# Open Marketplace and Service Orchestration for Virtual Optical Networks

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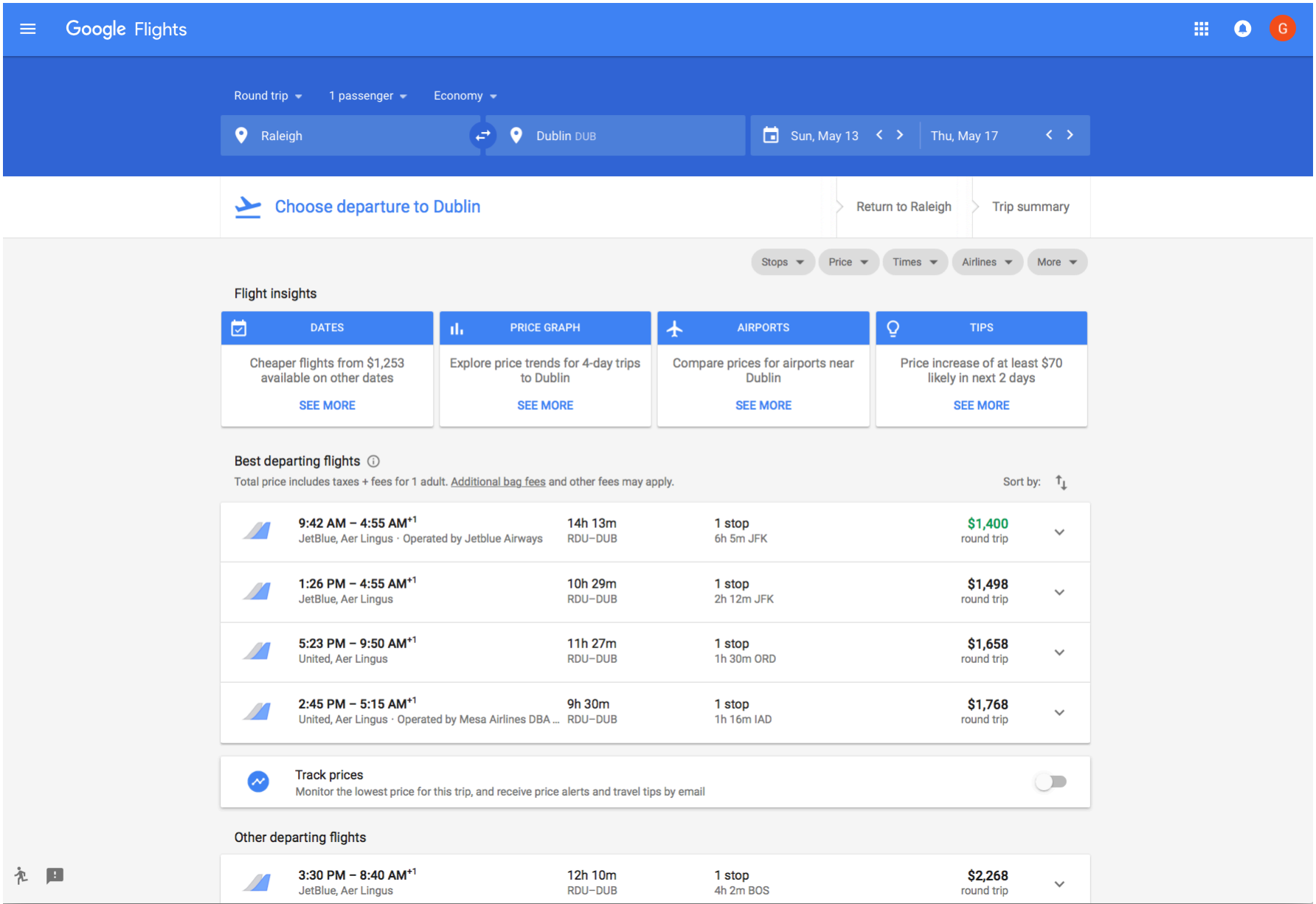
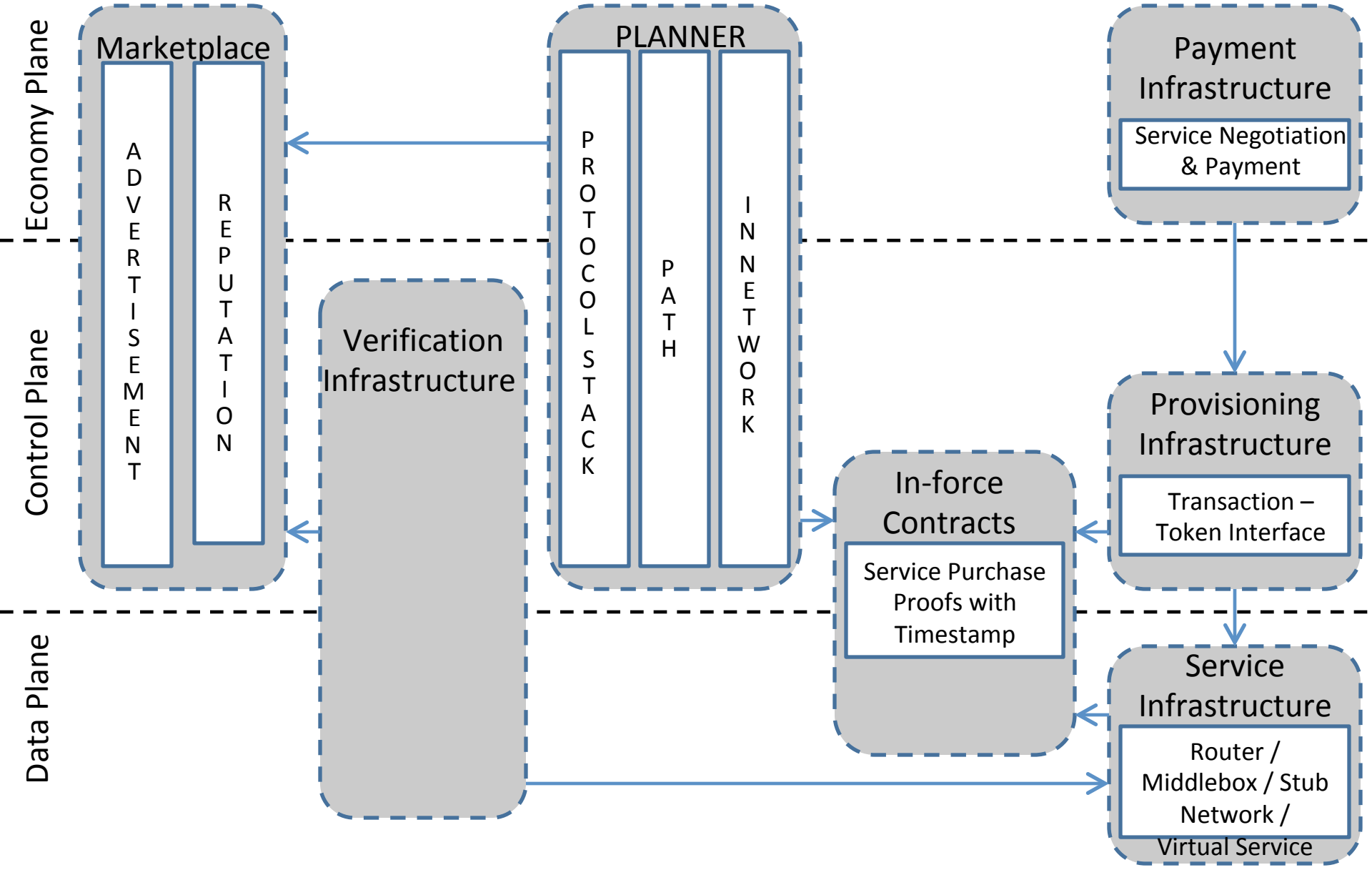
# Analogy: Google Flight Planner



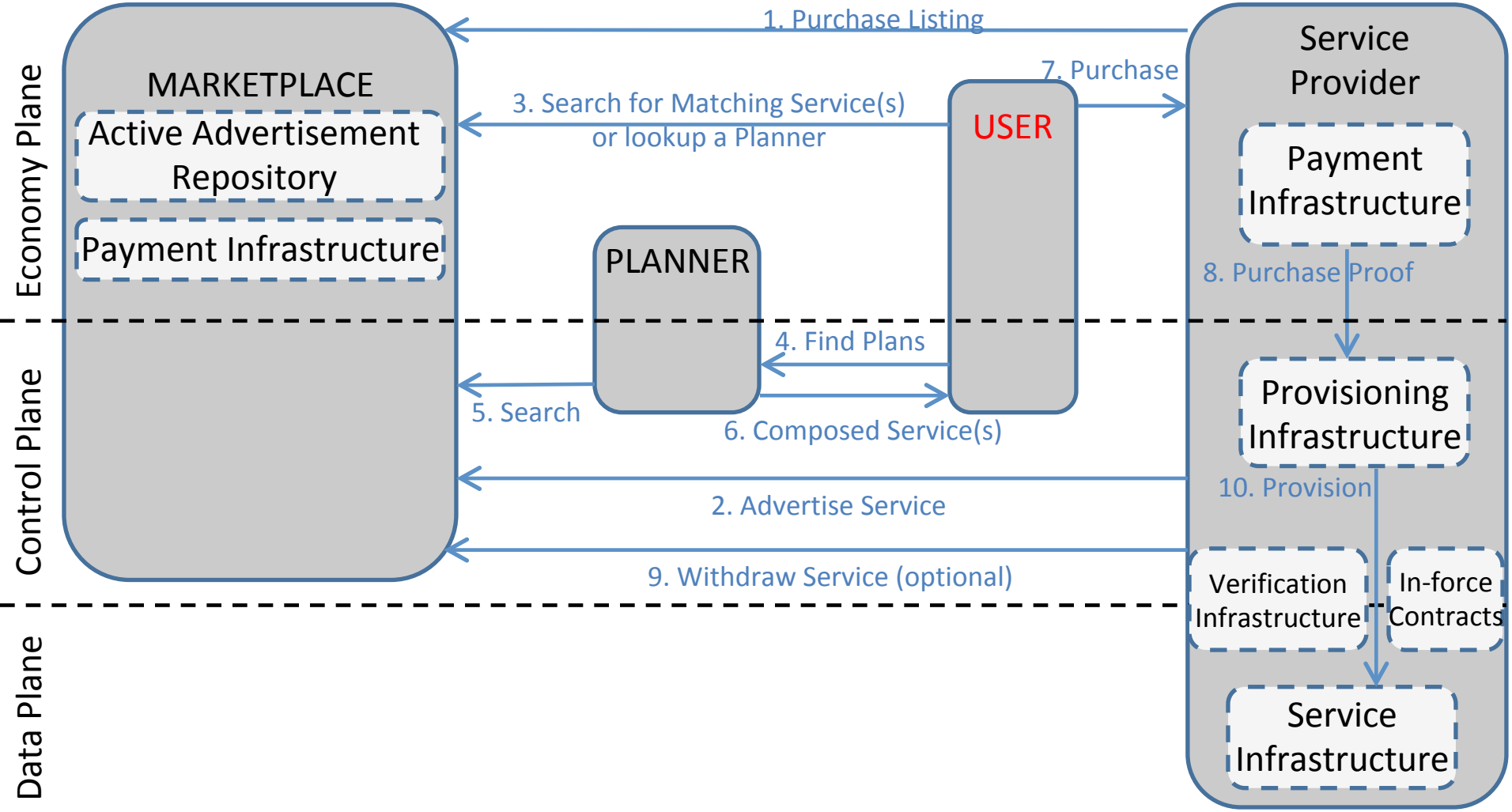
# Outline

- A Marketplace for Network Services
  - ChoiceNet Architecture
  - Marketplace and Planner
- Service Orchestration
  - NFV Model and Optical Network Context
  - P2MP Shortest Path Tour Problem

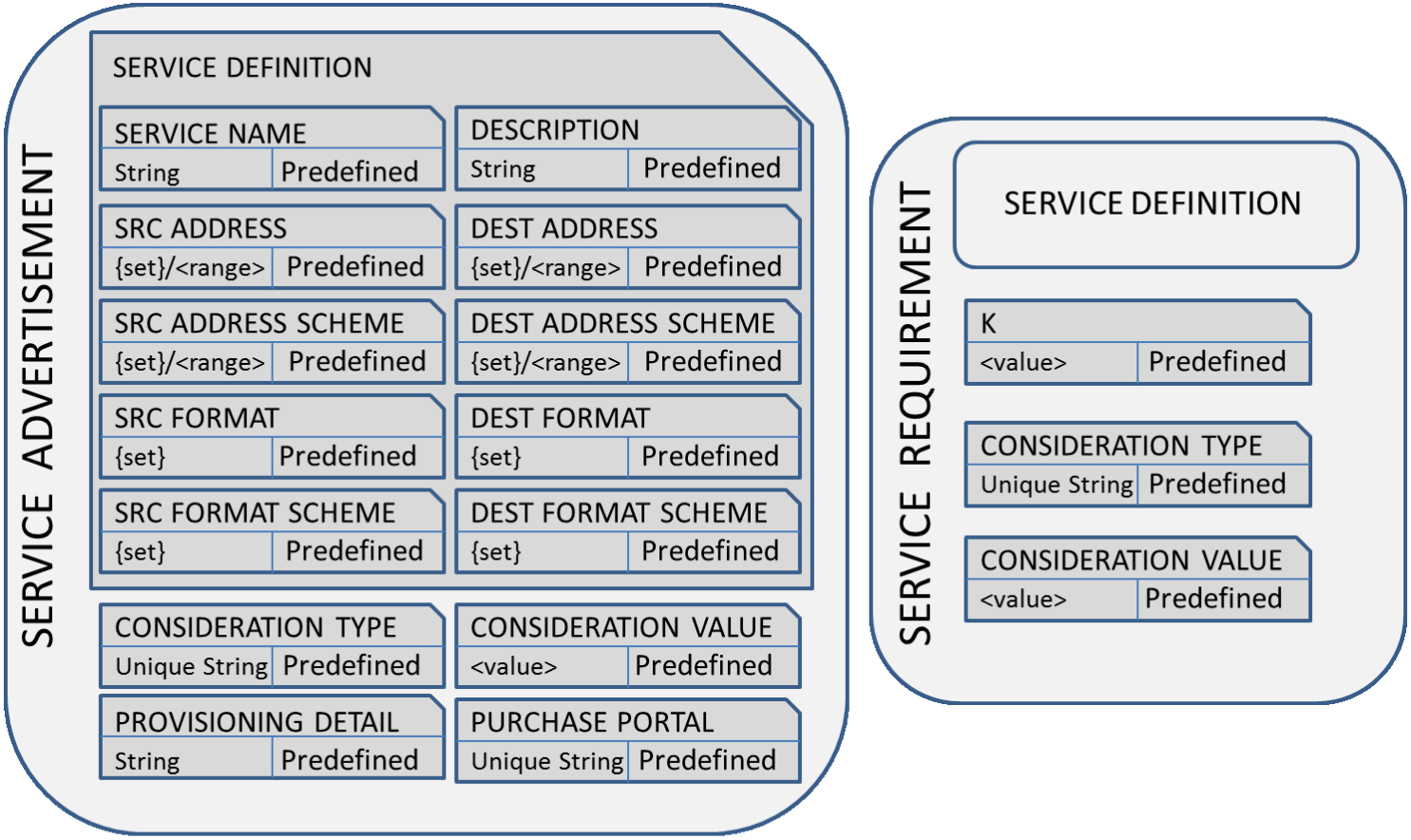
# ChoiceNet Marketplace for Network Services



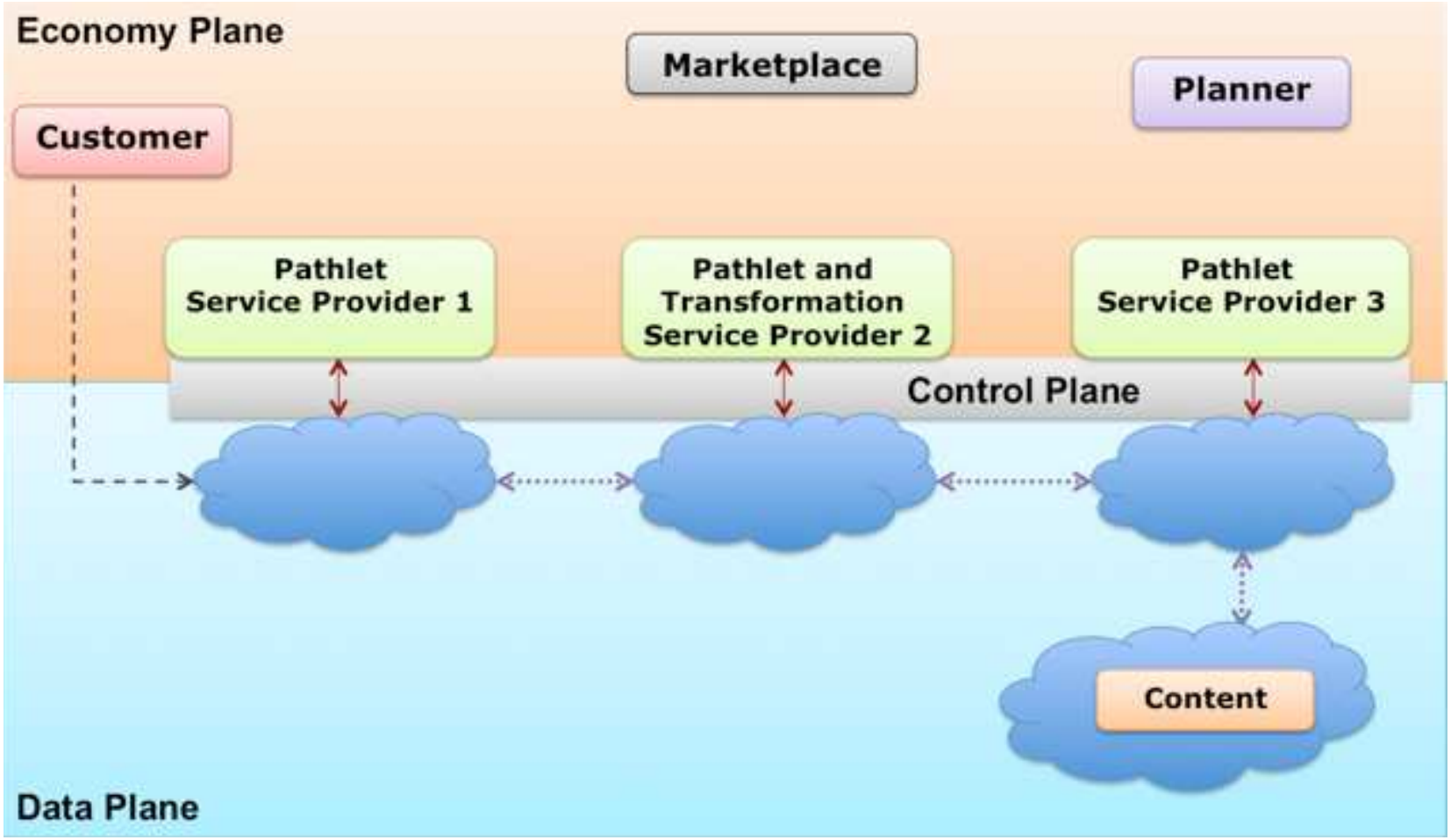
# High Level Interaction



# Semantically Enriched Service Ads



# ChoiceNet Demo Topology



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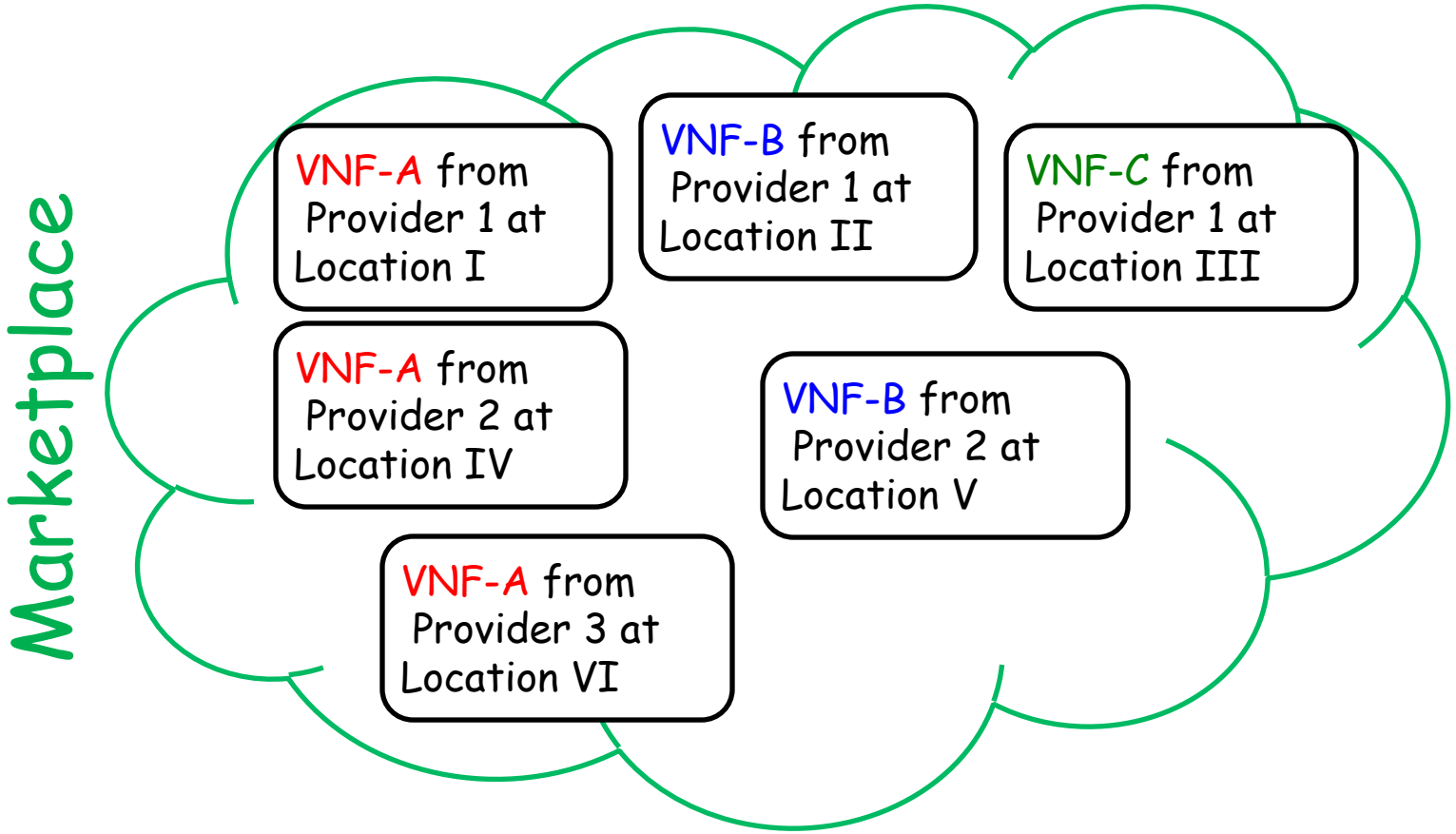
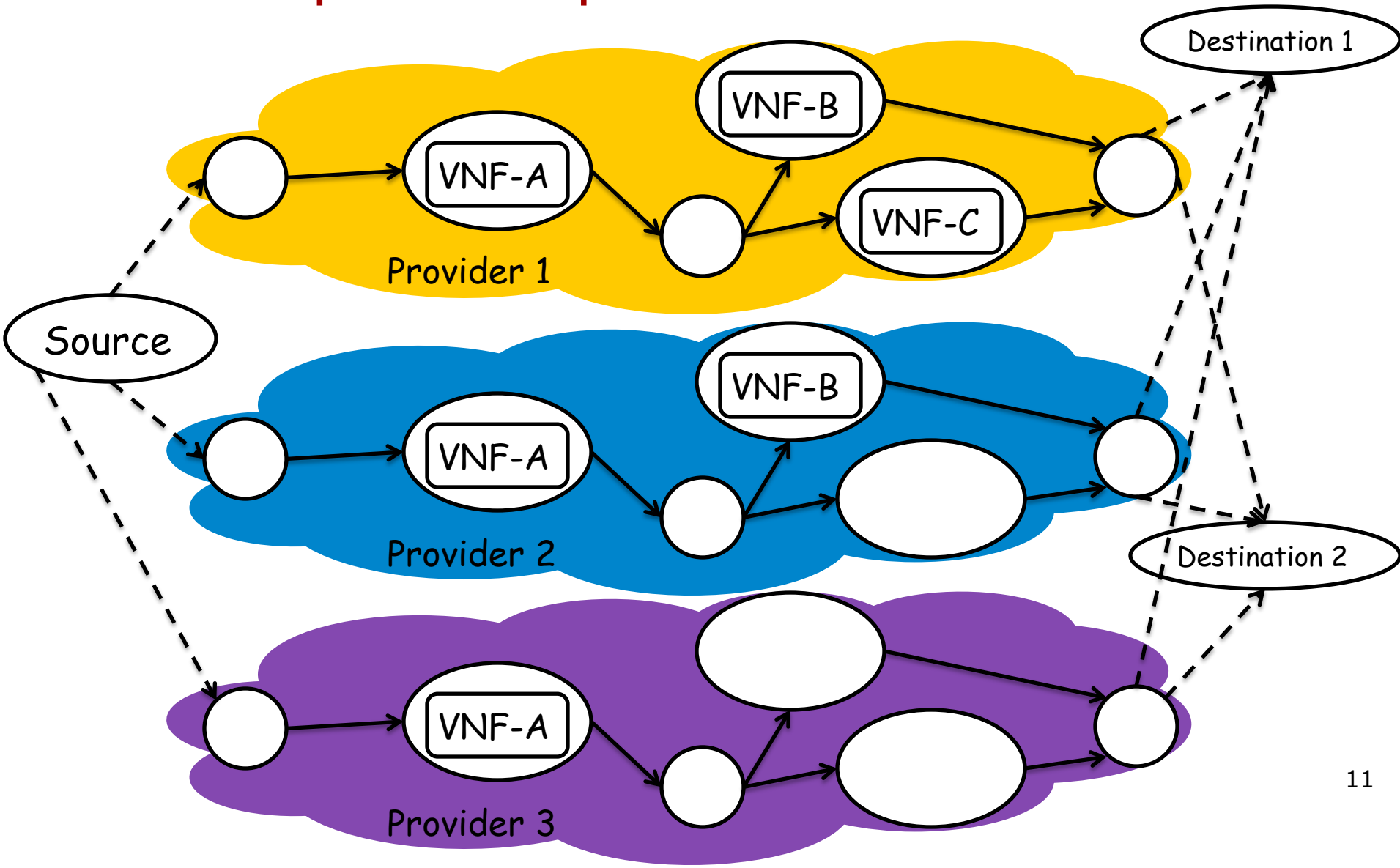
# NFV Model in the context of ChoiceNet



# Optical Network Context

- Sophisticated Programmable Devices
  - Optical monitors and sensors
  - Variable optical attenuators
  - Bandwidth-variable transponders
  - Amplifiers and impairment compensation devices
  - ROADMs
  - Flexible spectrum selective switches
  - Optical splitters
  - …

# NFV Graph: Example



# Service Orchestration on NFV Graph

- Topology is superset of VN topologies
- Nodes/Edges represent virtual entities
  - Multiple virtual nodes per physical node
  - Parallel edges

Large graphs → scalable algorithms

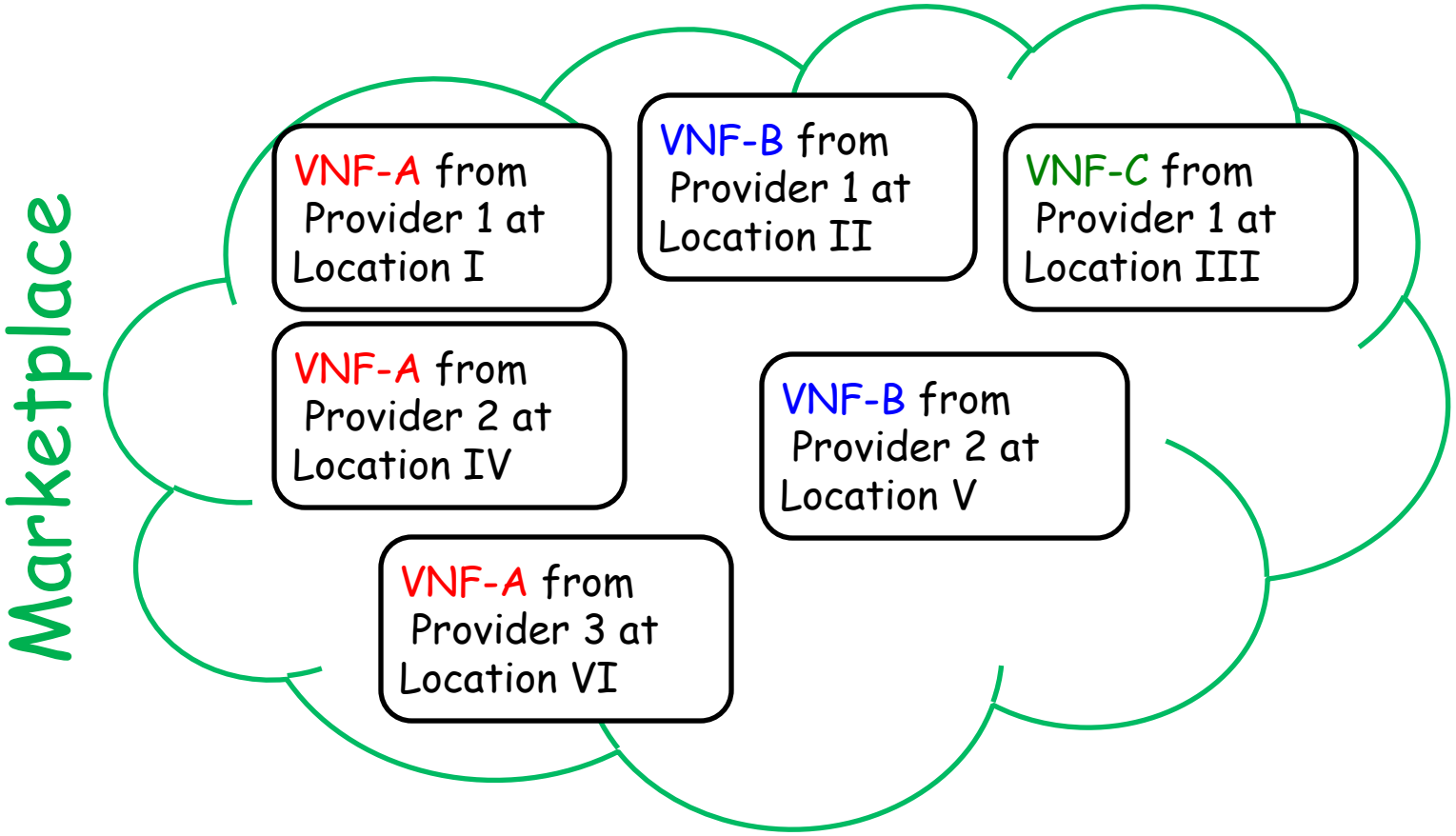
# Service Orchestration: Shortest Path Tour Problem (SPTP)

*Given*

- *a graph $G = \{N, E\}$*
- *a source $s$ and destination $d$*
- *$K$ non-empty ordered node sets $S_1, S_2, \ldots, S_K$, such that $S_i \subset N$*

*find the shortest path from $s$ to $d$ such that the path visits one node $n_i \in S_i$ of every set $S_i$, $i = 1, \ldots, K$, in the given order, i.e., $n_1, n_2, \ldots, n_K$.*

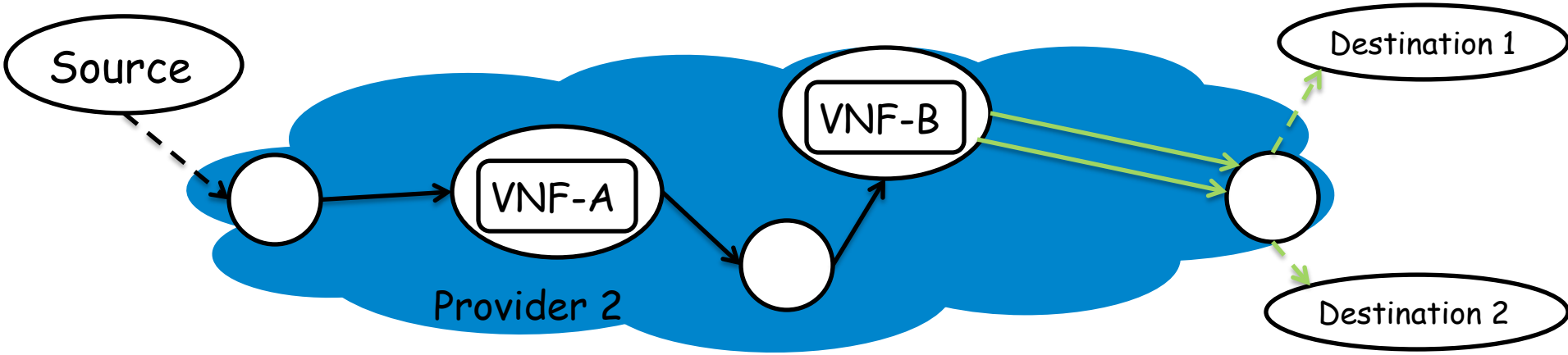
# SPTP


Marketplace
VNF-A from Provider 1 at Location I
VNF-B from Provider 1 at Location II
VNF-C from Provider 1 at Location III
VNF-A from Provider 2 at Location IV
VNF-B from Provider 2 at Location V
VNF-A from Provider 3 at Location VI

# P2MP-SPTP

Set I = {I, IV, VI}

Set II = {II, V}



AVERAGE RUNNING TIME (IN SECONDS) OF OUR ALGORITHM TO SOLVE P2MP-SPTP

| | | $k=1$ | | | $k=2$ | | | $k=3$ | | | $k=4$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $N$ | $\Delta$ | $M=2$ | $M=4$ | $M=8$ | $M=2$ | $M=4$ | $M=8$ | $M=2$ | $M=4$ | $M=8$ | $M=2$ | $M=4$ | $M=8$ |
| 1000 | 2 | 0.04324 | 0.08458 | 0.17306 | 0.0414 | 0.08166 | 0.16584 | 0.04056 | 0.08141 | 0.16102 | 0.0405 | 0.0797 | 0.16128 |
| | 3 | 0.0501 | 0.09792 | 0.19795 | 0.04751 | 0.09394 | 0.18942 | 0.04681 | 0.09387 | 0.18535 | 0.04676 | 0.09287 | 0.18596 |
| | 4 | 0.06994 | 0.13483 | 0.27256 | 0.06641 | 0.13228 | 0.26554 | 0.06552 | 0.13167 | 0.26078 | 0.06573 | 0.1303 | 0.26213 |
| | 5 | 0.07725 | 0.1528 | 0.30158 | 0.07404 | 0.147 | 0.29484 | 0.07389 | 0.14825 | 0.29393 | 0.07408 | 0.14719 | 0.29487 |
| 2000 | 2 | 0.17413 | 0.34667 | 0.68324 | 0.17126 | 0.33195 | 0.65452 | 0.16322 | 0.3212 | 0.64251 | 0.16298 | 0.32105 | 0.63134 |
| | 3 | 0.21837 | 0.43511 | 0.86546 | 0.21683 | 0.42536 | 0.84286 | 0.21247 | 0.4254 | 0.85354 | 0.21541 | 0.4222 | 0.83347 |
| | 4 | 0.26384 | 0.52766 | 1.04008 | 0.26234 | 0.51041 | 1.01864 | 0.25425 | 0.51412 | 1.01286 | 0.25942 | 0.50435 | 1.01448 |
| | 5 | 0.3053 | 0.60819 | 1.20743 | 0.30137 | 0.5911 | 1.17768 | 0.29254 | 0.5898 | 1.15671 | 0.29487 | 0.57646 | 1.16156 |
| 3000 | 2 | 0.4034 | 0.80138 | 1.58029 | 0.39145 | 0.77083 | 1.57162 | 0.39127 | 0.78169 | 1.55459 | 0.39346 | 0.76178 | 1.53388 |
| | 3 | 0.50435 | 0.98411 | 1.95159 | 0.48306 | 0.98064 | 1.94662 | 0.48391 | 0.96243 | 1.92723 | 0.488 | 0.9444 | 1.90324 |
| | 4 | 0.54207 | 1.11959 | 2.22108 | 0.55442 | 1.09921 | 2.21439 | 0.55444 | 1.12262 | 2.22104 | 0.56459 | 1.09202 | 2.19943 |
| | 5 | 0.61366 | 1.2748 | 2.5501 | 0.62496 | 1.2509 | 2.49379 | 0.63225 | 1.26157 | 2.50682 | 0.63836 | 1.25774 | 2.47685 |
| 4000 | 2 | 0.72241 | 1.39973 | 2.83001 | 0.69922 | 1.36145 | 2.66832 | 0.67913 | 1.32105 | 2.53718 | 0.67751 | 1.30977 | 2.62299 |
| | 3 | 0.89938 | 1.76487 | 3.58951 | 0.85358 | 1.73223 | 3.37386 | 0.89709 | 1.67892 | 3.24119 | 0.85957 | 1.68032 | 3.22716 |
| | 4 | 1.03653 | 2.10116 | 3.98855 | 0.9715 | 1.98775 | 3.83469 | 0.96385 | 1.87807 | 3.62008 | 0.95753 | 1.8564 | 3.68269 |
| | 5 | 1.25635 | 2.5306 | 4.80257 | 1.19211 | 2.54138 | 4.7413 | 1.19453 | 2.33547 | 4.48676 | 1.24731 | 2.32187 | 4.54973 |
| 5000 | 2 | 1.09231 | 2.15912 | 4.19843 | 1.07995 | 2.044 | 3.99808 | 1.06102 | 1.99967 | 4.05524 | 1.05971 | 2.02657 | 3.9953 |
| | 3 | 1.39378 | 2.70822 | 5.29489 | 1.37967 | 2.67659 | 5.11438 | 1.36784 | 2.66511 | 5.28403 | 1.35193 | 2.64737 | 5.23518 |
| | 4 | 1.41373 | 2.6871 | 5.32409 | 1.30994 | 2.65433 | 5.15203 | 1.33458 | 2.58562 | 5.16531 | 1.31004 | 2.57086 | 5.17844 |
| | 5 | 1.77974 | 3.53069 | 6.93992 | 1.72774 | 3.38791 | 6.72808 | 1.63398 | 3.32734 | 6.50819 | 1.61203 | 3.24615 | 6.37525 |

# Thank You!