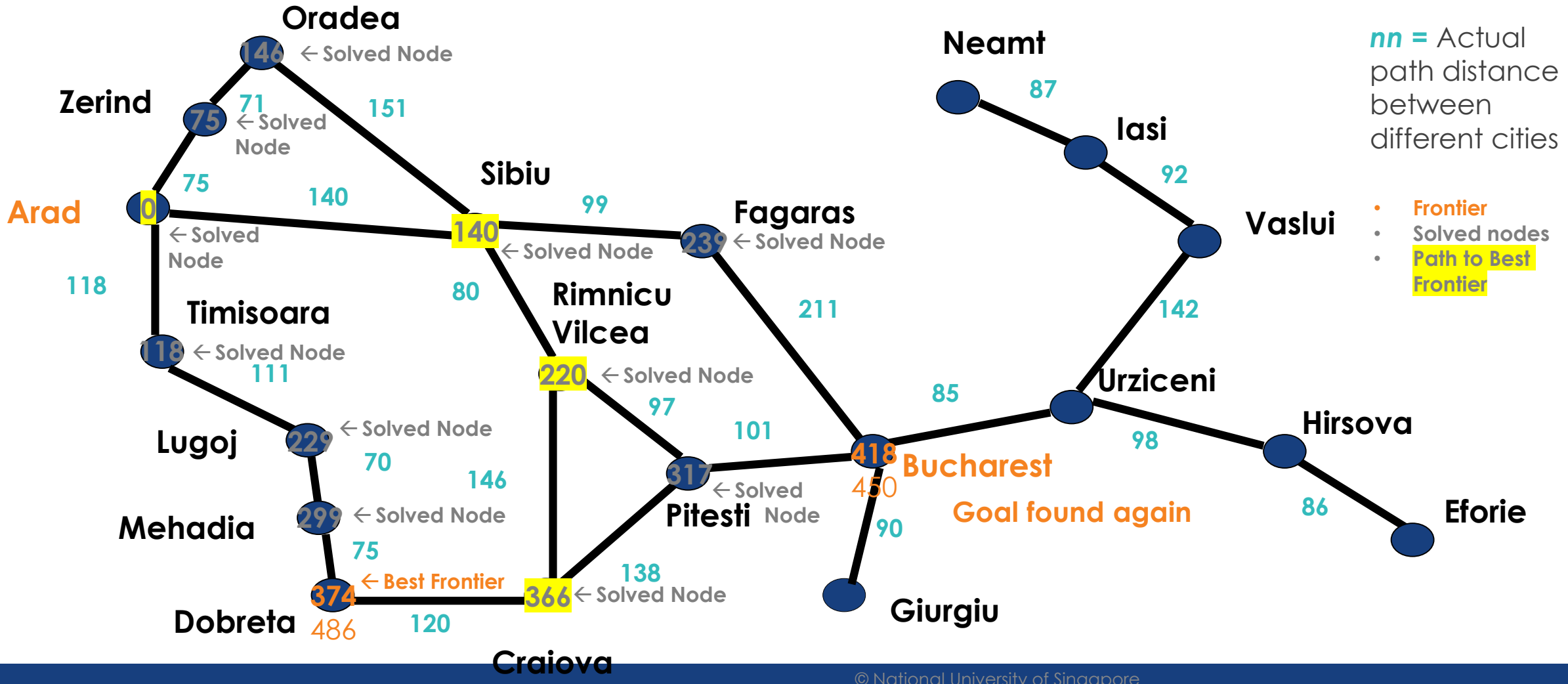
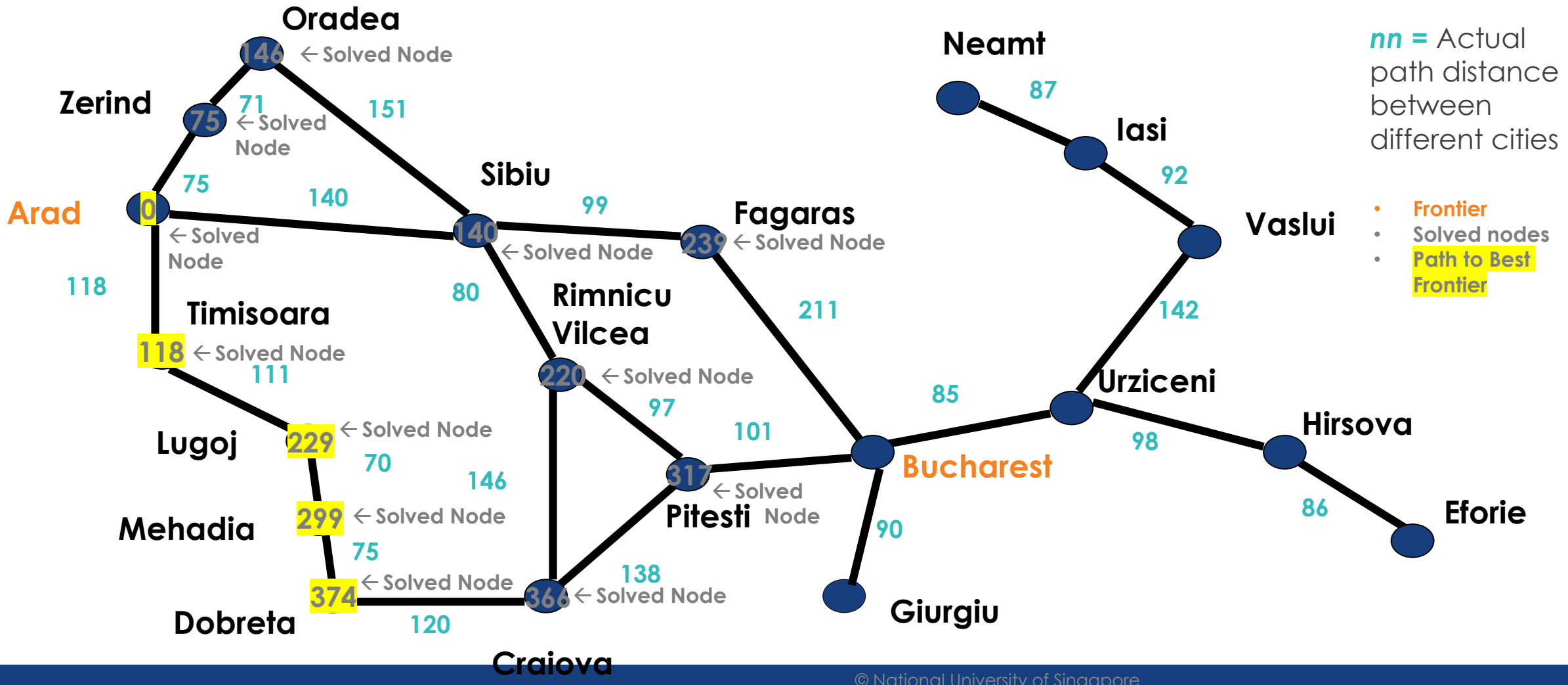


Uninformed Search Techniques (Graph)

Update list of Solved Nodes;



Uninformed Search Techniques (Graph)

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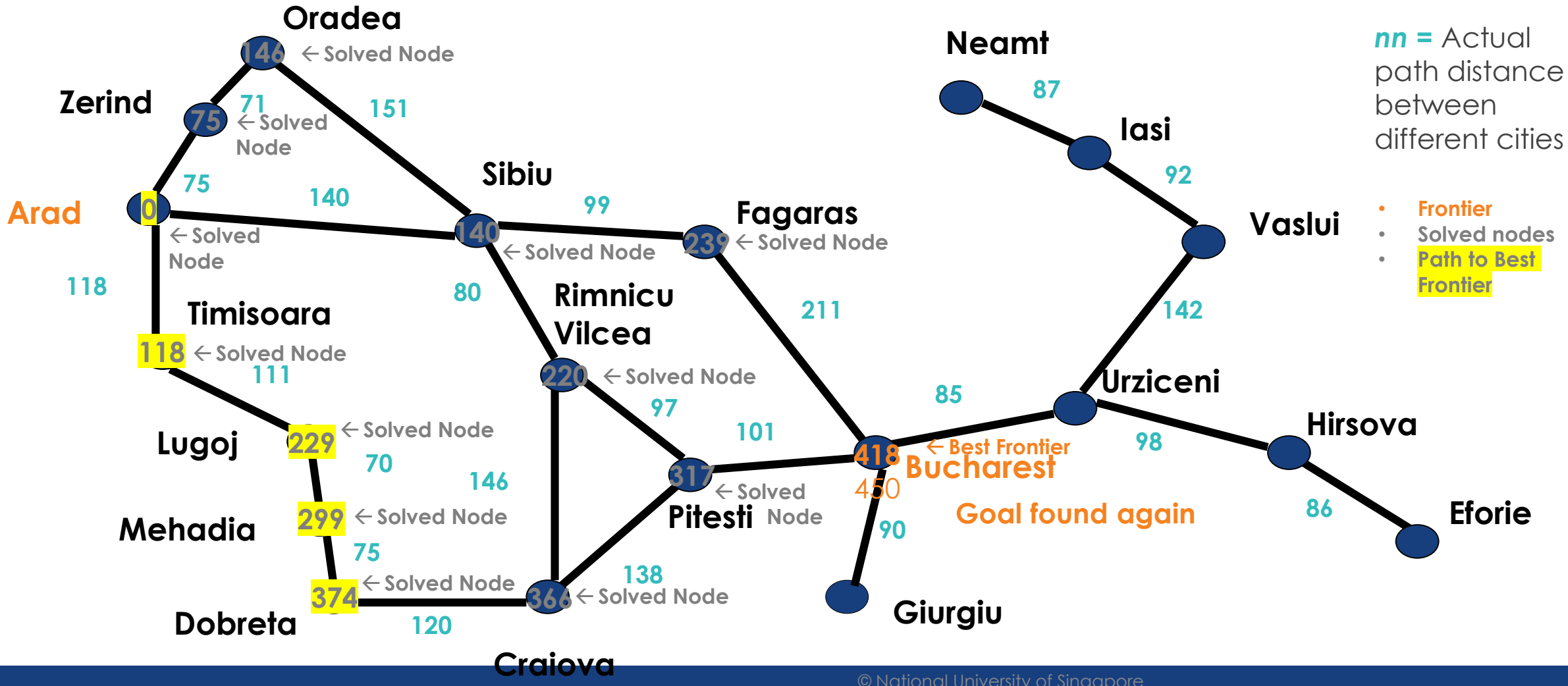
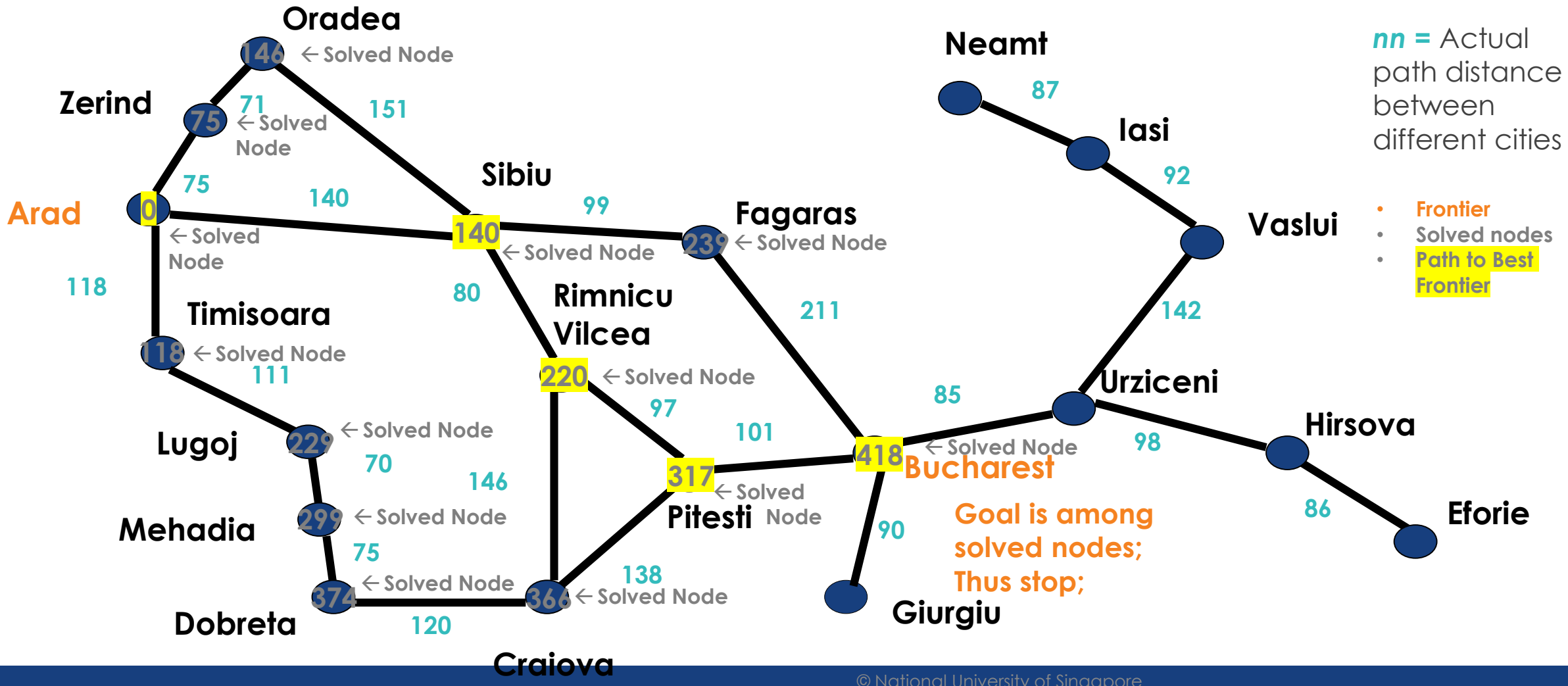


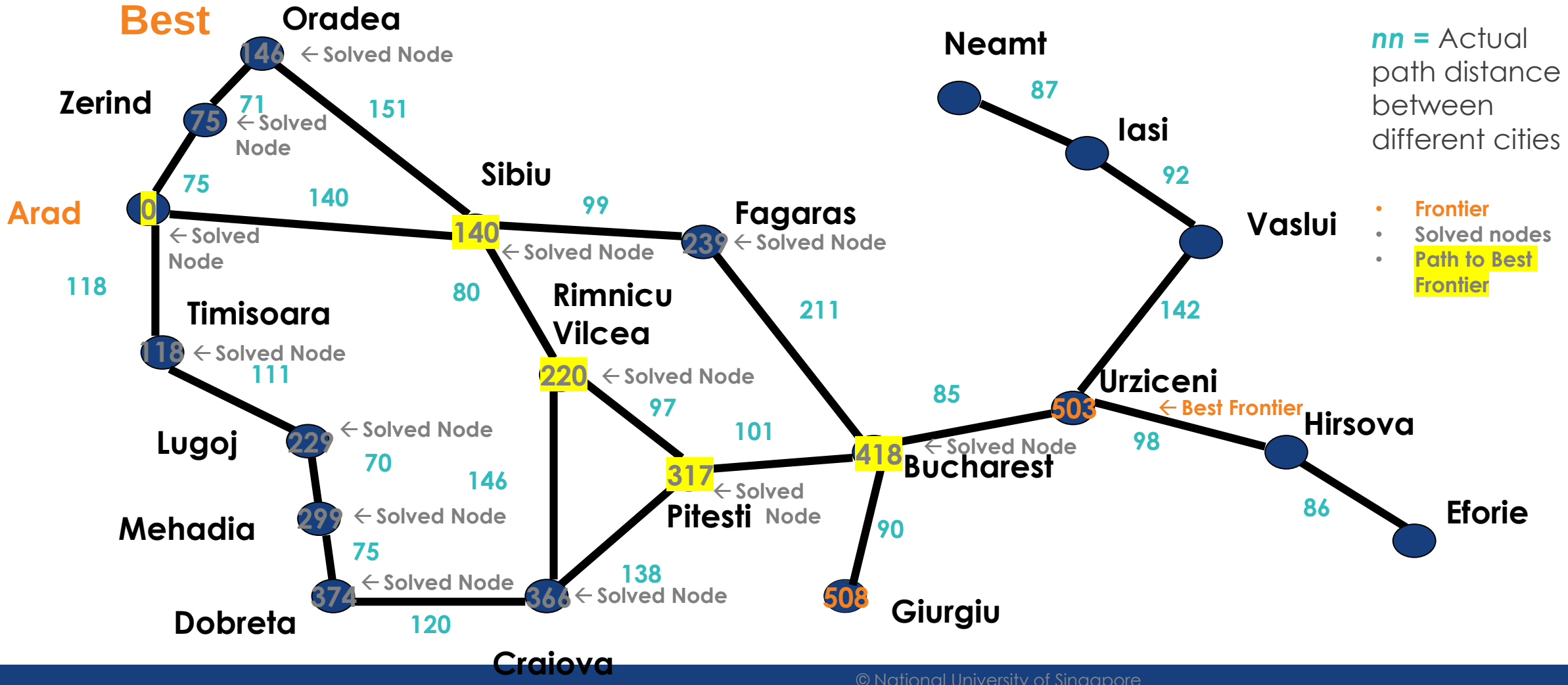
Uninformed Search Techniques (Graph)

Update list of Solved Nodes; Best Arad→Bucharest path is found;



Uninformed Search Techniques (Graph)

Continue for all shortest paths starting from Arad to any other city…



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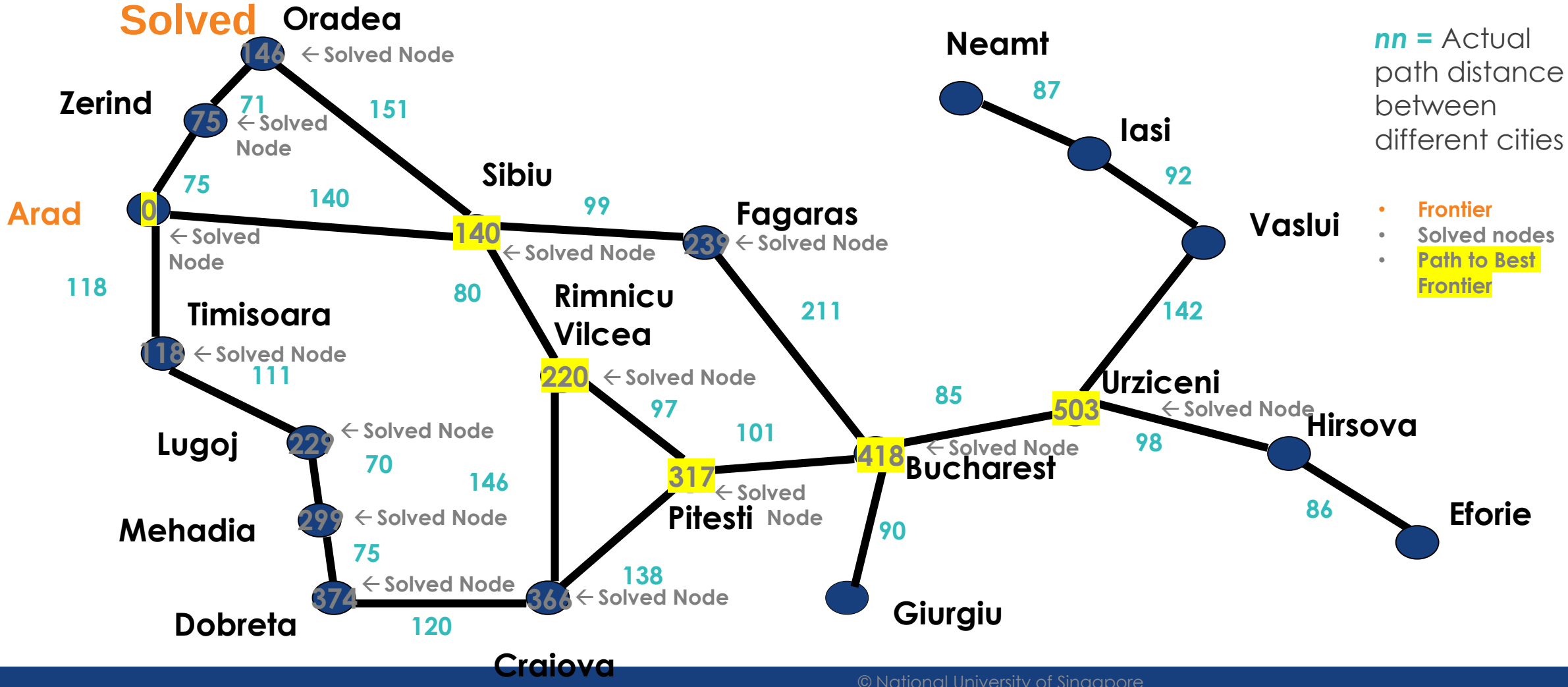

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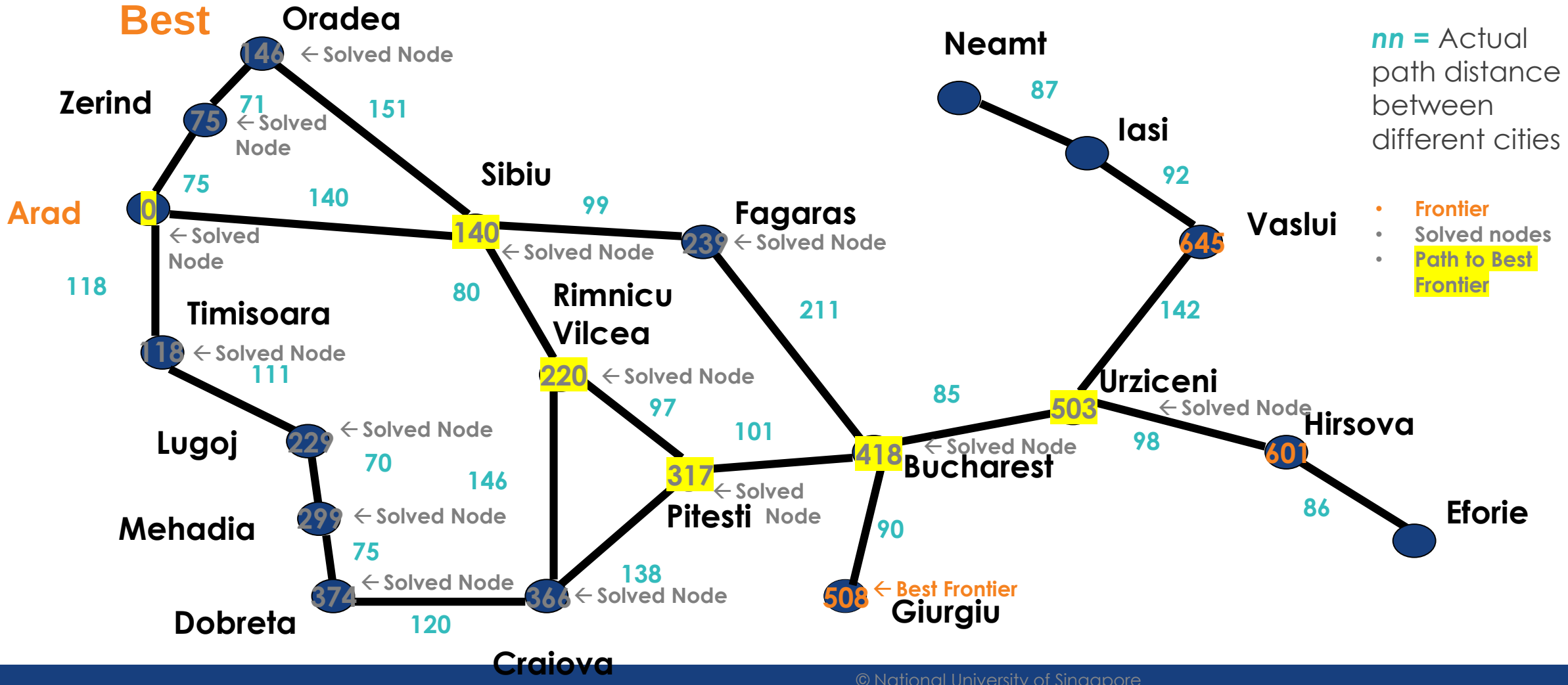

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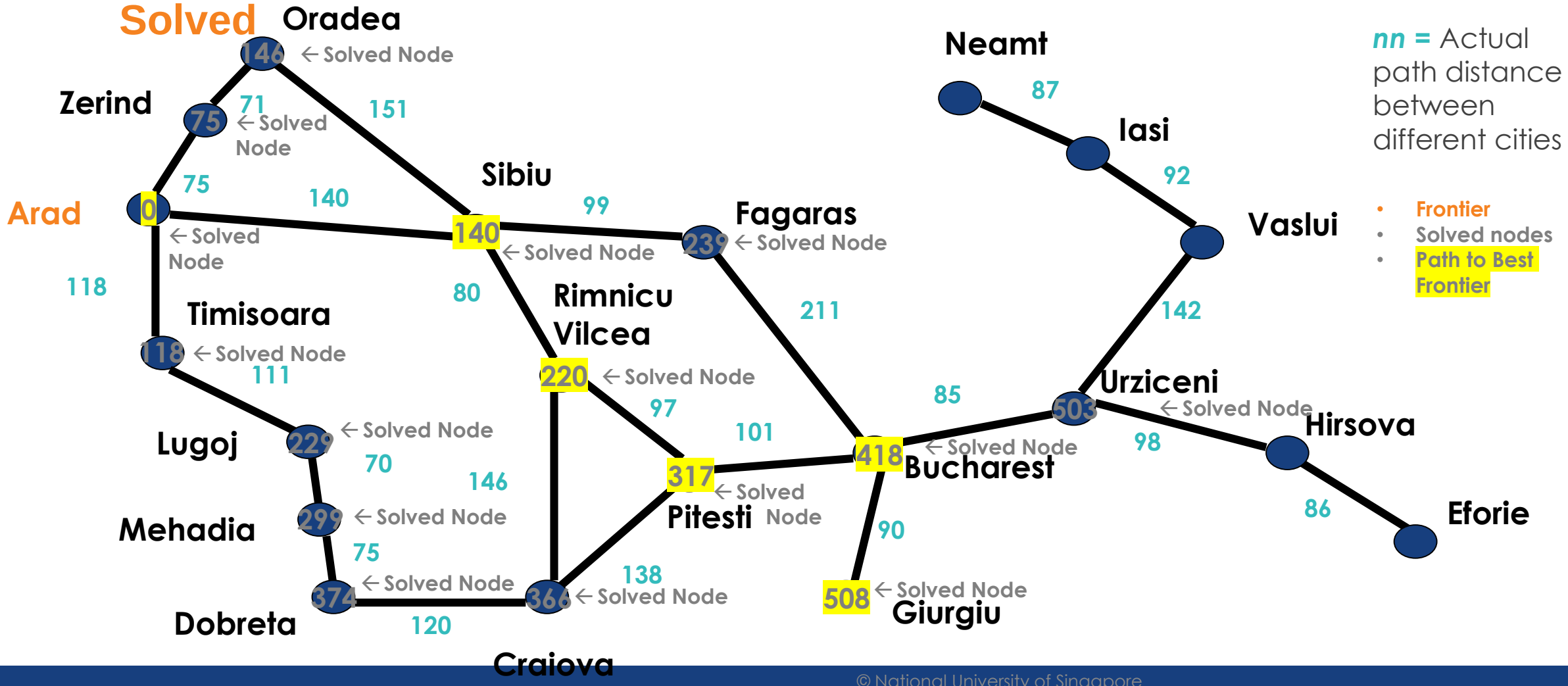

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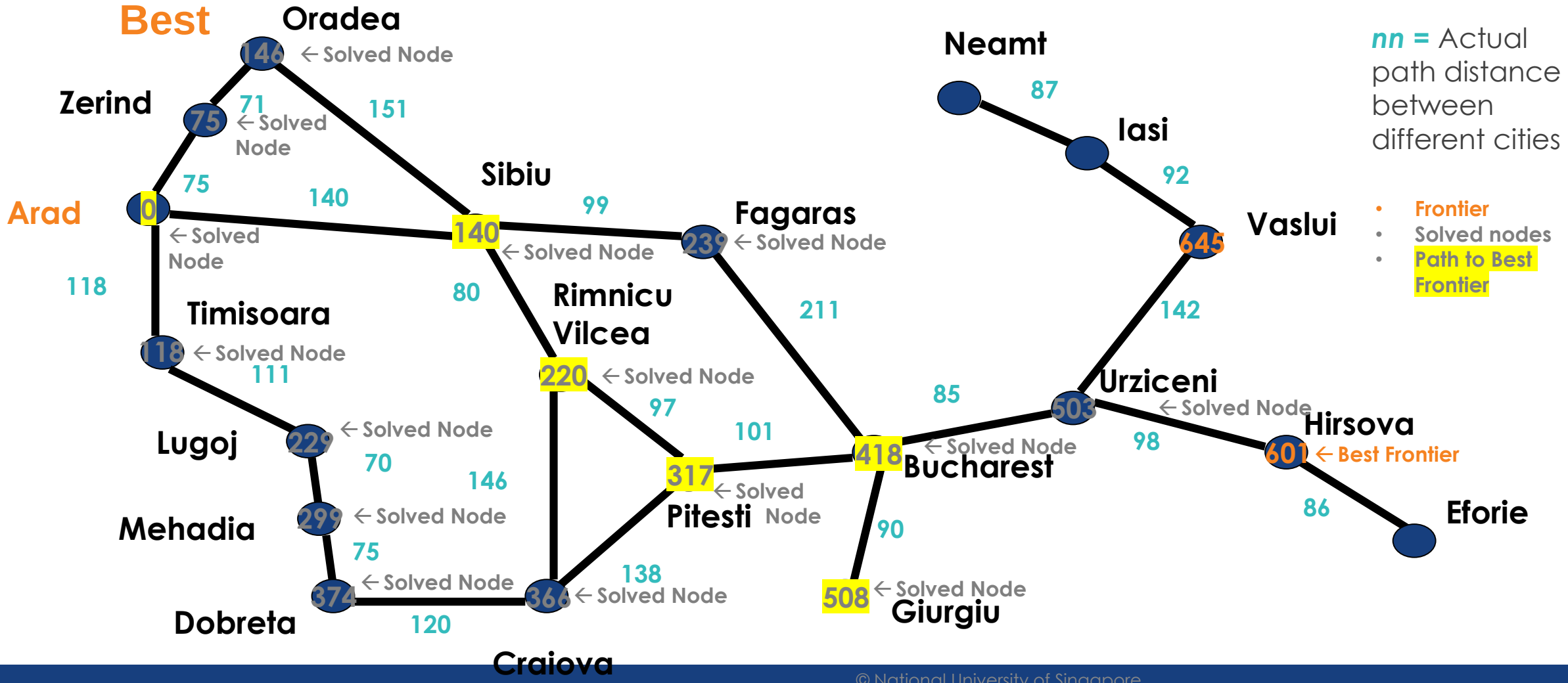

Uninformed Search Techniques (Graph)

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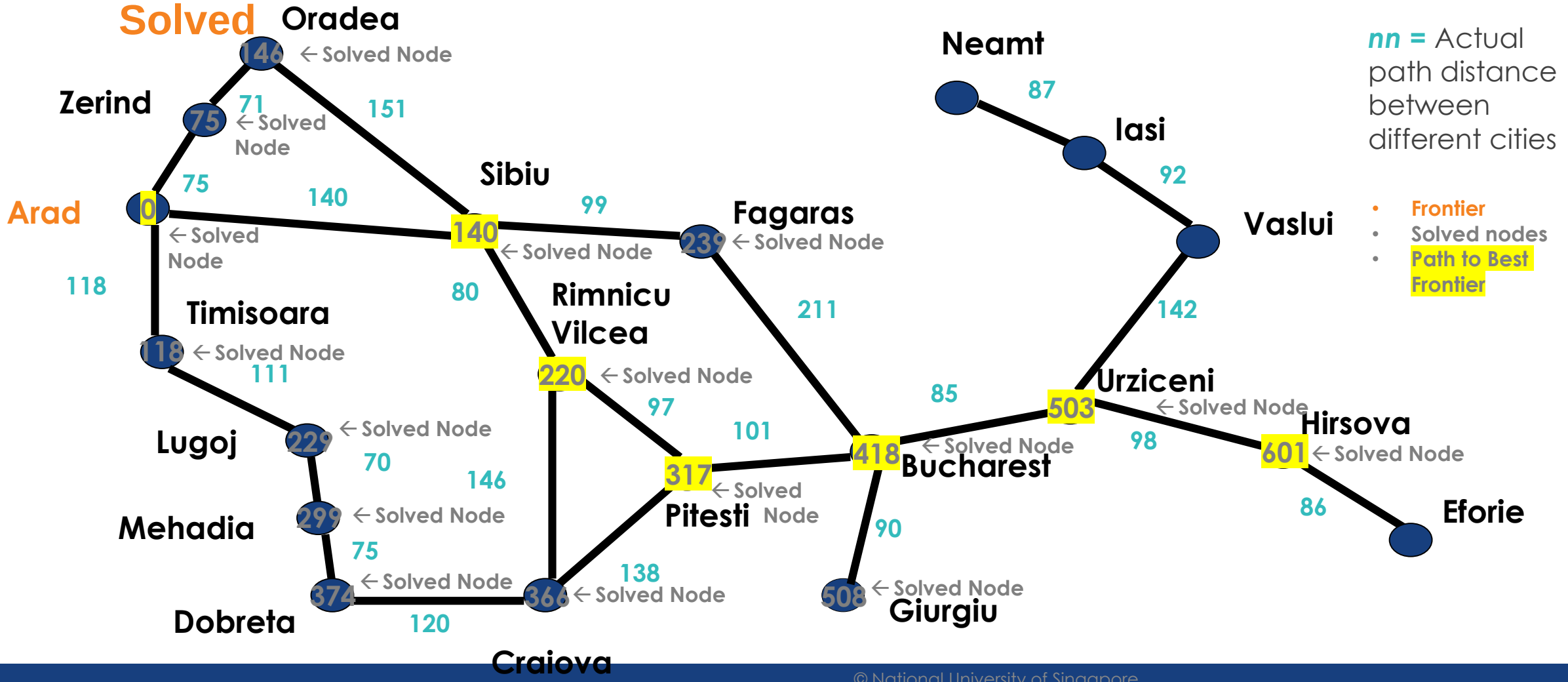

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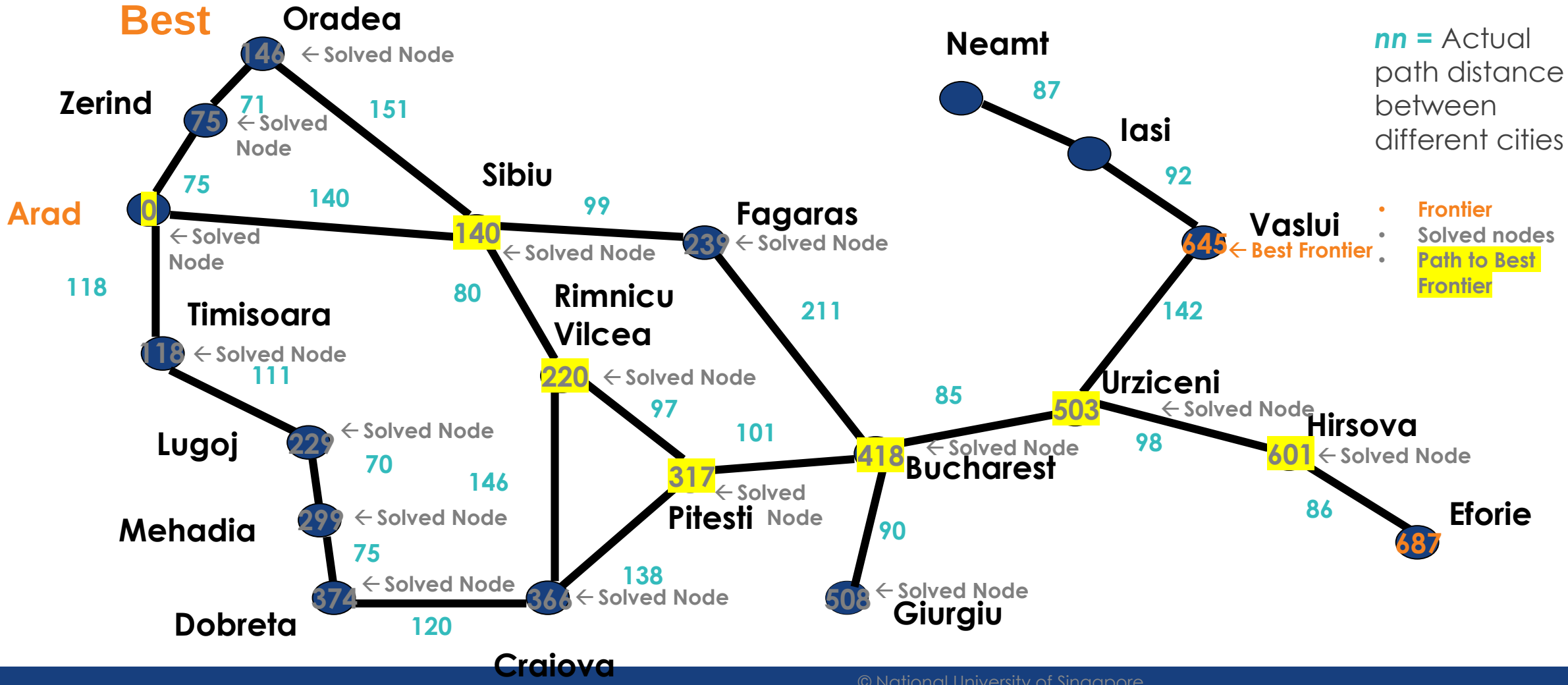
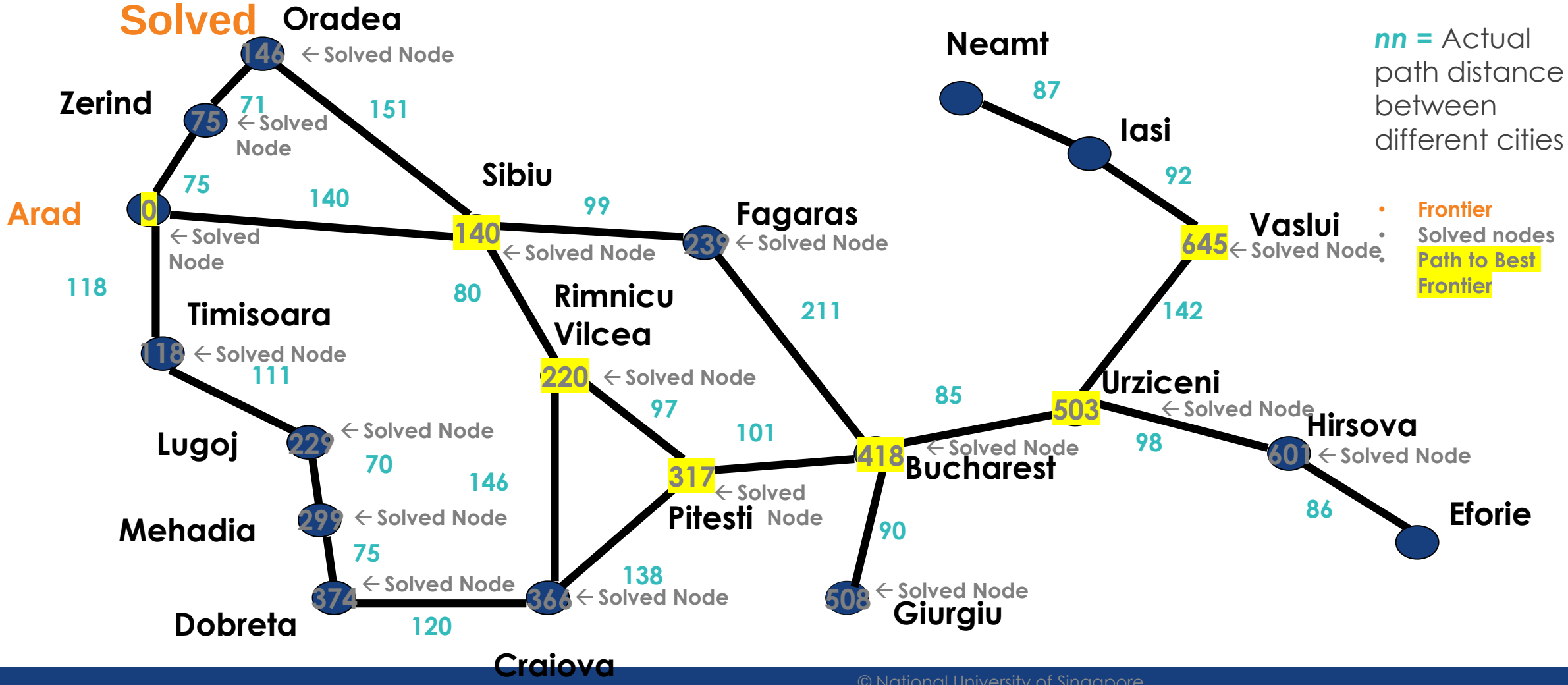


Uninformed Search Techniques (Graph)

Continue for all shortest paths starting from Arad to any other city…



Uninformed Search Techniques (Graph)

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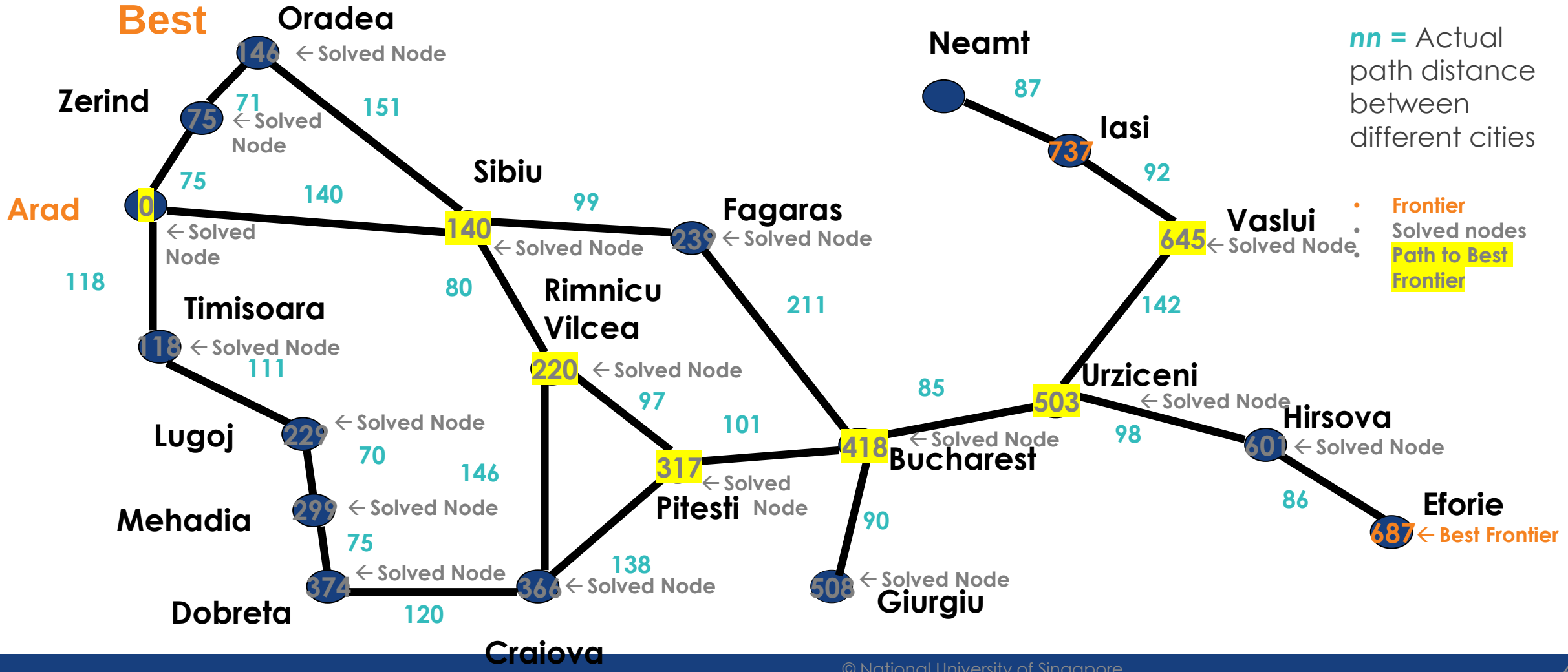

Uninformed Search Techniques (Graph)

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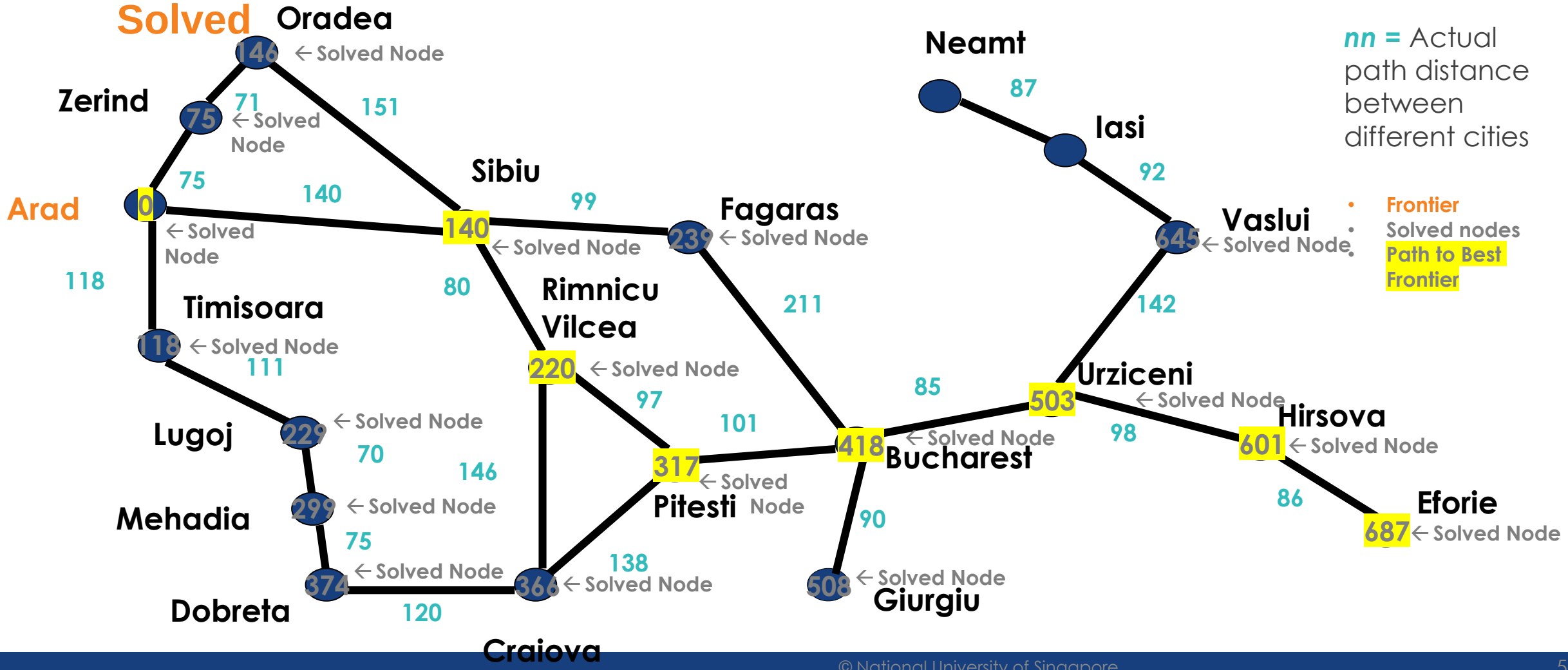

Uninformed Search Techniques (Graph)

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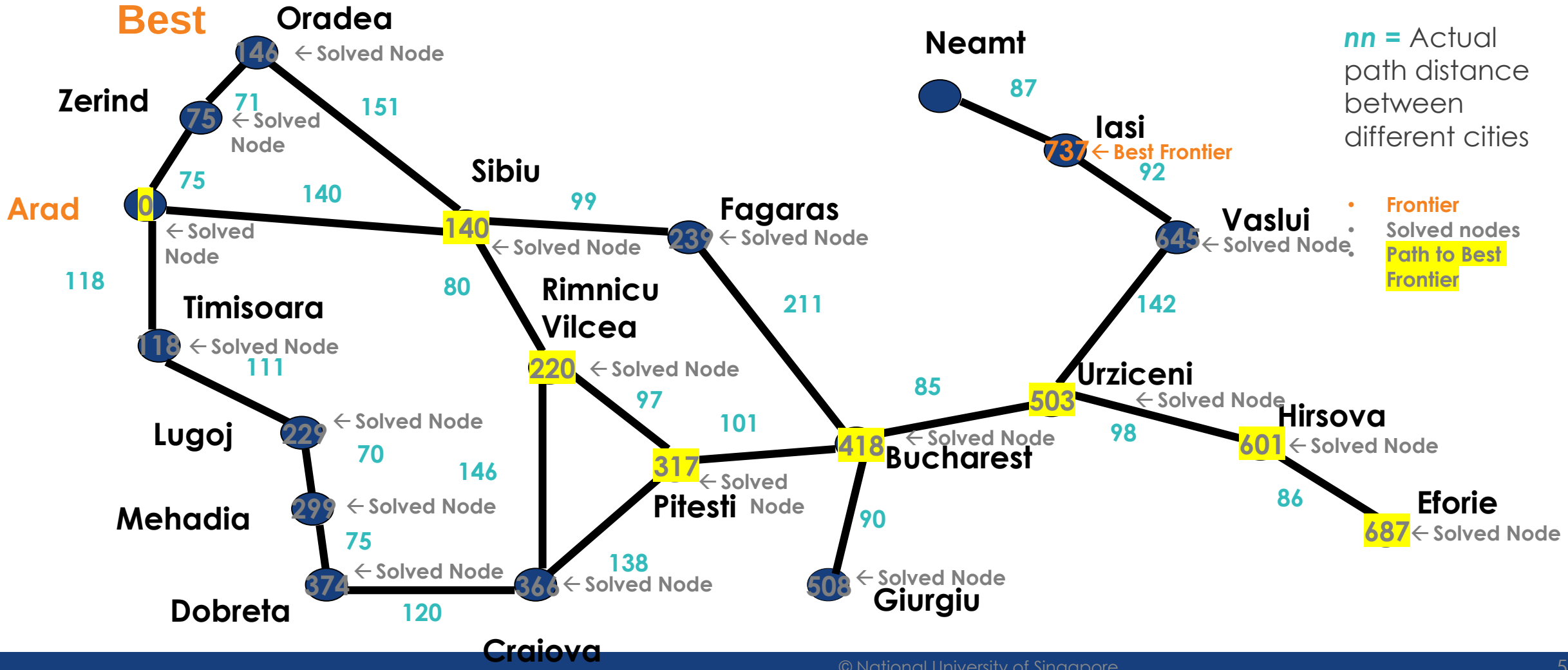

Uninformed Search Techniques (Graph)

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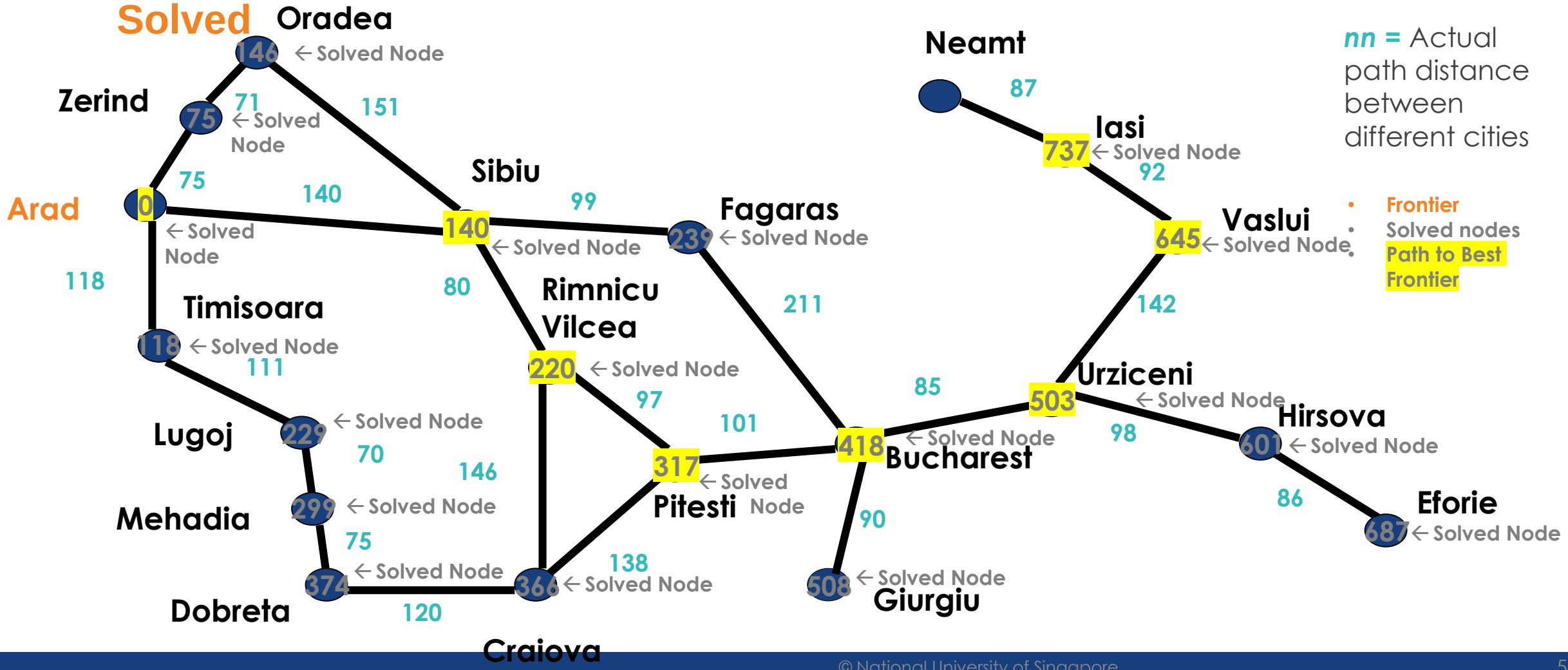

Uninformed Search Techniques (Graph)

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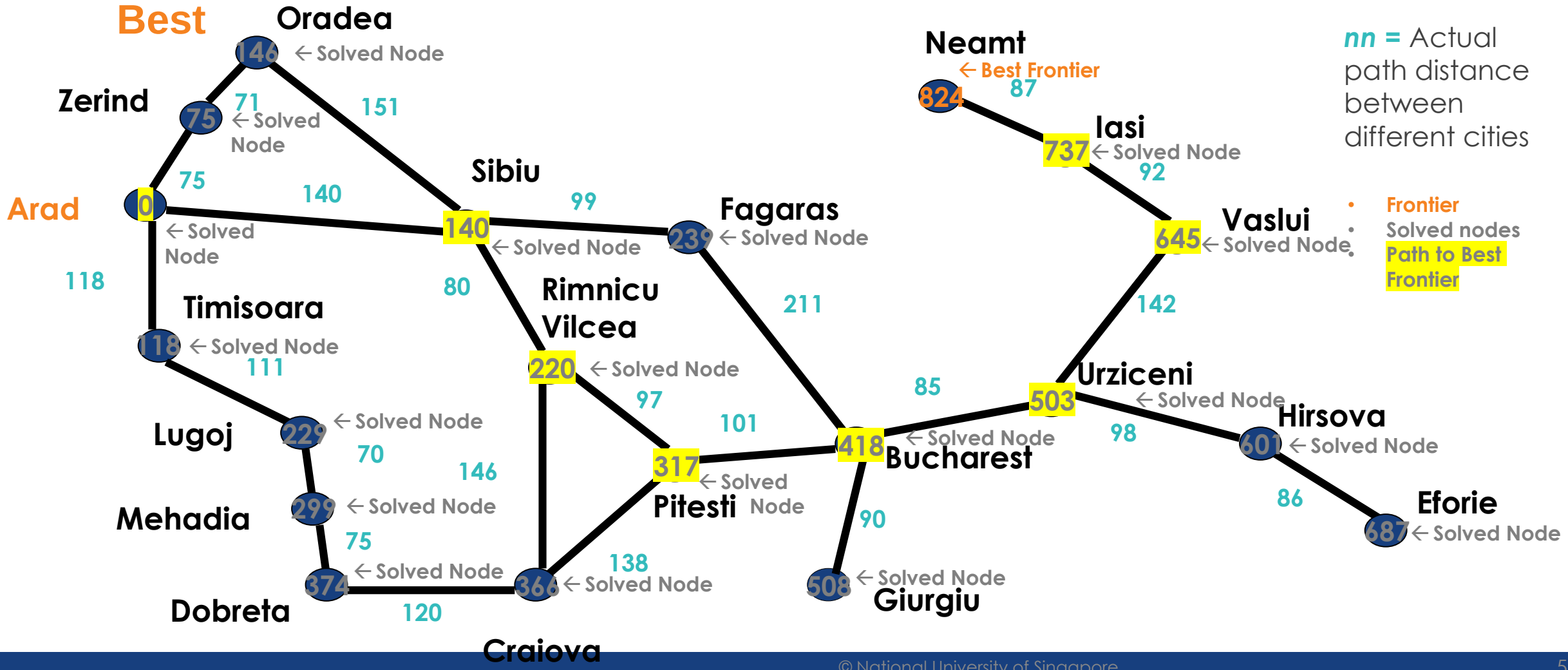

Uninformed Search Techniques (Graph)

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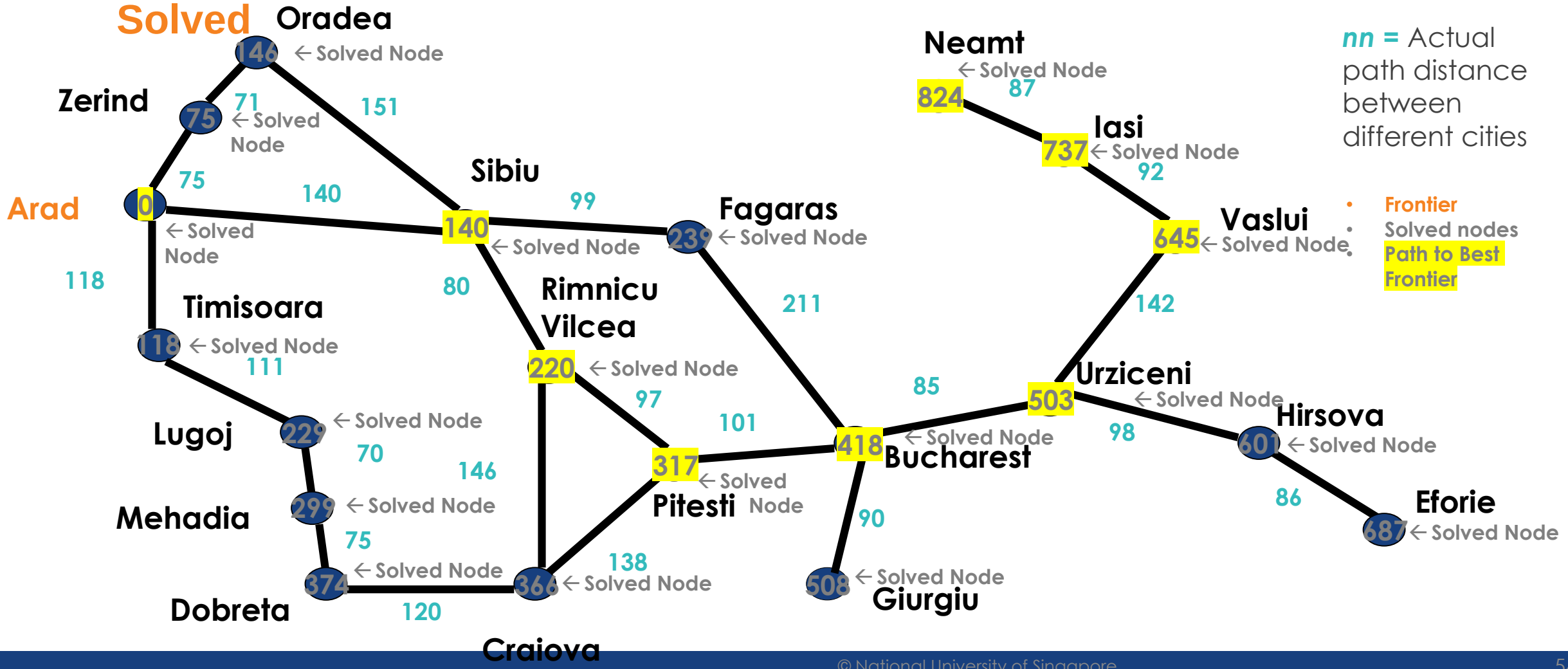
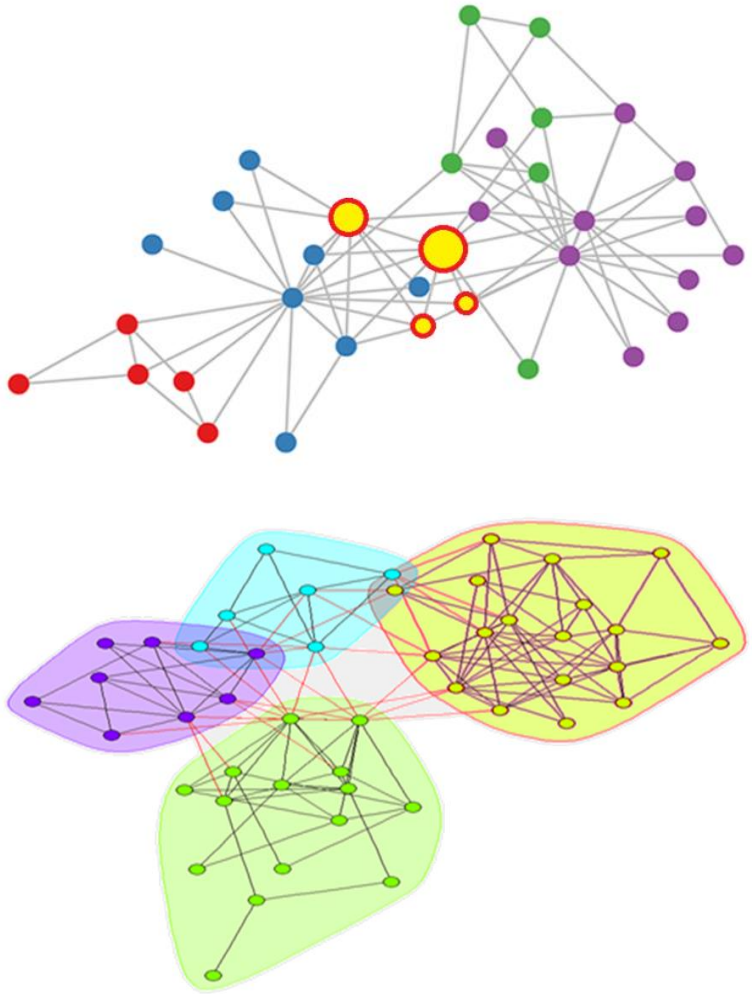


Uninformed Search Techniques (Graph)

Various graph algorithms:

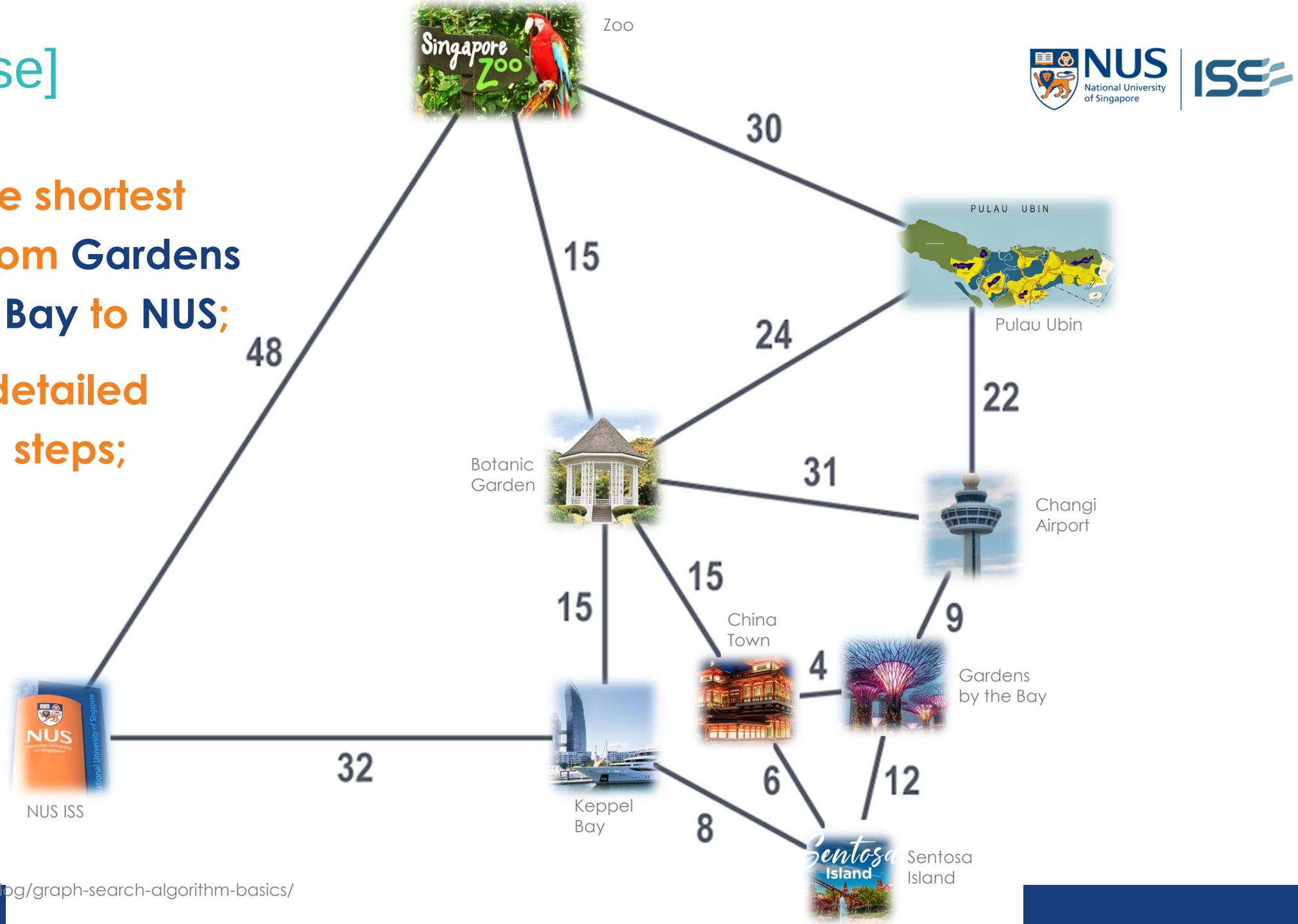
- **Pathfinding:** Paths are fundamental to graph analytics and algorithms, so this is where we'll start our chapters with specific algorithm examples. Finding shortest paths is probably the most frequent task performed with graph algorithms and is a precursor for several different types of analysis. The shortest path is the traversal route with the fewest hops or lowest weight. If the graph is directed, then it's the shortest path between two nodes as allowed by the relationship directions.
- **Centrality:** Centrality is all about understanding which nodes are more important in a network. But what do we mean by importance? There are different types of centrality algorithms created to measure different things, such as the ability to quickly spread information versus bridging distinct groups.
- **Community Detection:** Connectedness is a core concept of graph theory that enables a sophisticated network analysis such as finding communities. Most real-world networks exhibit substructures (often quasi-fractal) of more or less independent subgraphs.



Source: Graph Algorithms: Practical Examples in Apache Spark and Neo4j Book by Amy E. Hodler and Mark Needham

[Exercise]

- **Find the shortest path from Gardens by the Bay to NUS;**
- **Show detailed search steps;**



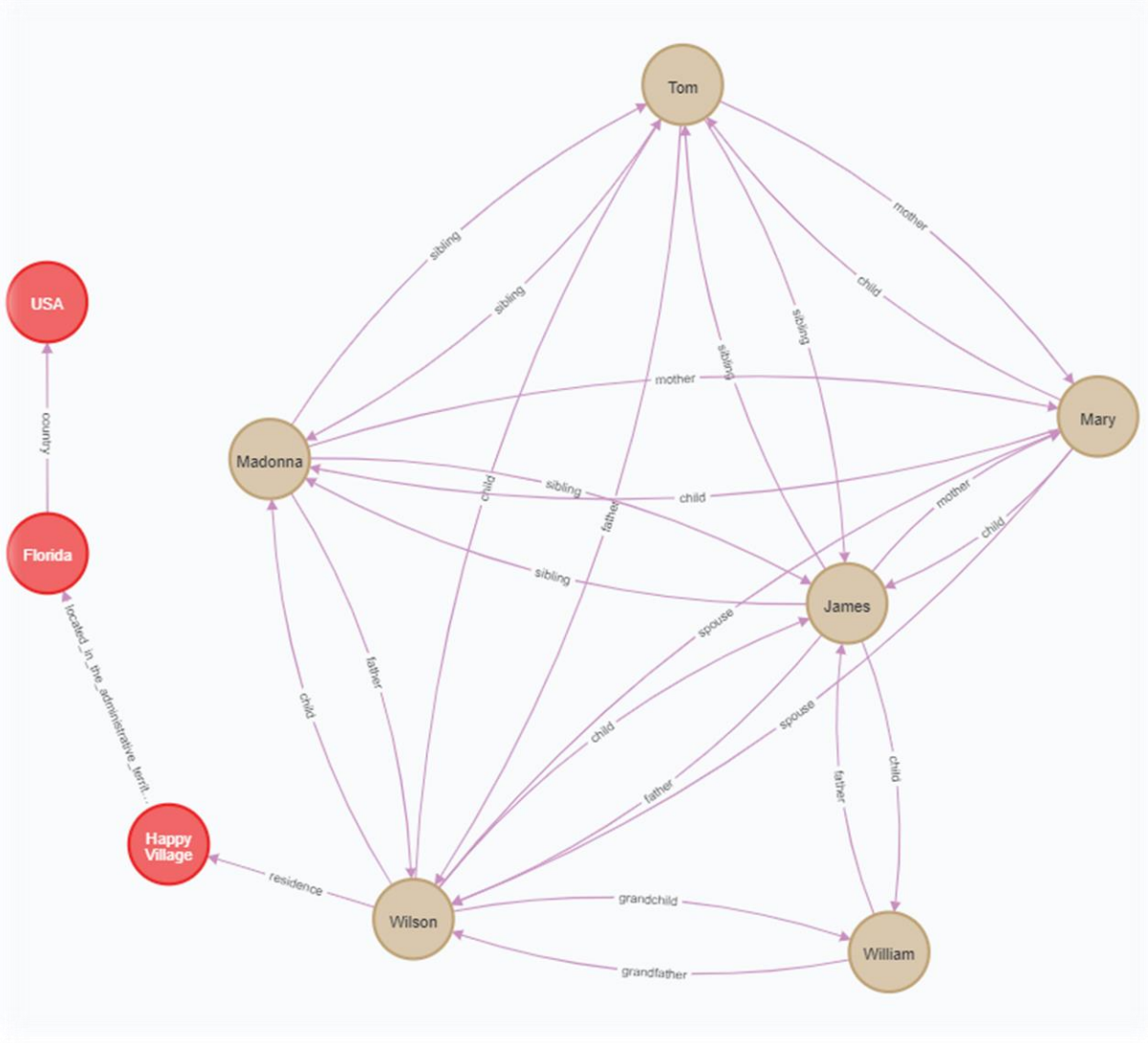
: https://neo4j.com/blog/graph-search-algorithm-basics/

Knowledge Graph

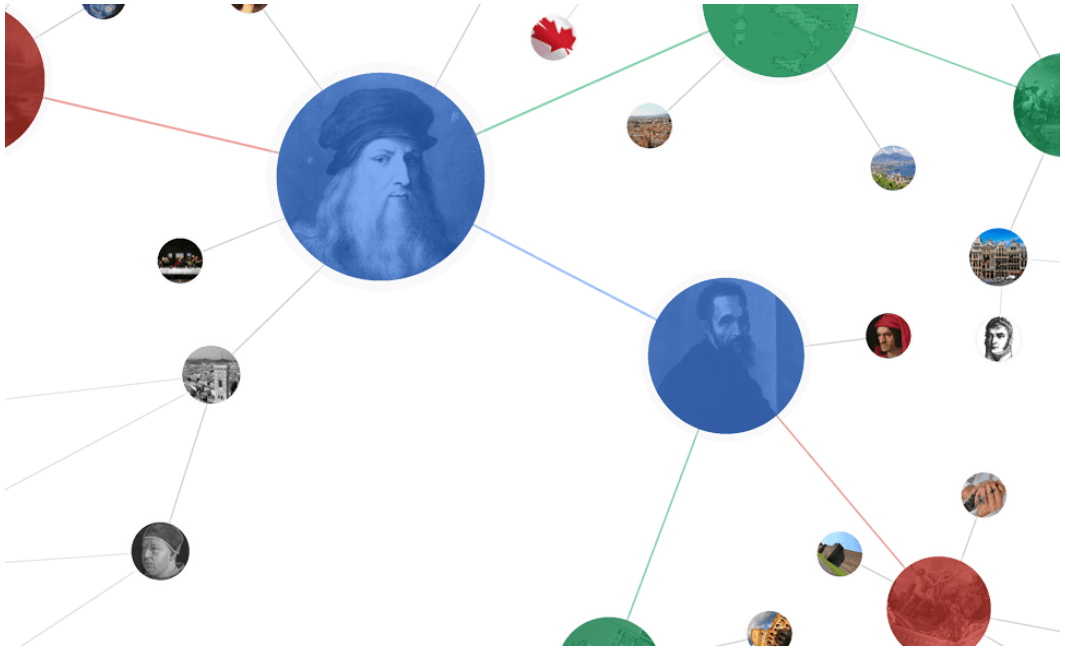
Knowledge Graph Review

- **A knowledge graph is a knowledge base that uses a graph-structured data model or topology to store, integrate, represent, and query data/knowledge.**

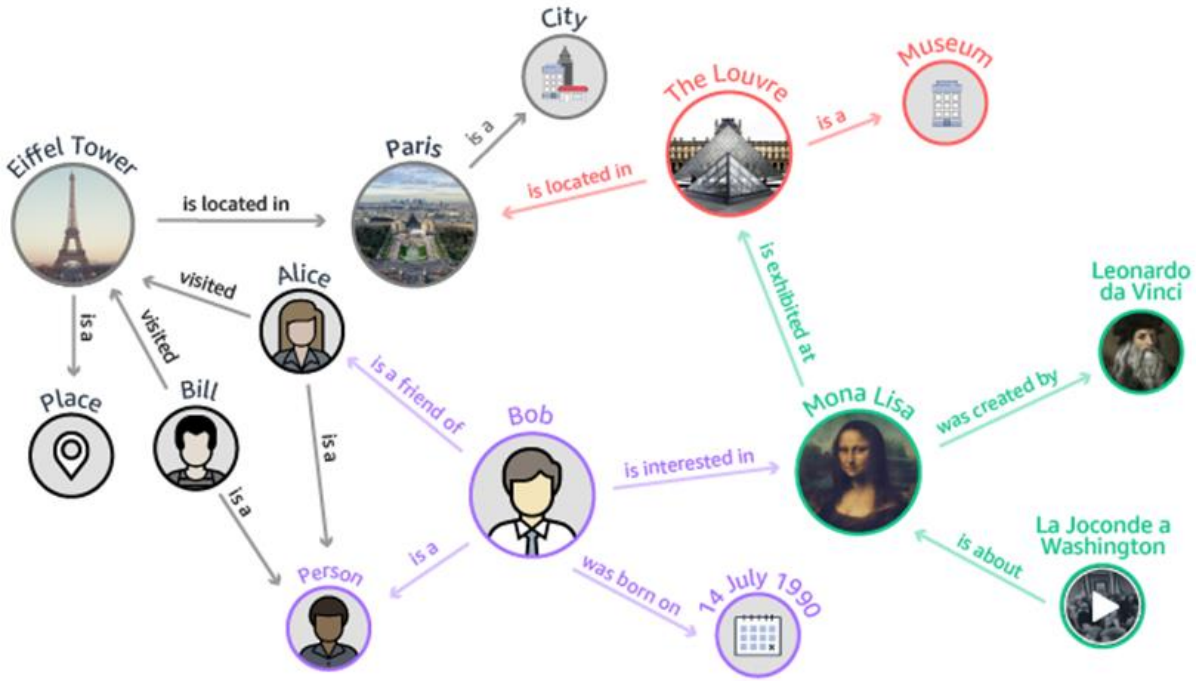
- **Normally, the edge/link is relationship(predicate). The node/vertex is entity/instance.**



Knowledge Graph Review



Source https://www.tampa-seo.com/wp-content/uploads/static-graph.png



Source
https://d1.awsstatic.com/products/Neptune/knowledge_graph.b0e9408219d92f2ca3c7a05cccf9a5a72e34ddbd.png

Knowledge Graph Discovery & Reasoning

- **Learning Objectives**
  - Learn build knowledge graph (KG) in graph database
  - Learn do inference and query in knowledge graph
- **Package to use**
  - Spacy, neo4j, openNRE
- **Technique**
  - Entity & relationship extraction
  - Knowledge graph reasoning
- **Case/Scenario**
  - A family relationship tutorial to learn how to build KG and do inference
  - “Animal Farm” for workshop
- **Requirement**
  - Familiar with python

What is OpenNRE?

- **In SpaCy, we call 'nlp tool' to extract the entity from a sentence**

```
raw_sentence = 'Sam lives in Singapore'
nlp = spacy.load('en_core_web_lg')

token_sentence = nlp(raw_sentence)
for i, ent in enumerate(token_sentence.ents):
    print(i,':',ent.text, ent.label_)
```

```
0 : Sam PERSON
1 : Singapore GPE
```

- **However, how to get the relationship(predicates) between two entities?**
- **We need relationship-extraction function. That's when openNRE comes. OpenNRE is a pre-trained model model to extract relationship between two entities from a sentence.**

KG Construction Tutorial

- **./corpus/Family.txt contains textual resources/sentences about the relationships between some persons.**

Happy Village is located in Florida, USA.
Mr. Wilson is a well-known local silversmith in Happy Village.
He is very very old.
When Mr. Wilson was young, he came to Happy Village to seek refuge from a war.
Mr. Wilson found his wife Mary here and raised three children.
James is the elder son of Wilson.
Tom is the younger son of Wilson.
Mr. Wilson also has a daughter named Madonna.
William is James's son.

KG Construction Flow

1. Extract Entities

```
for ent in doc.ents:
    if ent.label_ in ['PERSON', 'GPE'] and ent.text not in names_of_entities:
        names_of_entities.append(ent.text)
        entities.append(ent)
```

2. Generate Nodes

```
for ent in entities:
    if exist_ent.get(ent.text) is None:
        exist_ent[ent.text] = ent.text
        query = (
            "MERGE (node: "+ent.label_+" {name: $name})"
            "RETURN node"
        )
```

3. Extract Relationships

```
for i in range(len(entities)):
    for j in range(i + 1, len(entities)):
        text_i = entities[i].text
        text_j = entities[j].text
        loc_h = sentence.find(text_i)
        loc_t = sentence.find(text_j)
        result = model.infer({'text': sentence, 'h': {'pos': (loc_h, loc_h + len(text_i))},
                              't': {'pos': (loc_t, loc_t + len(text_j))}})
```

4. Generate Relationships

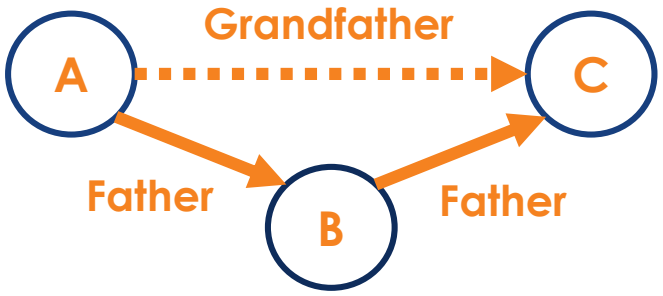
```
if record not in exist_relationship:
    exist_relationship.append(record)
    if record[3] > 0.8:
        query = (
            "MATCH (n1 {name: $name1})"
            "MATCH (n2 {name: $name2})"
            "MERGE (n1) - [r:"+record[2]+"] -> (n2)"
            "RETURN n1, n2, r"
        )
```

KG Construction: Extraction

- **In KG, we establish relationships and nodes. These information can be directly extracted from the corpus. E.g. from two raw sentences**
  - William is James's son.
  - James is the elder son of Wilson.
- **The openNRE can extract 'Father' relationship:**
  - William – HasFather → James & James – HasFather → Wilson
- **However, some relationships cannot be directly extracted from raw sentences** (due to ? Non-existence lah)**. E.g. how to generate/infer the 'Grandfather' relationship?**
  - William – HasGrandfather → Wilson

KG Construction: Extension (inference)

- **We can add inference rules (additional knowledge) to automatically extend the knowledge graph.**
- **E.g. WHEN A HasFather B AND B HasFather C THEN A HasGrandfather C**

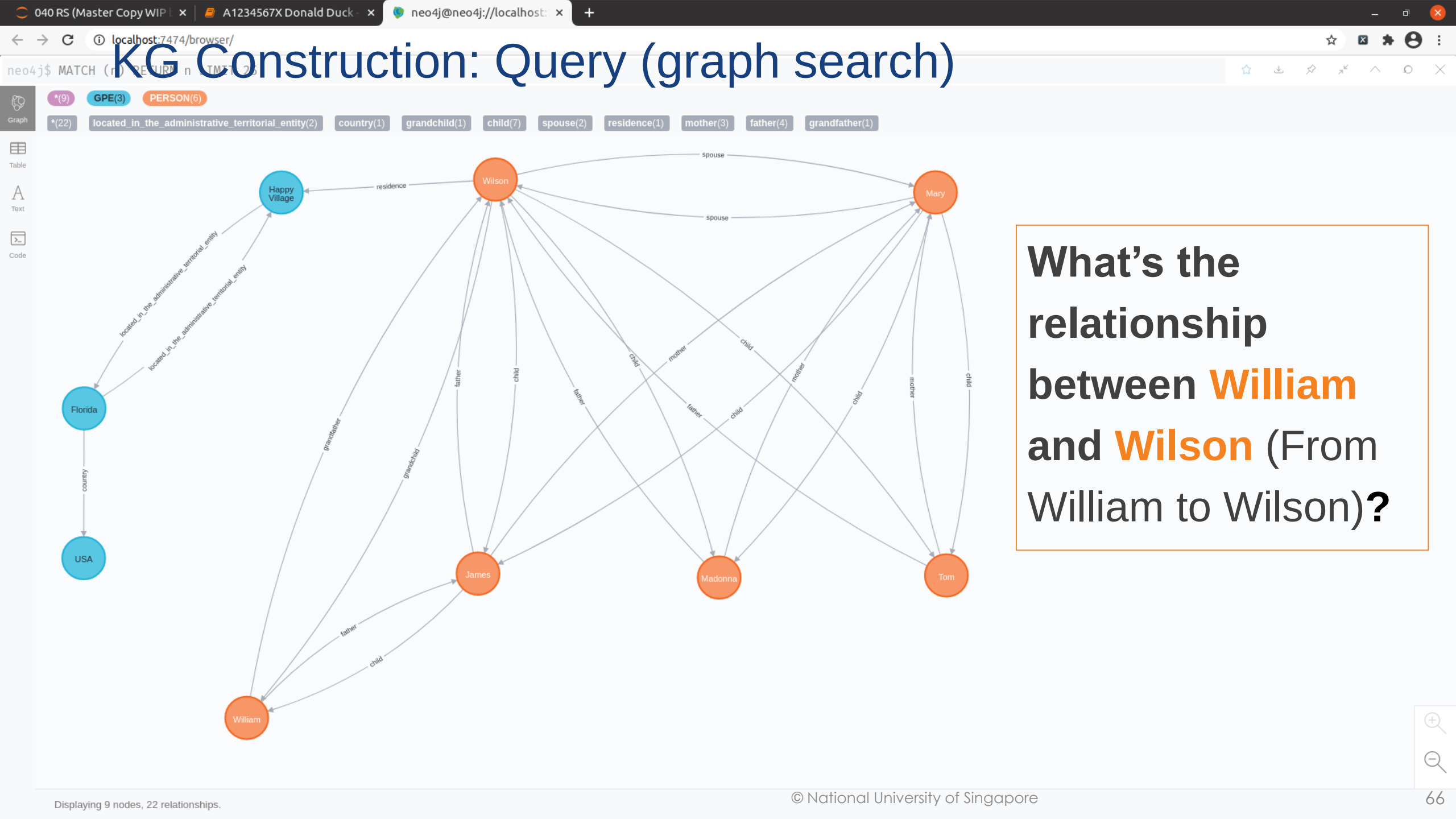



```
# Rule 3: Grandfather relationship/link

# WHEN:
# (n1:PERSON)-[r:father]->(n2:PERSON)  # n1 has a father : n2
# (n2:PERSON)-[r2:father]->(n3:PERSON) # n2 has a father : n3
# THEN:
# (n1)-[r3:grandfather]->(n3) # n1 has a grandfather : n3
# (n3)-[r4:grandchild]->(n1)  # n3 has a grandchild  : n1

query = (
        "MATCH (n1:PERSON)-[r:father]->(n2:PERSON)-[r2:father]->(n3:PERSON)"
        "MERGE (n1)-[r3:grandfather]->(n3)"
        "MERGE (n3)-[r4:grandchild]->(n1)"
        "RETURN n1, n3"
)
```

KG Construction: Query (graph search)



What's the relationship between William and Wilson (From William to Wilson)**?**

The Hottest Cool Thing in AI?

Horse ←→ Zebra

Magic?

“An astronaut riding a horse in photorealistic style”

Text Prompt → Image

Text → Video

Surreal Realistic Stylized

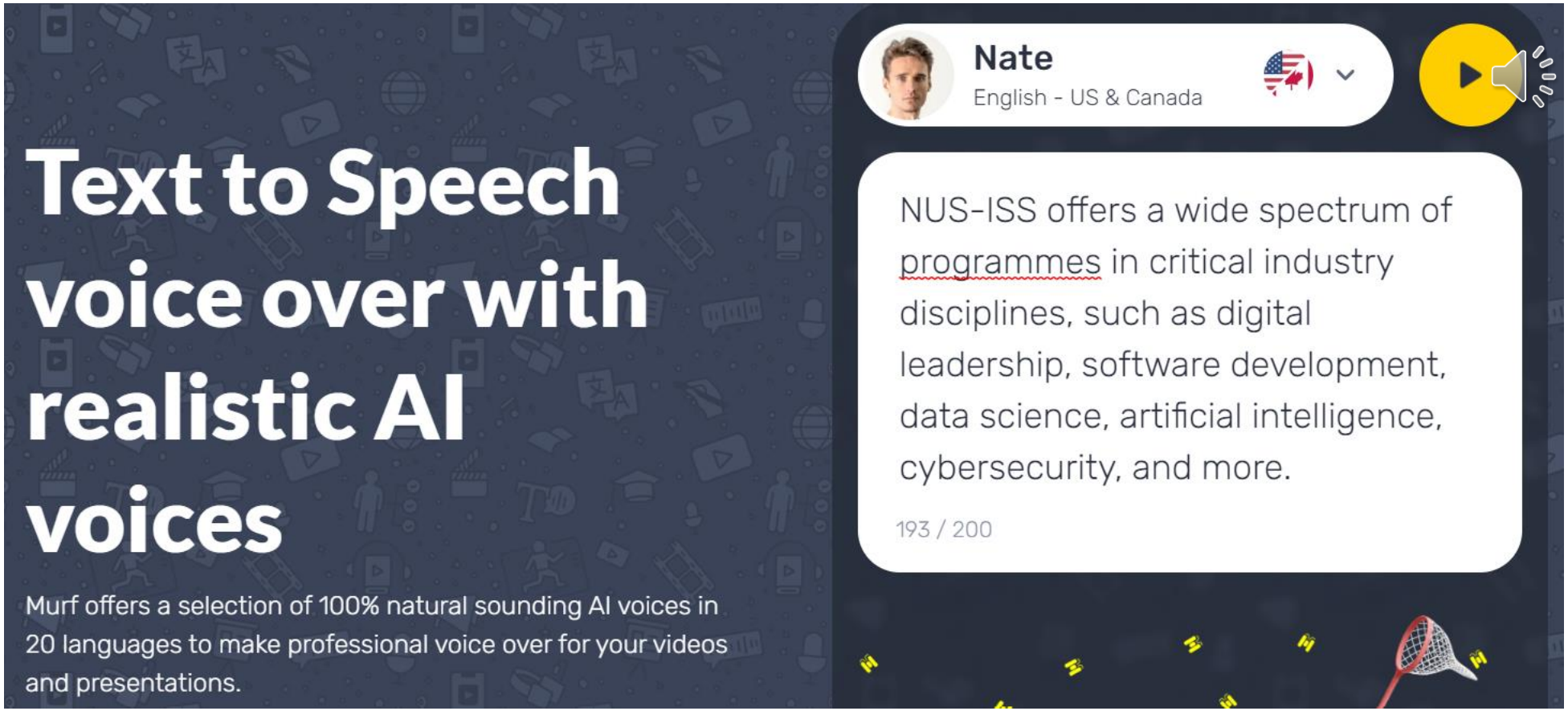
A teddy bear painting a portrait →

Robot dancing in times square

Cat watching TV with a remote in hand

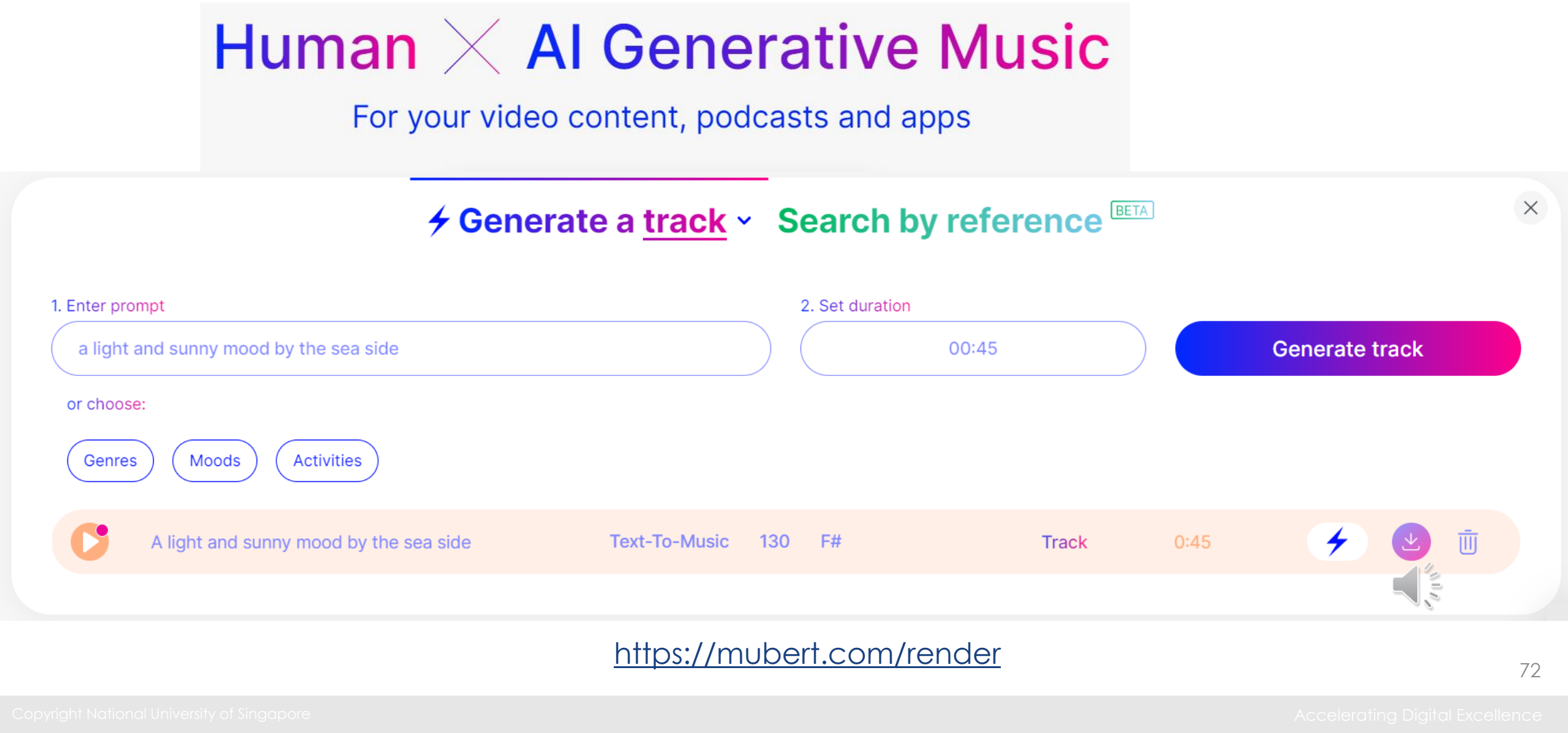
Meta AI: Make-A-Video
https://makeavideo.studio/

Voice Over



https://murf.ai/
https://murf.ai/text-to-speech

Text → Music



https://mubert.com/render

Image → Music

Image to Music

Sends an image in to CLIP Interrogator to generate a text prompt which is then run through Mubert text-to-music to generate music from the input image!

Image

Text Captions

If player do not work, try to copy/paste the link in a new browser window

CLIP Interrogator Caption: 'a teddy bear painting a picture of a teddy bear, an airbrush painting, screengrab, british stopmotion, wow!, oli on painting'

—

OpenAI Musical Adaptation: 'You did not use any OpenAI API key to pimp your result :)'

—

Audio file link: https://static-eu.gcp.mubert.com/b2b/recorder/imgtomusic/3d80ac788b4d4fb68418002da9991064.wav

https://huggingface.co/spaces/fffiloni/img-to-r

Result

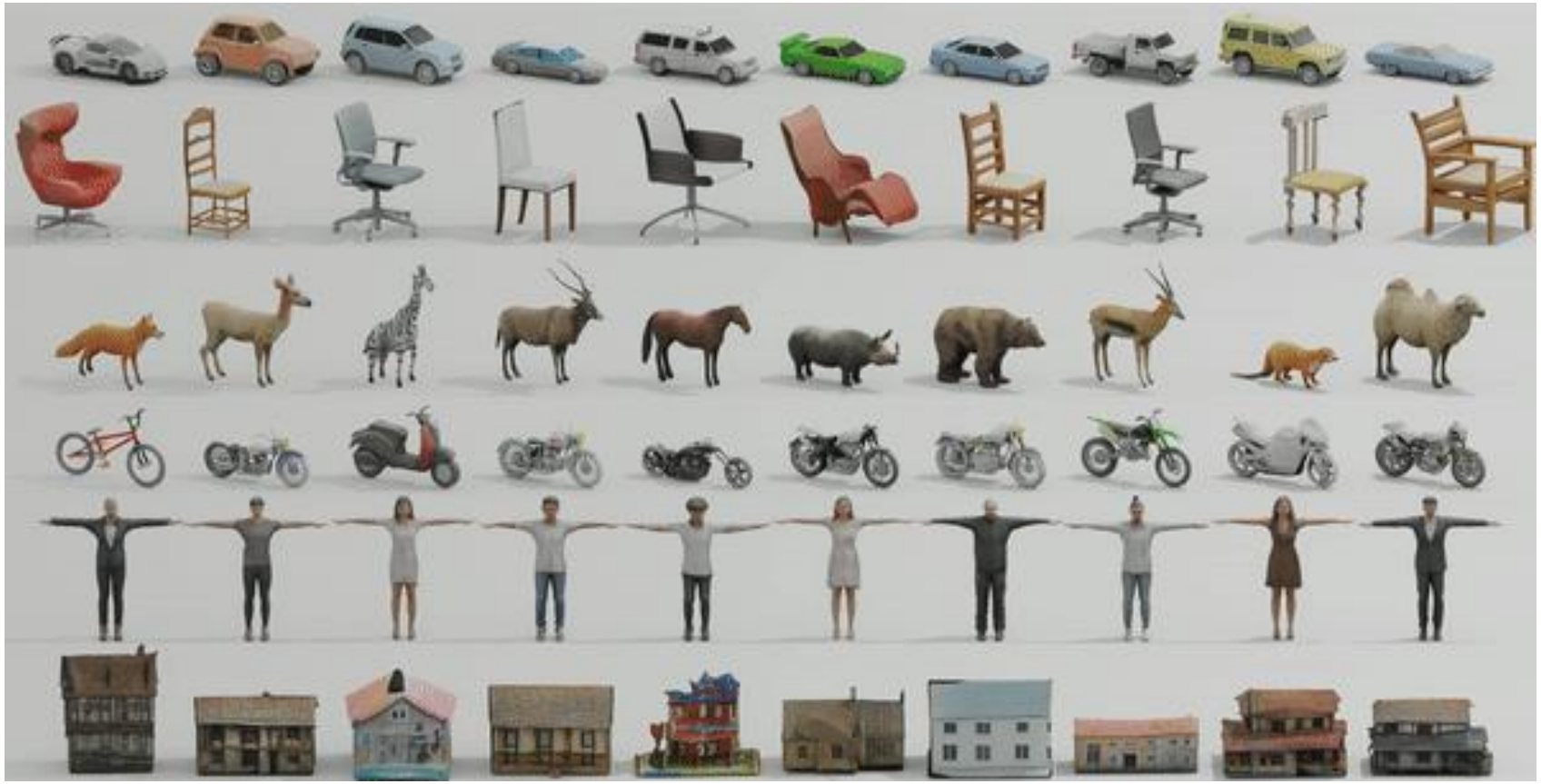
0:54 / 0:54

Visual Understanding

Image Captioning
"two cartoon monsters sitting around a campfire"

Visual question answering
prompt = "Question: What is a dinosaur holding? Answer:"
"A torch“
https://huggingface.co/blog/blip-2

2D → 3D Visual



GET3D: A Generative Model of High Quality 3D Textured Shapes Learned from Images
https://nv-tlabs.github.io/GET3D/

Image → Video

Single image | Pair of images

Input image

https://makeavideo.studio/

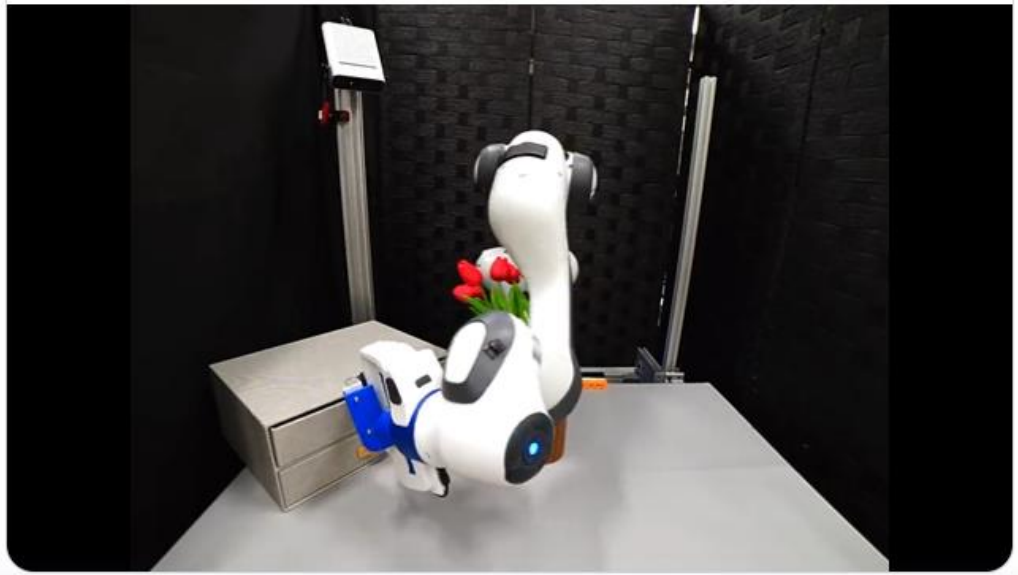
Robotics + LLM/GAI

Wenlong Huang @wenlong_huang · Jul 8

How to harness foundation models for *generalization in the wild* in robot manipulation?

Introducing VoxPoser: use LLM+VLM to label affordances and constraints directly in 3D perceptual space for zero-shot robot manipulation in the real world!

voxposer.github.io



Jim Fan ✓
@DrJimFan

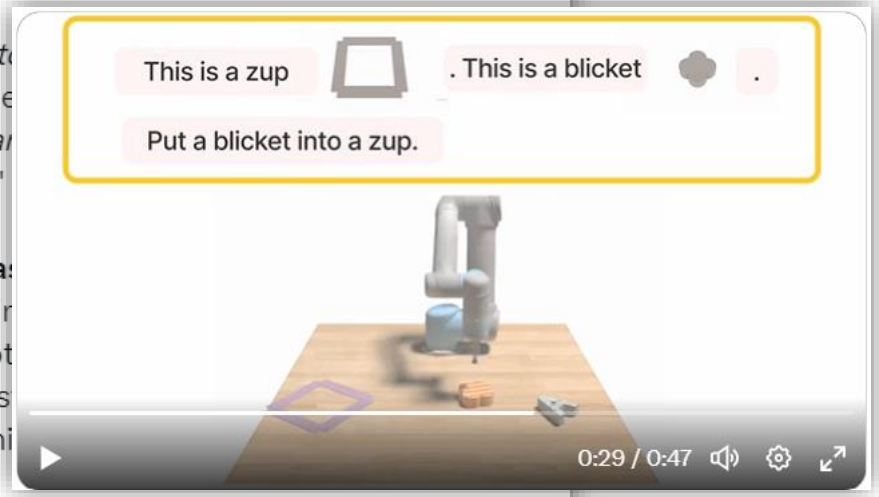
Robotics will be the last moat we conquer in AI. What would a RobotGPT's API look like?

Introducing VIMA, **an LLM with a robot arm attached** 🦾. It takes in **multimodal prompt:** text, images, videos, or mixture of them.

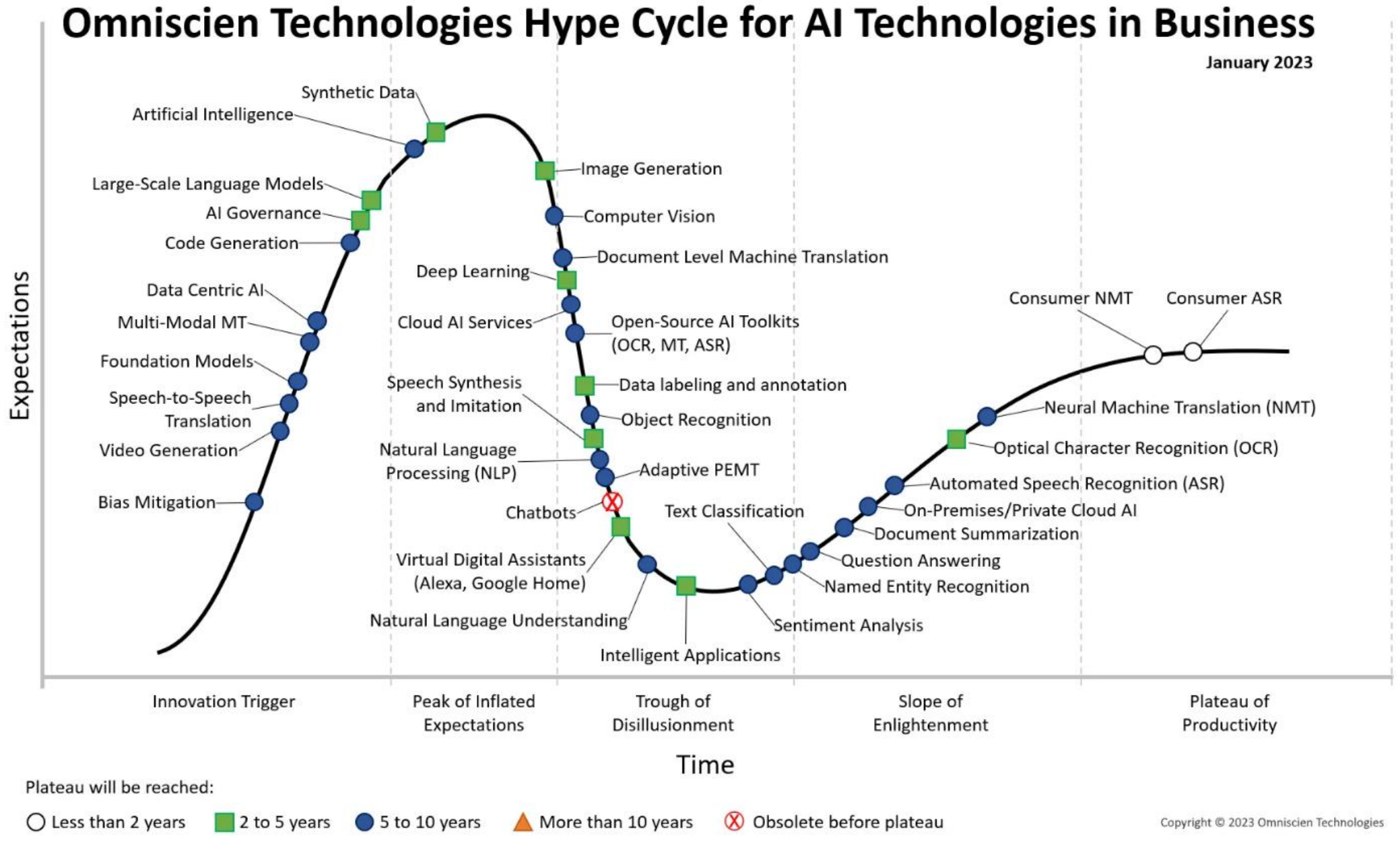
You can say "*rearrange the table t*
action: <video frames>". You can e
context: "*This is a wug <image> a*
the red wug on the green blicket."

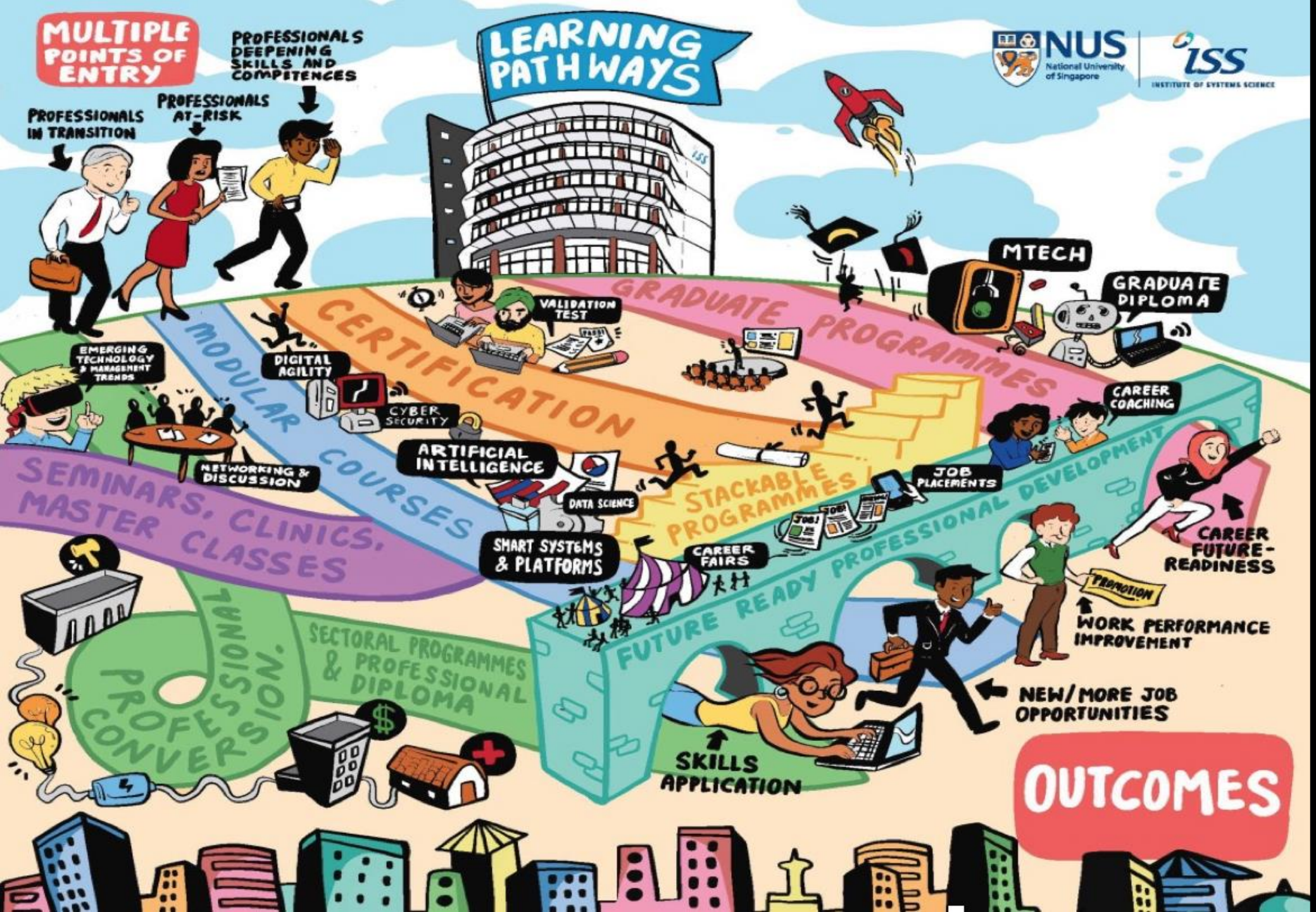
Multimodal prompting makes ta
more flexible for users. With a sir
like visual goal reaching, one-shot
concept learning, and safety cons
otherwise require a different traini

"VIMA" stands for **Vi**suo**M**otor **A**ttention. It is a Transformer that encodes a sequence of multimodal tokens in the prompt and decodes robot arm control autoregressively. VIMA is an **embodied AI agent: perceiving the environment and taking actions in the physical world,** one step at a time.



https://twitter.com/drfeifei/status/1677510109776465921
https://twitter.com/drfeifei/status/1683811726377234432

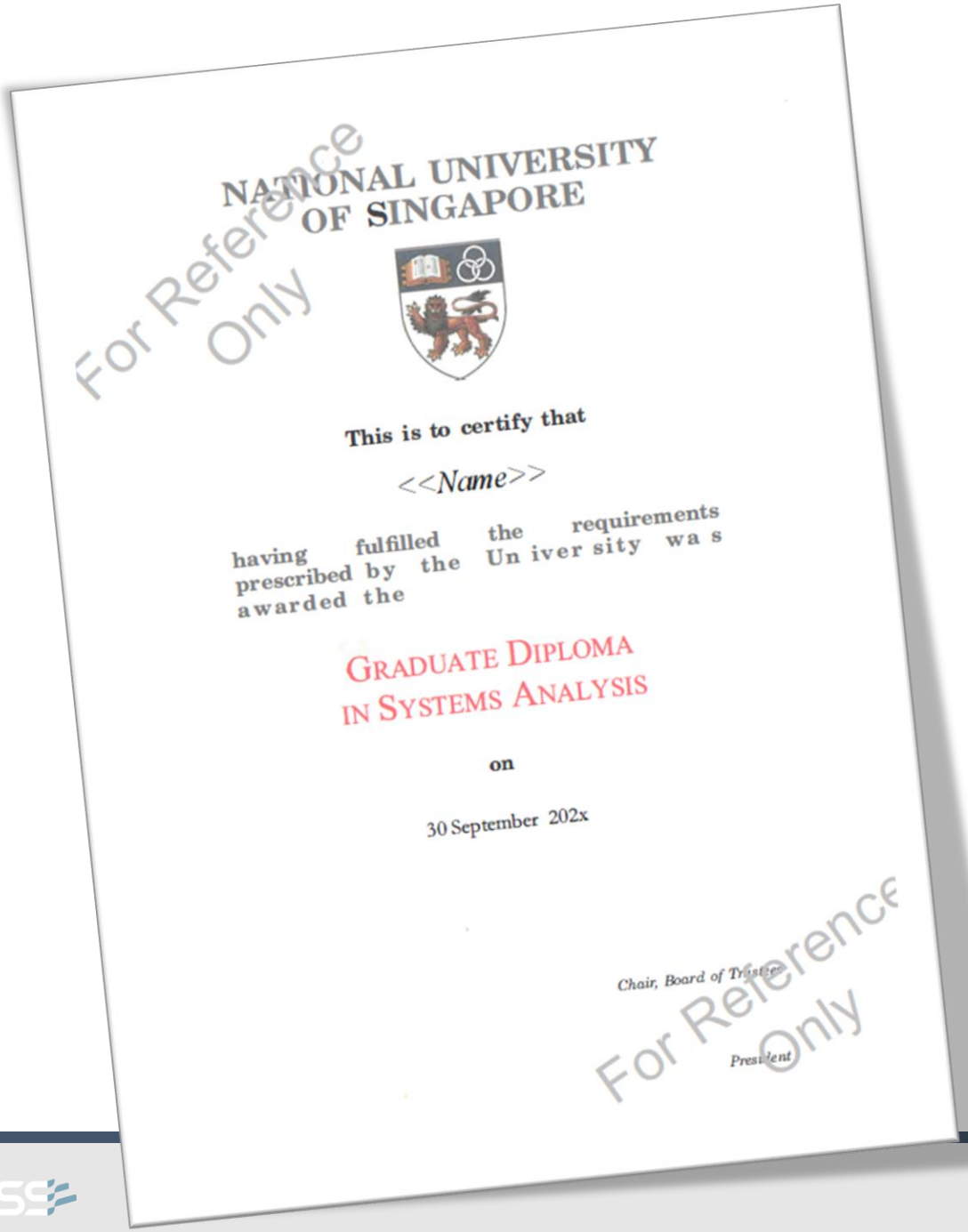

Omniscien Technologies Hype Cycle for AI Technologies in Business
January 2023
Expectations
Synthetic Data
Artificial Intelligence
Large-Scale Language Models
AI Governance
Code Generation
Data Centric AI
Multi-Modal MT
Foundation Models
Speech-to-Speech Translation
Video Generation
Bias Mitigation
Image Generation
Computer Vision
Document Level Machine Translation
Deep Learning
Cloud AI Services
Open-Source AI Toolkits (OCR, MT, ASR)
Data labeling and annotation
Speech Synthesis and Imitation
Object Recognition
Natural Language Processing (NLP)
Adaptive PEMT
Chatbots
Virtual Digital Assistants (Alexa, Google Home)
Natural Language Understanding
Intelligent Applications
Text Classification
Sentiment Analysis
Named Entity Recognition
Question Answering
Document Summarization
On-Premises/Private Cloud AI
Automated Speech Recognition (ASR)
Optical Character Recognition (OCR)
Neural Machine Translation (NMT)
Consumer NMT
Consumer ASR
Innovation Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
Time
Plateau will be reached:
Less than 2 years
2 to 5 years
5 to 10 years
More than 10 years
Obsolete before plateau
Copyright © 2023 Omniscien Technologies



Multiple Pathways

To

Degree & Success



NATIONAL UNIVERSITY
OF SINGAPORE

This is to certify that

<<Name>>

having fulfilled the requirements prescribed by the University was awarded the

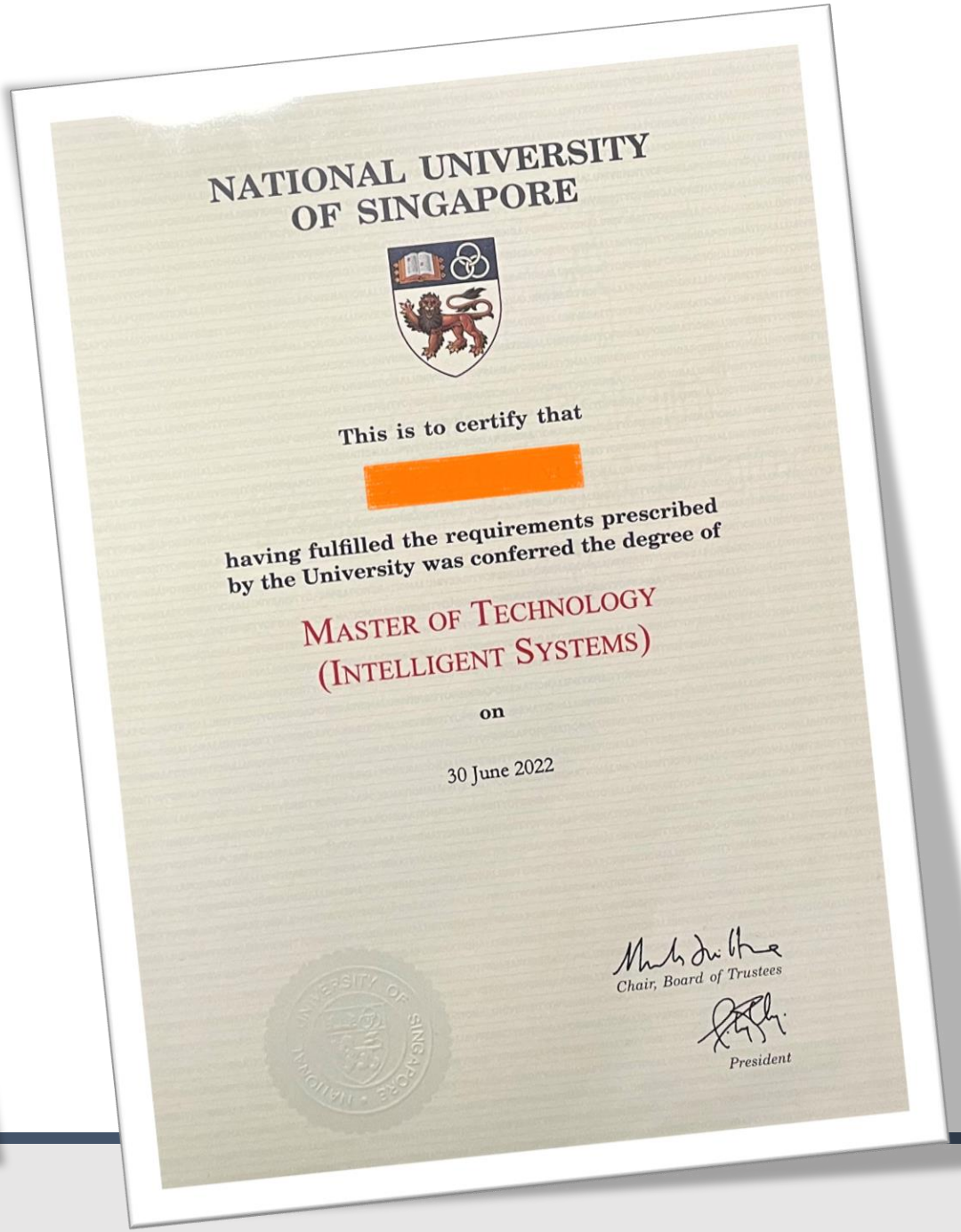
GRADUATE DIPLOMA
IN SYSTEMS ANALYSIS

on

30 September 202x

Chair, Board of Trustees

President



NATIONAL UNIVERSITY
OF SINGAPORE

This is to certify that

[redacted]

having fulfilled the requirements prescribed by the University was conferred the degree of

MASTER OF TECHNOLOGY
(INTELLIGENT SYSTEMS)

on

30 June 2022

Chair, Board of Trustees

President

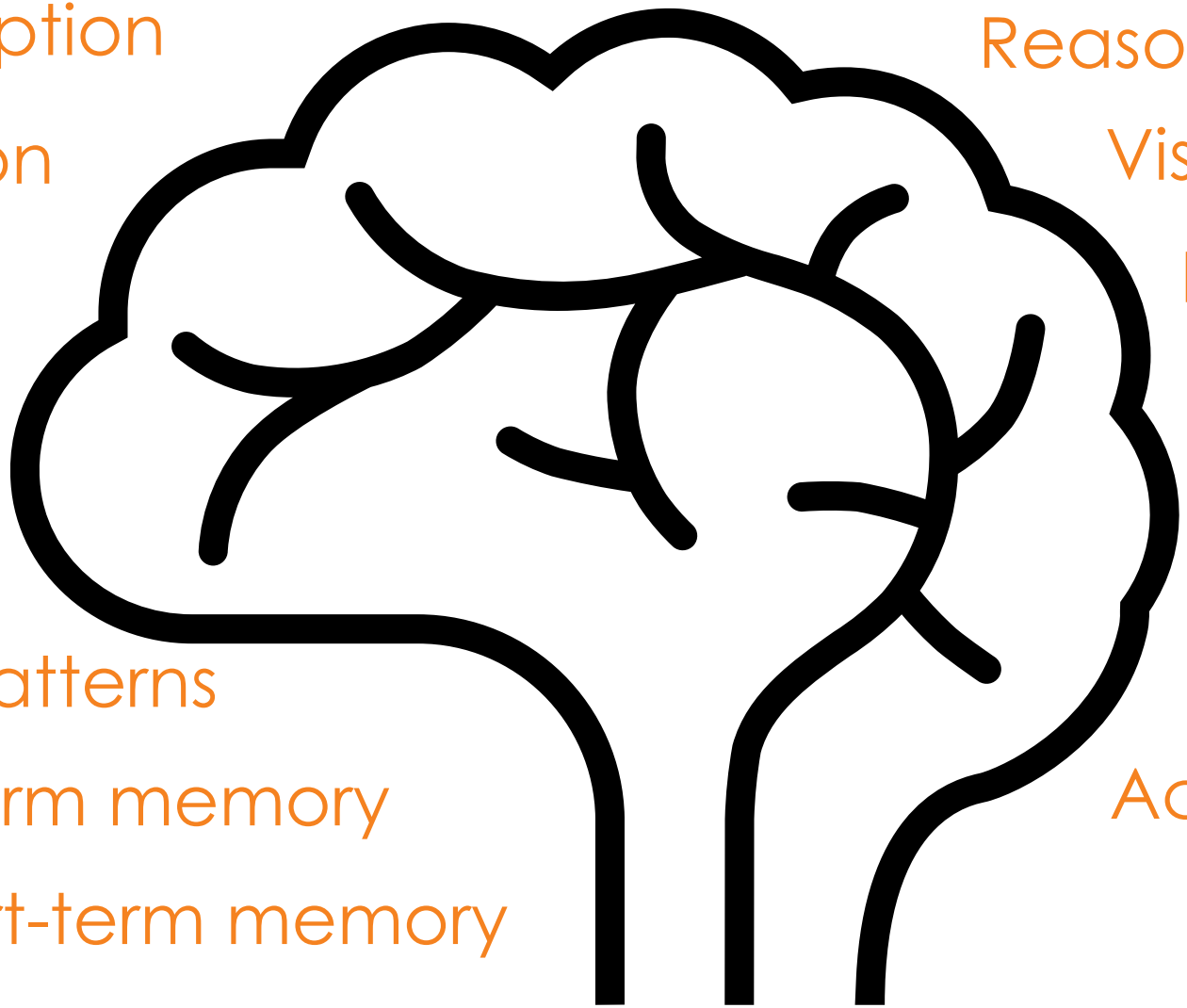
From Human Intelligence
To Machine Intelligence

What's intelligence?

"Intelligence measures a human/AI's ***ability*** to achieve ***goals*** in a wide range of ***environments***."

A Universal Measure of Intelligence for Artificial Agents, Legg & Hutter 2007

Cognitive Abilities (Functions)



Perception

Attention

Language

Learning

Abstraction

Recognize patterns

Long-term memory

Short-term memory

Reasoning

Vision

Hearing

Emotions

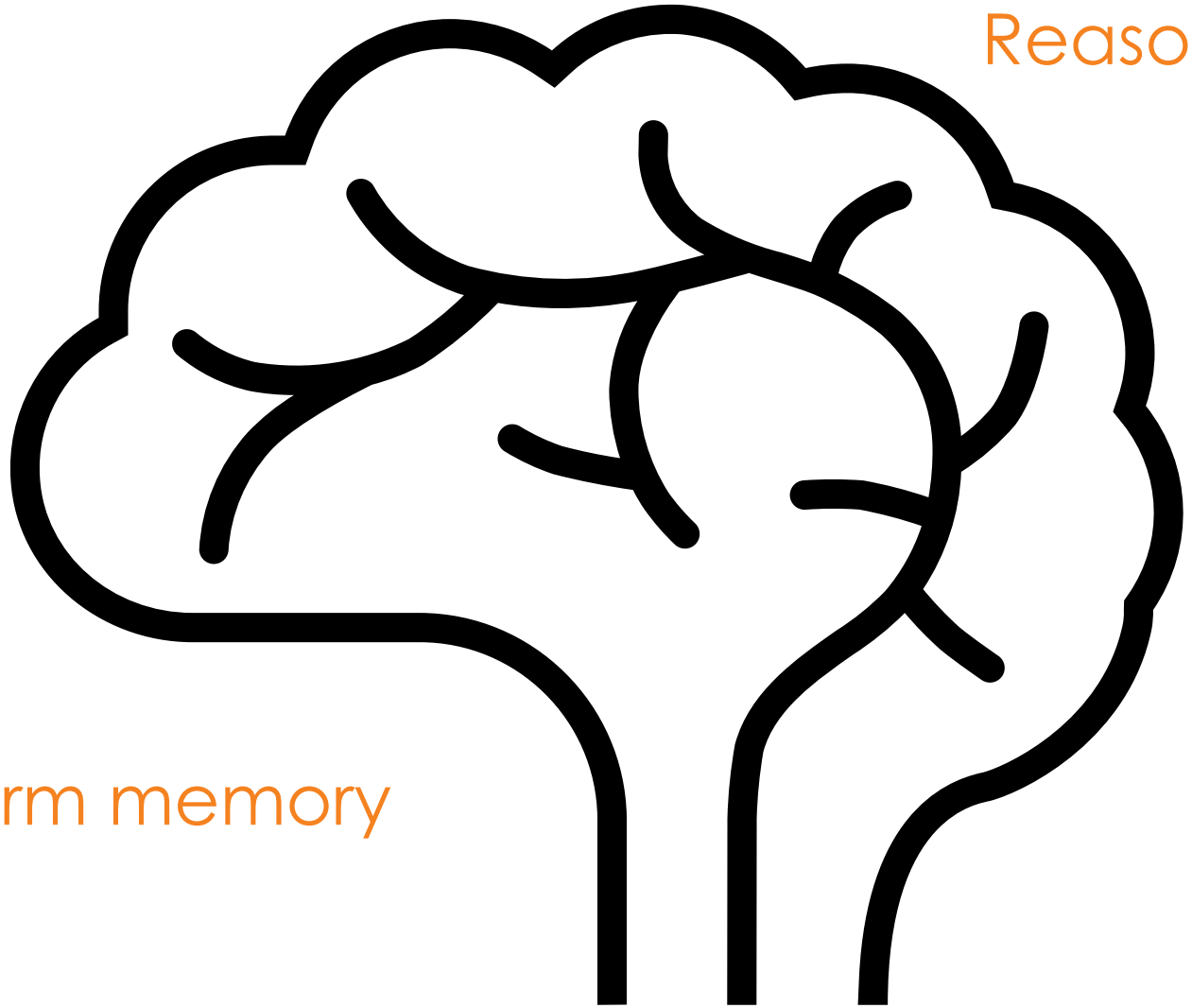
Motivation

Communication

Act

Core Cognitive Abilities (Functions)

Reasoning

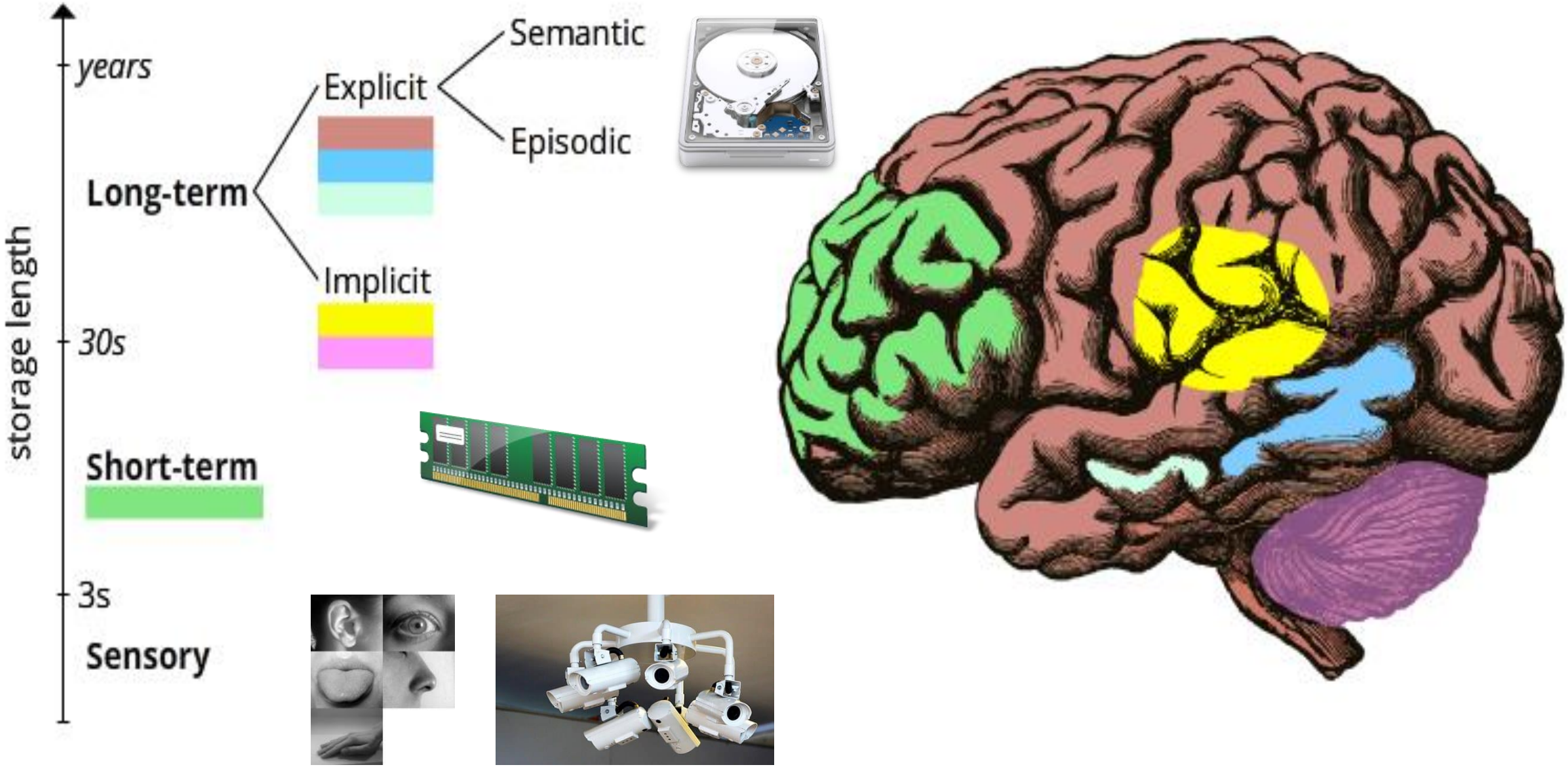


Learning

Long-term memory

Human Memory

to **store** data, e.g. abstract knowledge, sensory information, experiences, etc. and this ISS learning session as well.



Human Learning

to **generate new** knowledge

E.g. acquired understanding, behaviours, skills, values, useful to memorize & reuse

Model: Learn

Model: Recognize

Common Forms of Learning

1. Habituation

- Unsupervised Learning; Anomaly Detection

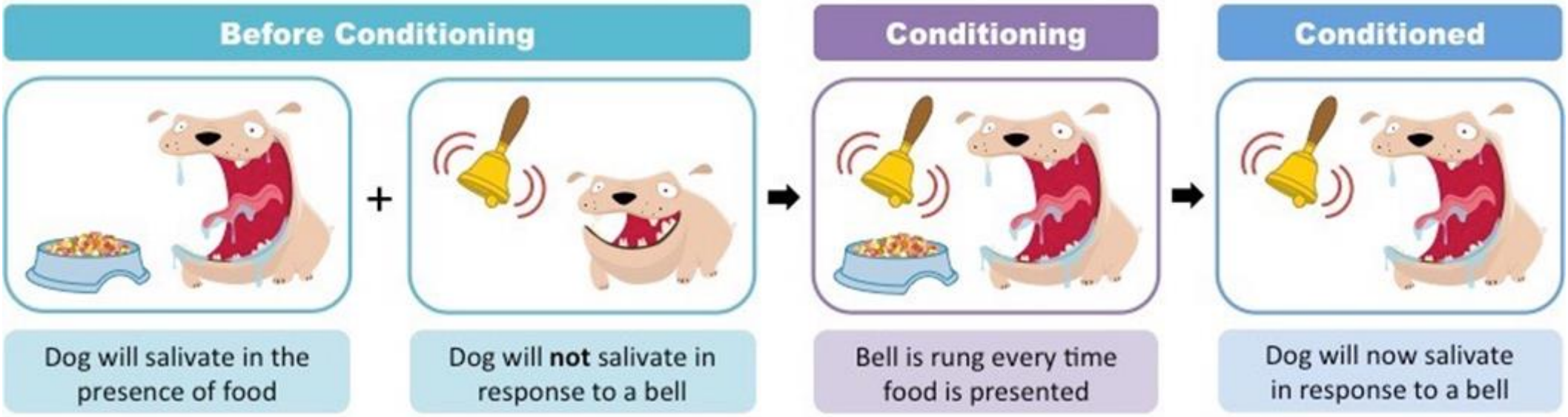
- Bird learned the knowledge/behaviour to ignore the fake threat;

Source https://ib.bioninja.com.au/options/option-a-neurobiology-and/a4-innate-and-learned-behav/habituation.html

Common Forms of Learning

2. Classical (Reflex) conditioning

- Association (between stimuli or events); Supervised Learning



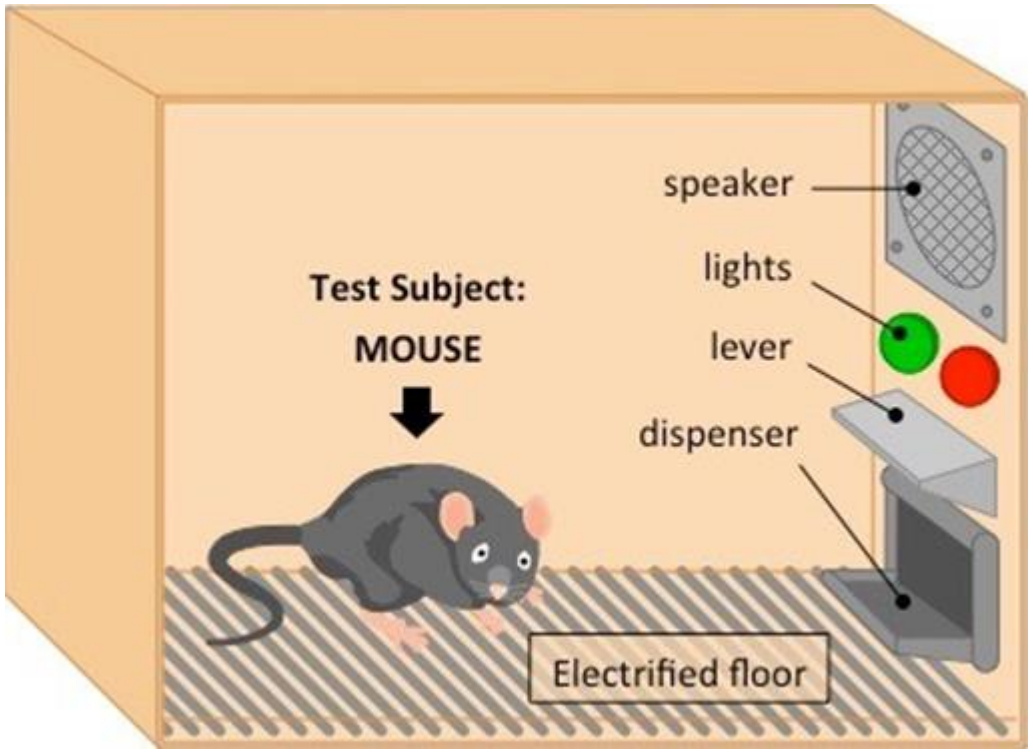
- Dog learned the knowledge of association/correlation: between food & bell ring;
- Dog learned the knowledge/behaviour of causation: food/bell ring → saliva

Source https://ib.bioninja.com.au/options/option-a-neurobiology-and/a4-innate-and-learned-behav/conditioning.html

Common Forms of Learning

3. Operant conditioning

- Reinforcement Learning; Generate & Test; Simulation



Subject / Reinforcement Learning Agent

- **Agent**: Mouse
- **Environment**: Cage
- **Goal**: Survive longer
- **Random Series of Actions**
- **Best Series of Actions** leading to survival & welfare

- Mouse learned the knowledge of button functions & steps to obtain food;

Source https://ib.bioninja.com.au/options/option-a-neurobiology-and/a4-innate-and-learned-behav/conditioning.html

Common Forms of Learning

3. Operant conditioning

AlphaGo
from
Google/DeepMind

Generate & Test
during self playing:
AlphaGo vs.
AlphaGo

Source https://miro.medium.com/max/600/0*4P_YVoNqmOa2ypuX.jpg

Common Forms of Learning

3. Operant conditioning

DiDi :
A Reinforcement Learning Agent

- **Agent**: DiDi
- **Environment**: NUS
- **Goal**: Unblock/Move scooter
- **Random Series of Actions**
- **Best Series of Actions** leading to goal

Source https://telescopeuser.wordpress.com/2018/08/20/didi-a-reinforcement-learning-agent/

Video https://youtu.be/8K-fNcJU0nk

Common Forms of Learning

4. Observational learning

- Imitation Learning; Unsupervised Learning;

Source https://courses.lumenlearning.com/wsu-sandbox/chapter/observational-learning-modeling/

Human Reasoning

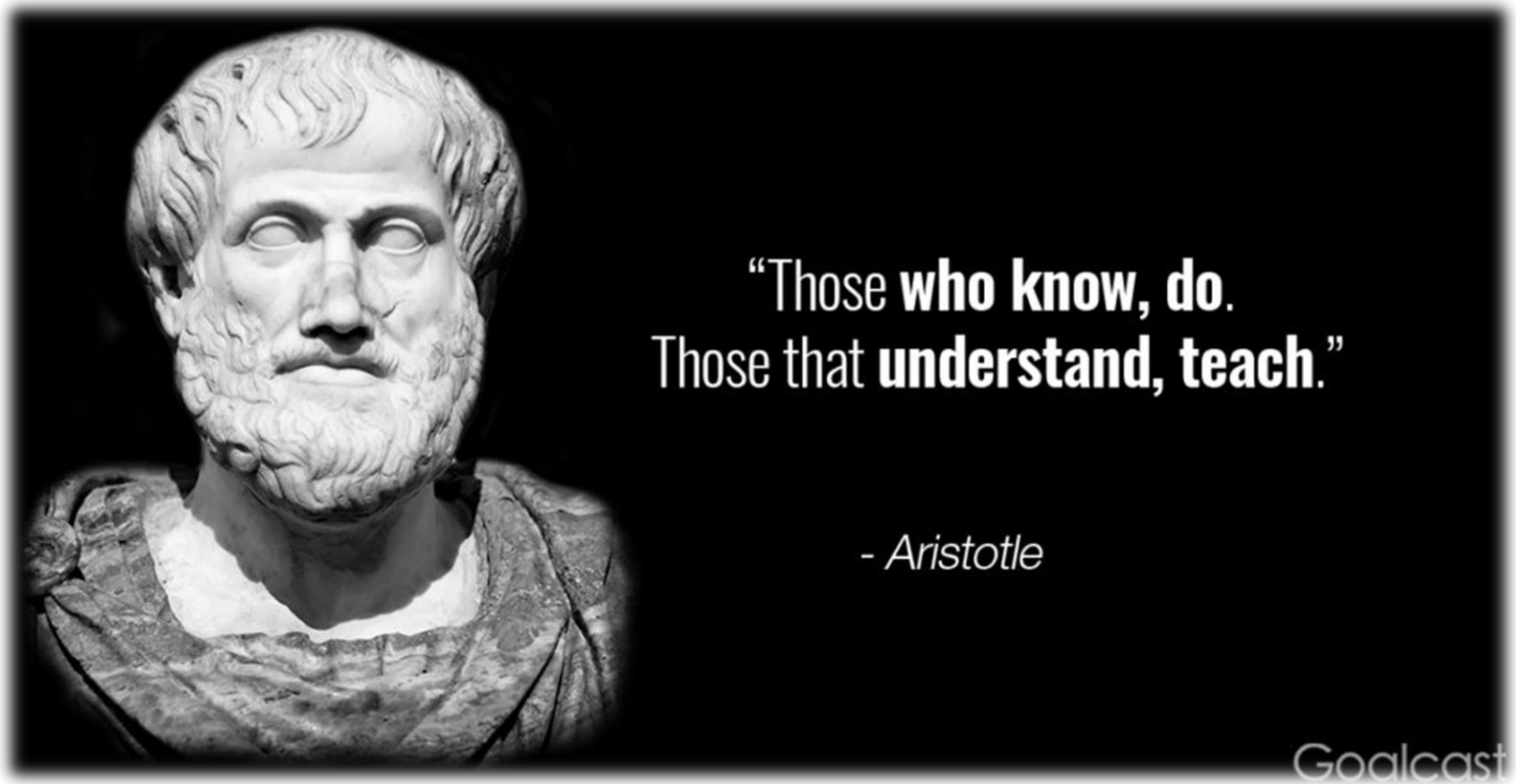
to **use existing** knowledge

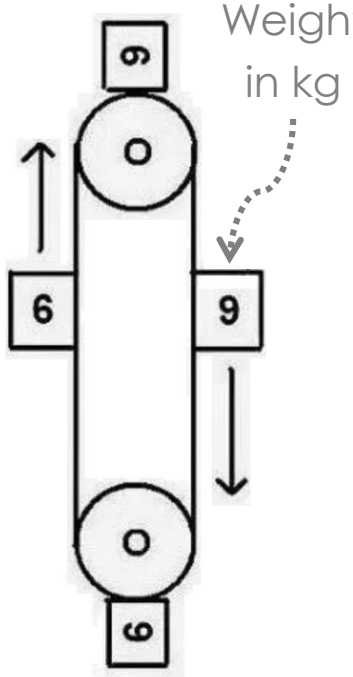
Model:
Reason/Think

Common Forms of Reasoning

1. Deductive Reasoning

- Aristotle's syllogism; Formal logic; Knowledge Graph; If-Then business rules; Declarative programing language like SQL; (Universal → Individuals)



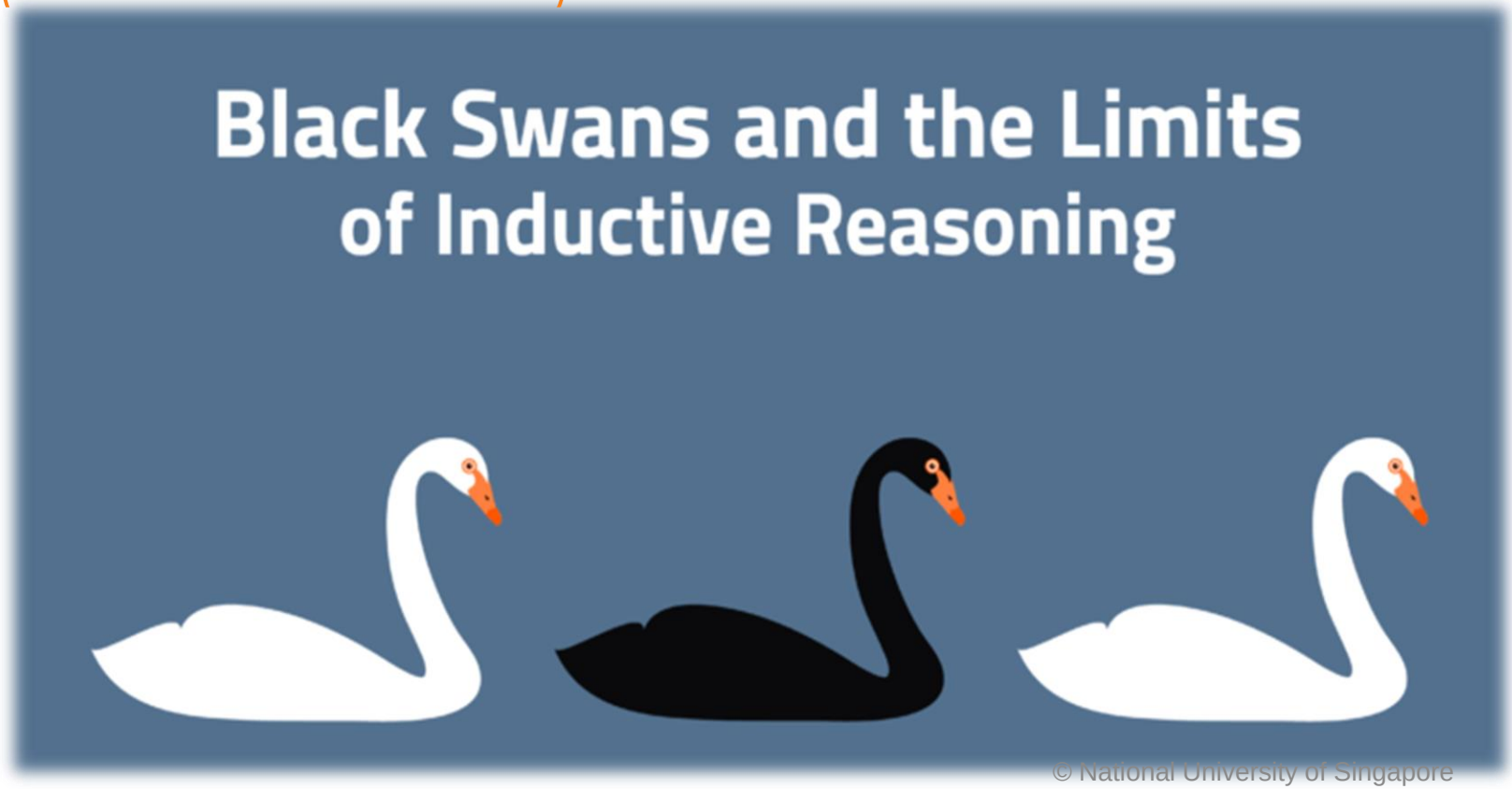


Sam's perpetual motion machine on sale! $0.99 only!

Common Forms of Reasoning

2. **Inductive Reasoning** (aka. learning)

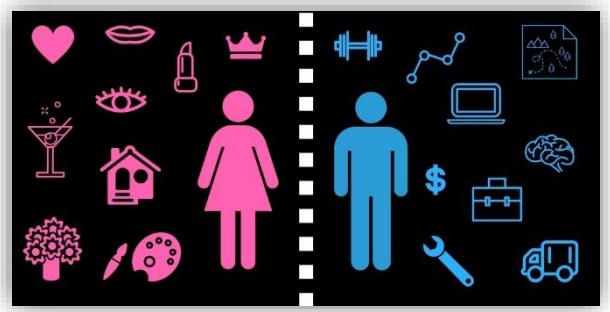
- Use meta knowledge to generate new knowledge using statistical method: learning / pattern recognition algorithms; central limit theorem; regression; (Individuals → Universal)



Common Forms of Reasoning

3. Analogical Reasoning

- Similarity based reasoning; Case based; K nearest neighbour; (including customer profiling for recommendation; even stereotyping)



Common Forms of Reasoning

4. Abductive Reasoning

- Probabilistic calculation; Prior/Conditional/Joint probability; Bayesian network; (Hypothesis ~ Evidence)

Would you prefer a **reasoning doctor** or a **learning doctor** during your medical consultation?

Common Forms of Reasoning

Other Reasoning Forms, e.g. Fuzzy Reasoning/Logic

- Lack of precise definition of vocabulary; Subjective to individuals

This is a human.

human or cat?

This is a cat.

END