

Open Marketplace and Service Orchestration for Virtual Optical Networks

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Analogy: Google Flight Planner

☰ Google Flights
☰ 🔔 G

Round trip ▾ 1 passenger ▾ Economy ▾

📍 Raleigh
↔️
📍 Dublin DUB
📅 Sun, May 13 < >
📅 Thu, May 17 < >

✈️ Choose departure to Dublin
Return to Raleigh
Trip summary

Stops ▾
Price ▾
Times ▾
Airlines ▾
More ▾

Flight insights

📅 DATES	📊 PRICE GRAPH	✈️ AIRPORTS	💡 TIPS
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Best departing flights ⓘ

Total price includes taxes + fees for 1 adult. [Additional bag fees](#) and other fees may apply. Sort by: ↑↓

	9:42 AM – 4:55 AM⁺¹ JetBlue, Aer Lingus · Operated by Jetblue Airways	14h 13m RDU–DUB	1 stop 6h 5m JFK	\$1,400 round trip ▾
	1:26 PM – 4:55 AM⁺¹ JetBlue, Aer Lingus	10h 29m RDU–DUB	1 stop 2h 12m JFK	\$1,498 round trip ▾
	5:23 PM – 9:50 AM⁺¹ United, Aer Lingus	11h 27m RDU–DUB	1 stop 1h 30m ORD	\$1,658 round trip ▾
	2:45 PM – 5:15 AM⁺¹ United, Aer Lingus · Operated by Mesa Airlines DBA ...	9h 30m RDU–DUB	1 stop 1h 16m IAD	\$1,768 round trip ▾

Track prices
 Monitor the lowest price for this trip, and receive price alerts and travel tips by email

Other departing flights

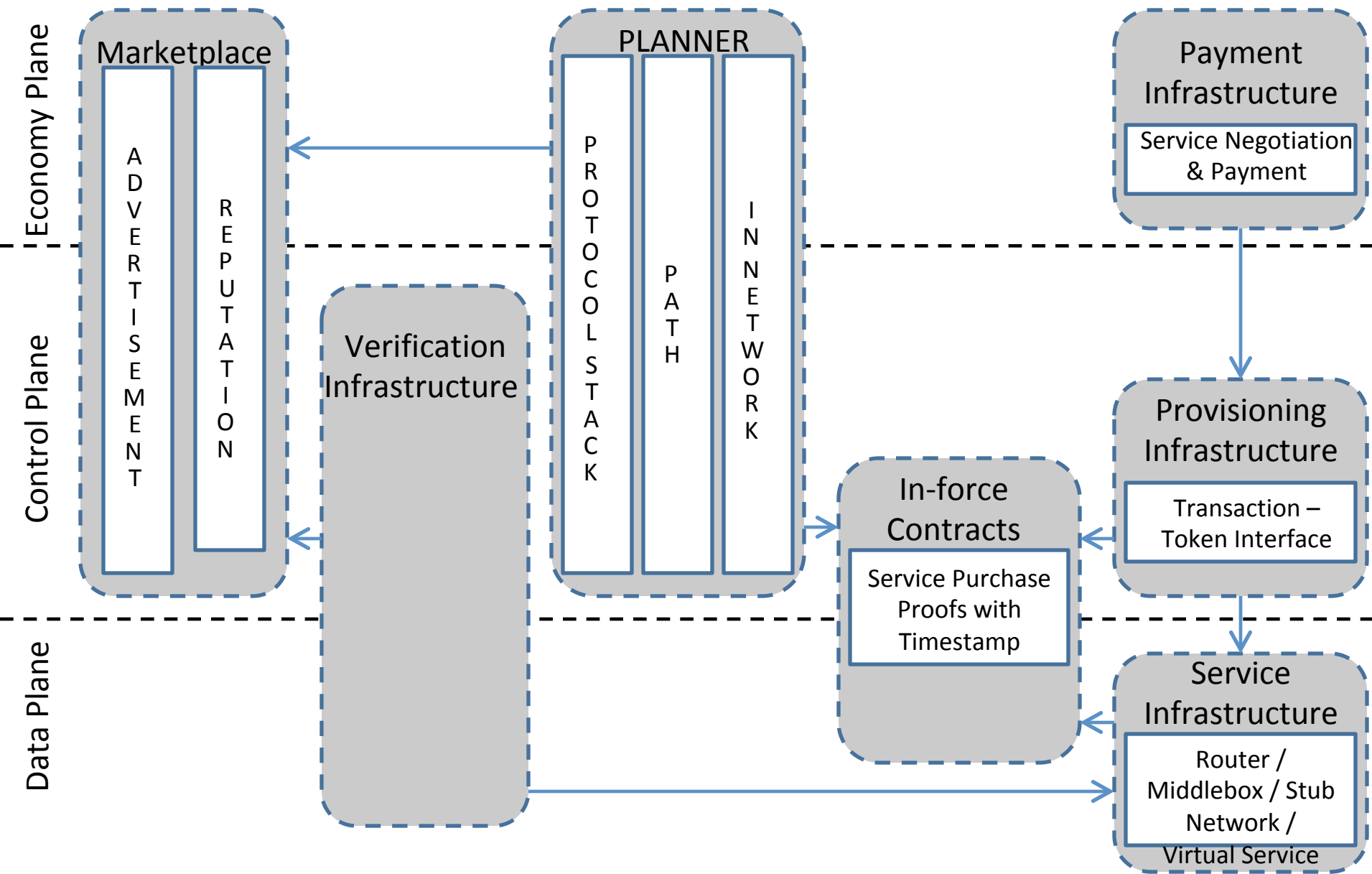
	3:30 PM – 8:40 AM⁺¹ JetBlue, Aer Lingus	12h 10m RDU–DUB	1 stop 4h 2m BOS	\$2,268 round trip ▾
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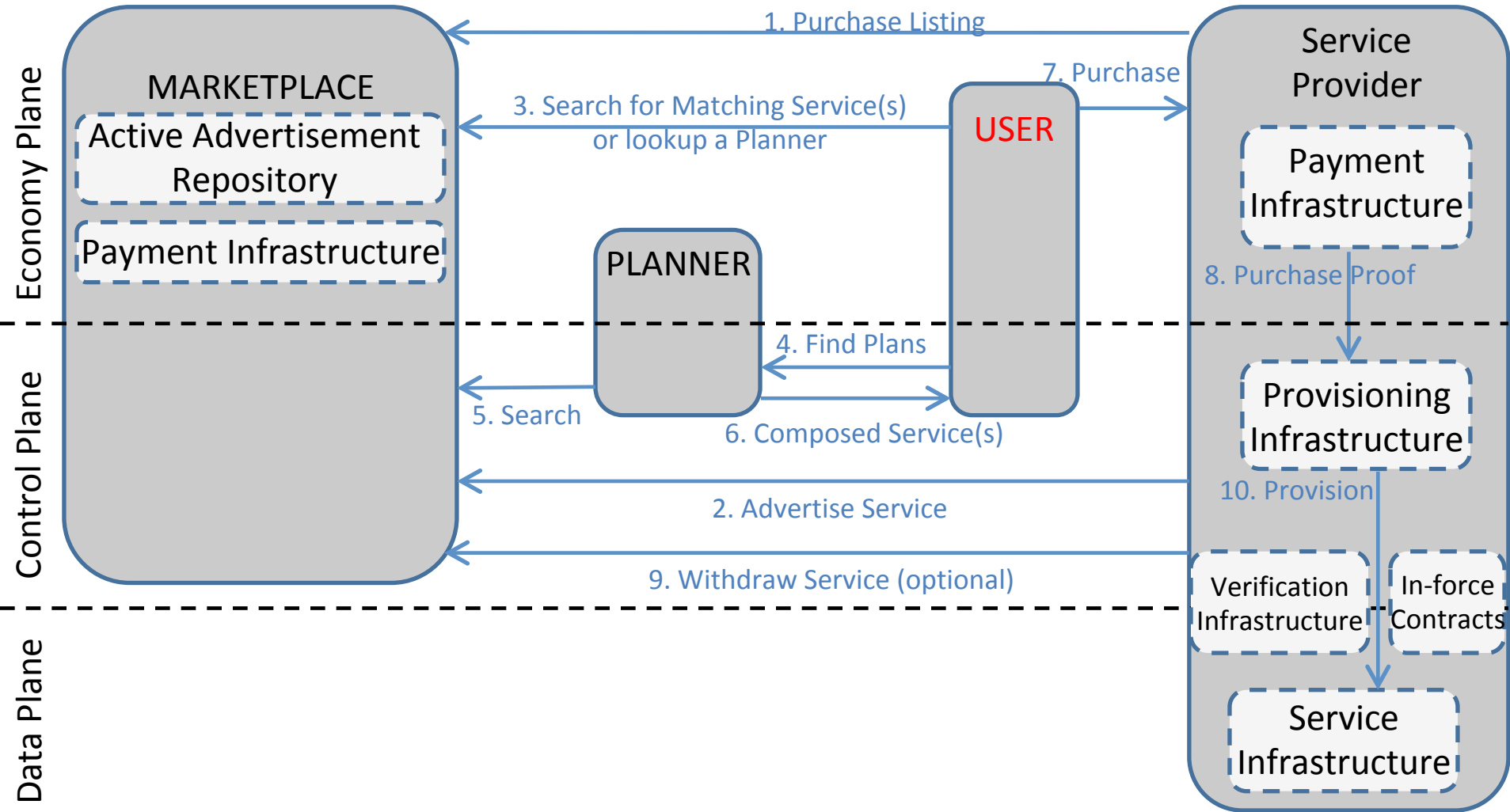
Outline

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

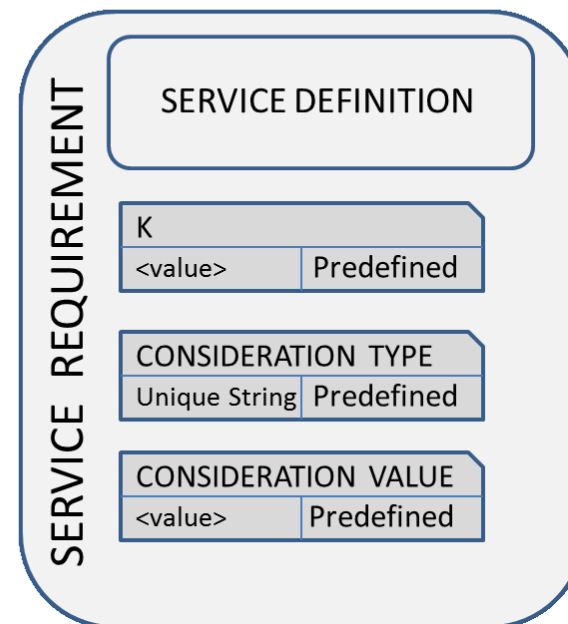
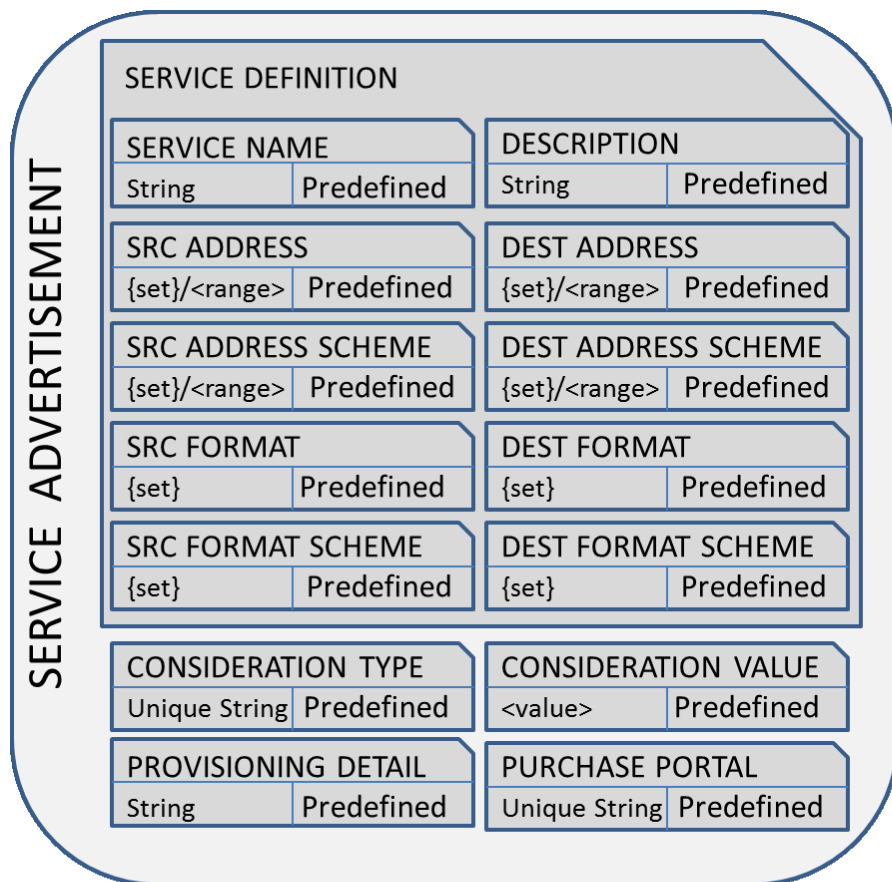
ChoiceNet Marketplace for Network Services



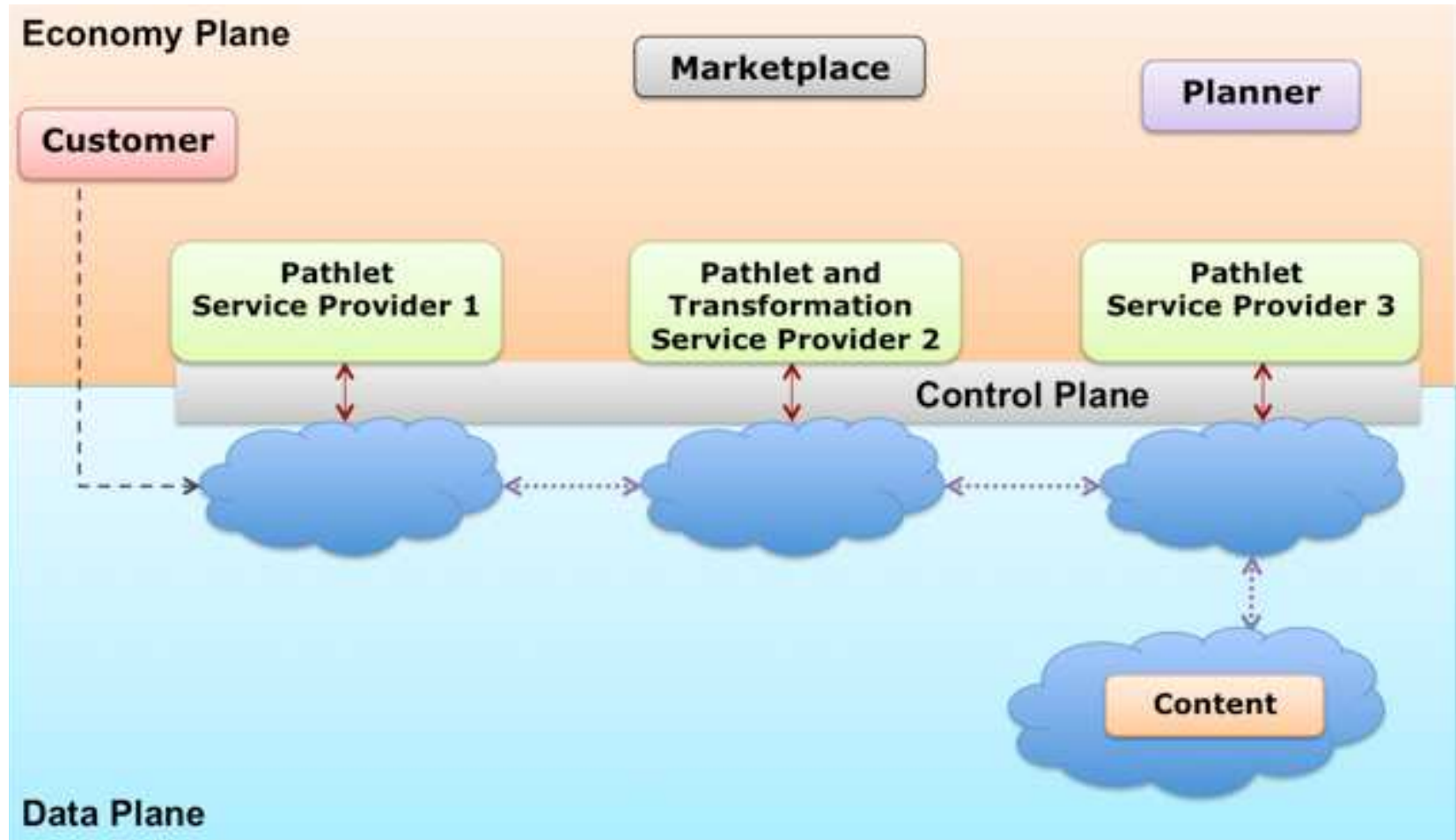
High Level Interaction



Semantically Enriched Service Ads



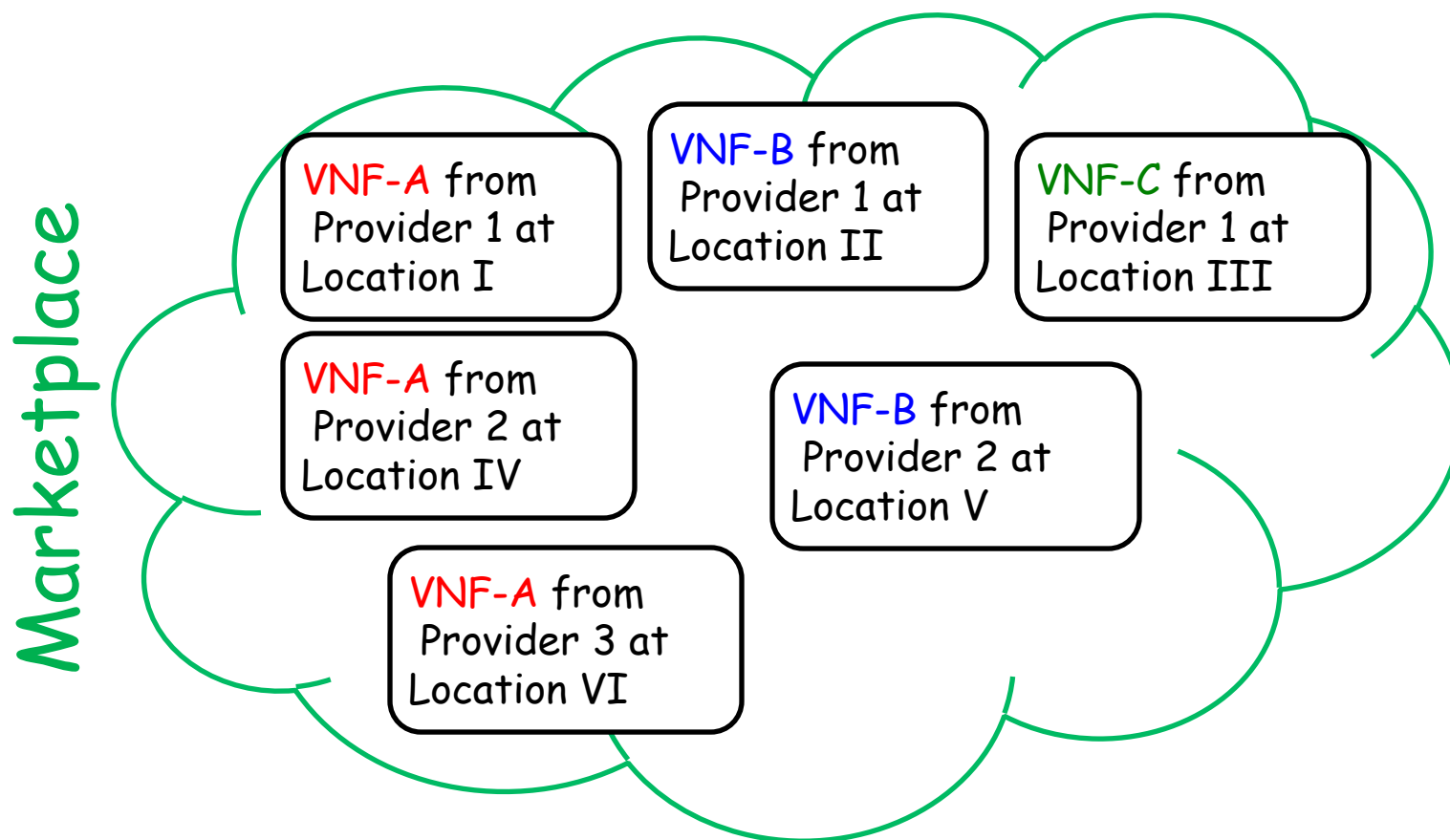
ChoiceNet Demo Topology



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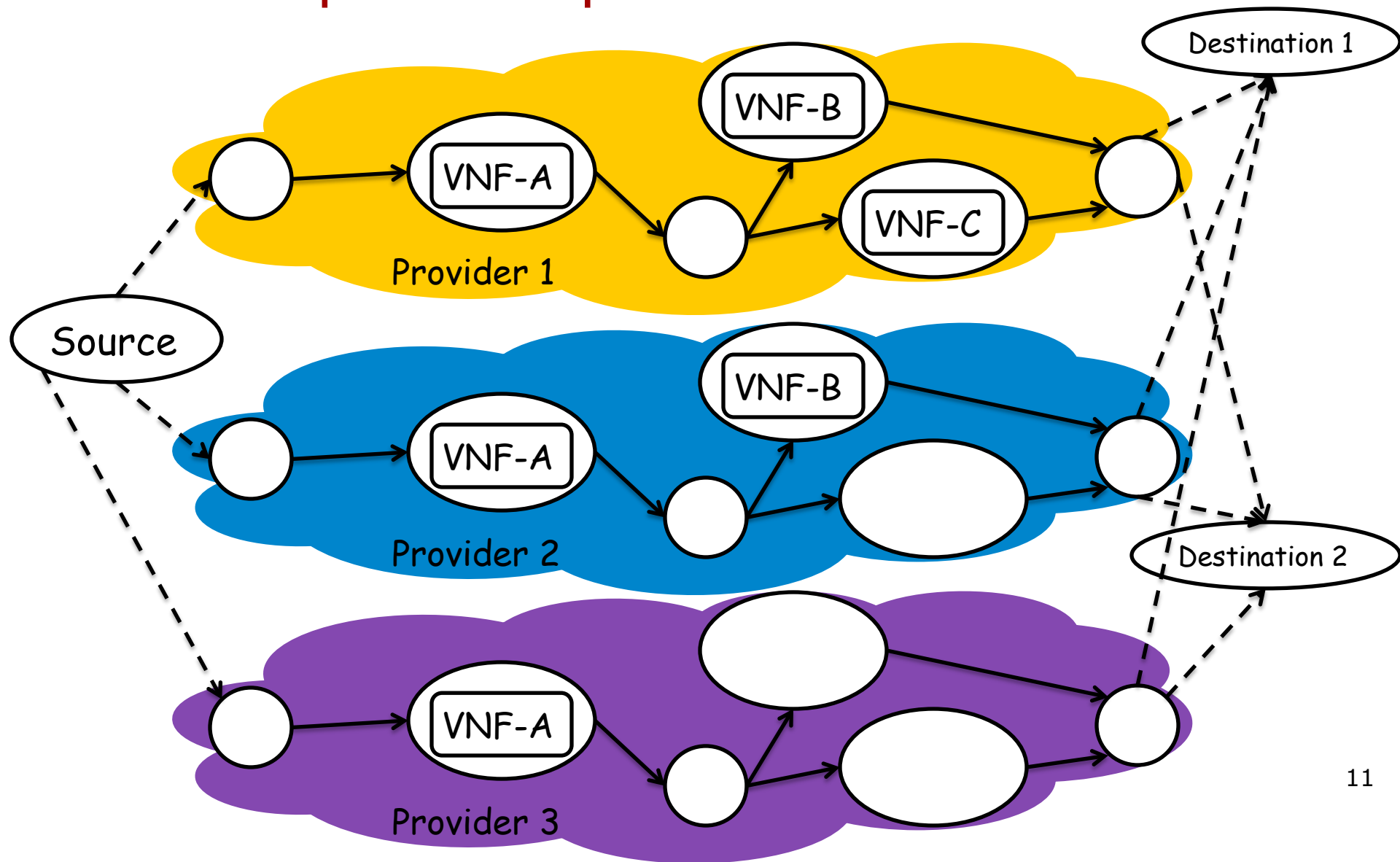
NFV Model in the context of ChoiceNet



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)

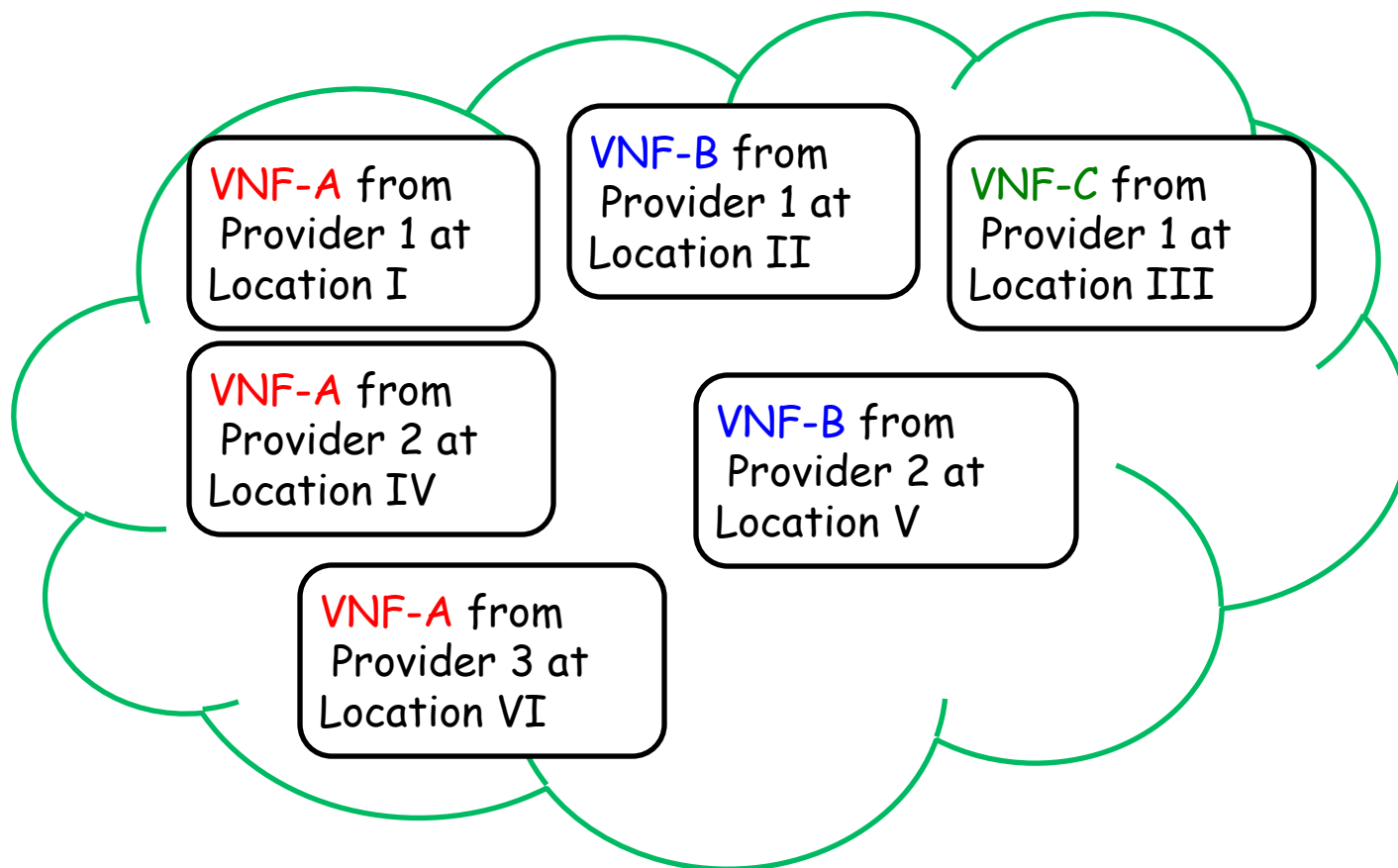
Given

- *a graph $G = \{N, E\}$*
- *a source s and destination d*
- *K non-empty ordered node sets S_1, S_2, \dots, 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 , $i = 1, \dots, K$, in the given order, i.e., n_1, n_2, \dots, n_K .

SPTP

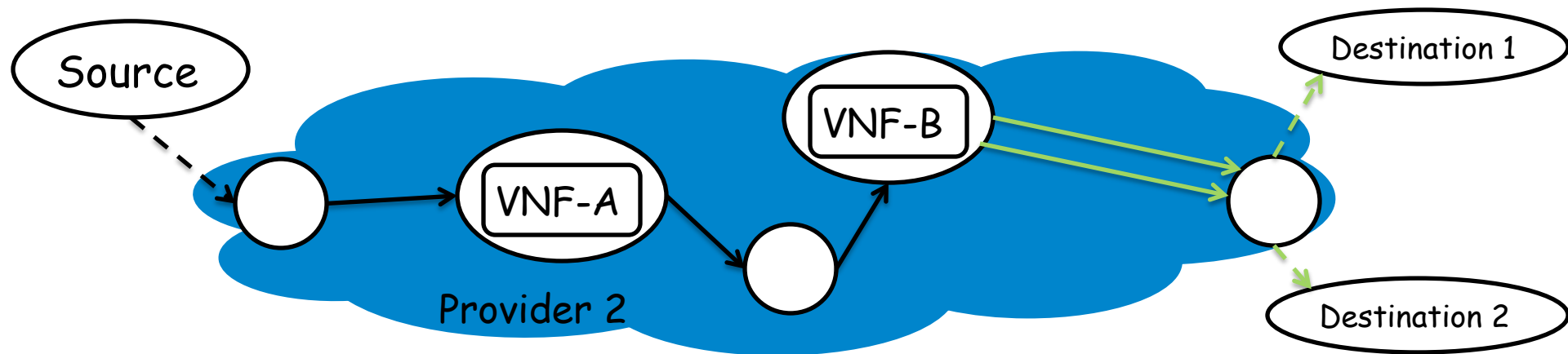
Marketplace



P2MP-SPTP

Set I = {I, IV, VI}

Set II = {II, V}



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

N	Δ	$k = 1$			$k = 2$			$k = 3$			$k = 4$		
		$M = 2$	$M = 4$	$M = 8$	$M = 2$	$M = 4$	$M = 8$	$M = 2$	$M = 4$	$M = 8$	$M = 2$	$M = 4$	$M = 8$
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!