Inferring a Nation's Inbound Route Diversity Using Country-Level Transit Influence of Autonomous Systems

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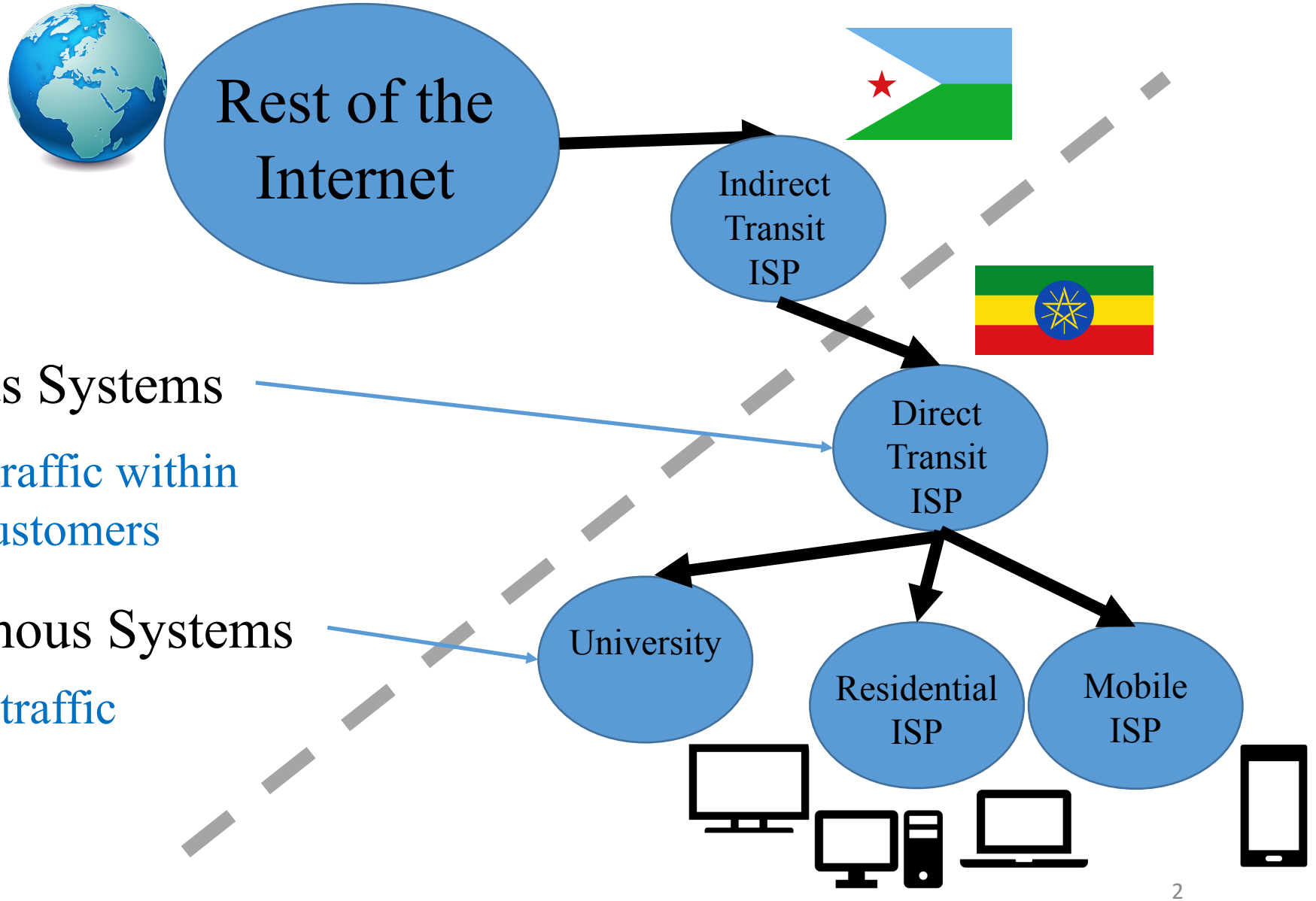
Center for Applied Internet Data Analysis

Why Study a Nation's Inbound Route Diversity?



Transit Autonomous Systems

Responsible for delivering traffic within their network and to their customers

Origin (access) Autonomous Systems

Responsible for delivering traffic within their network

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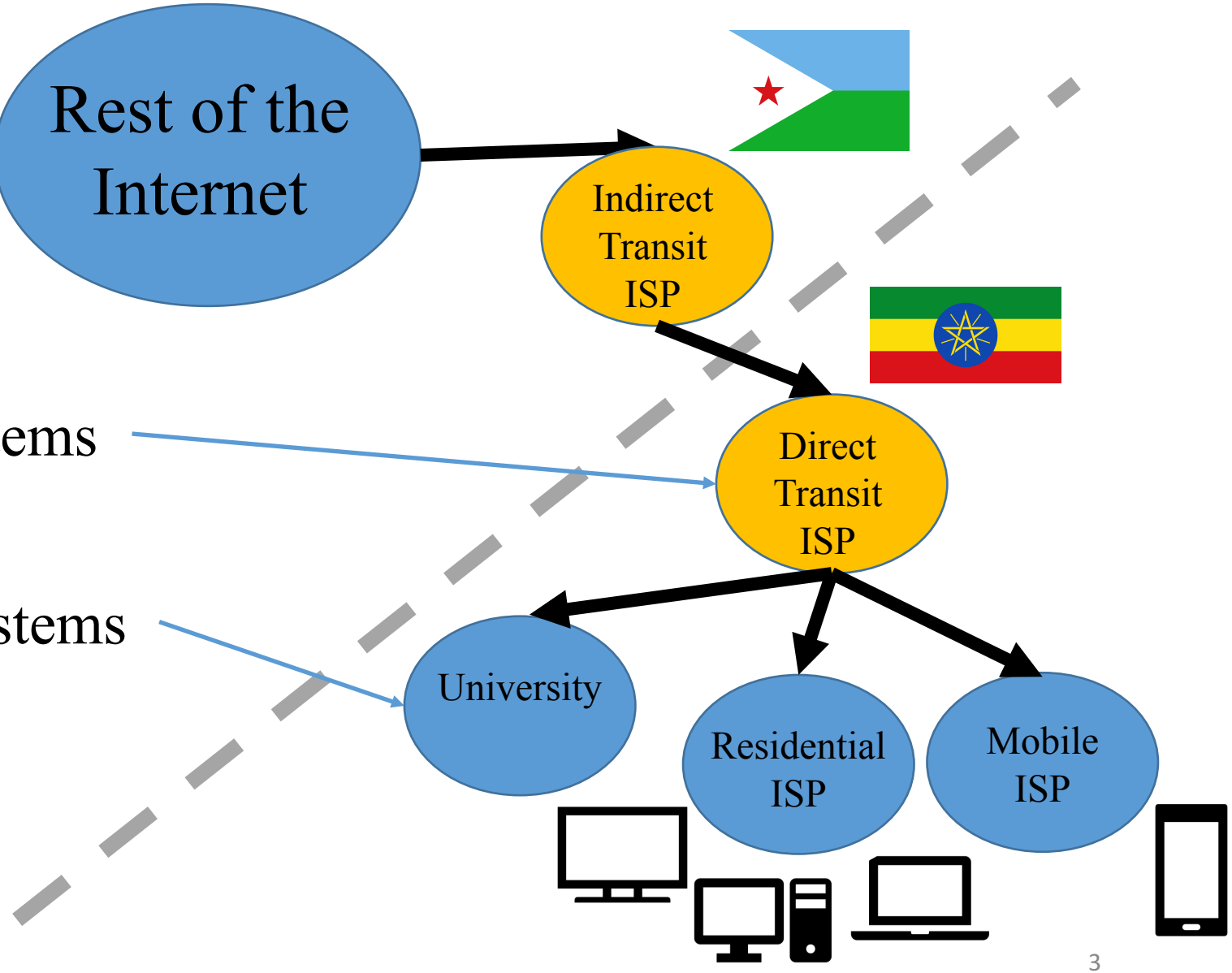

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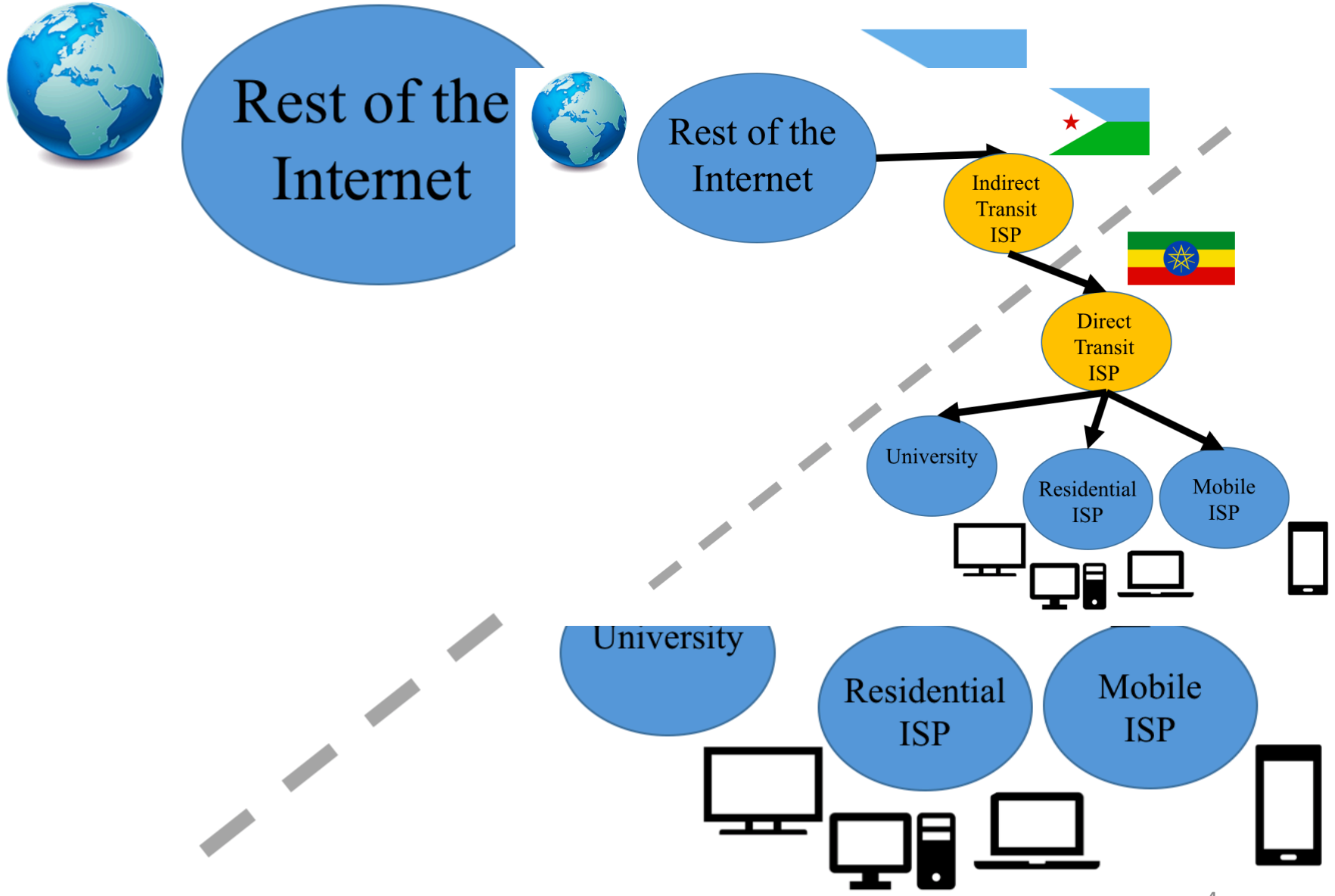
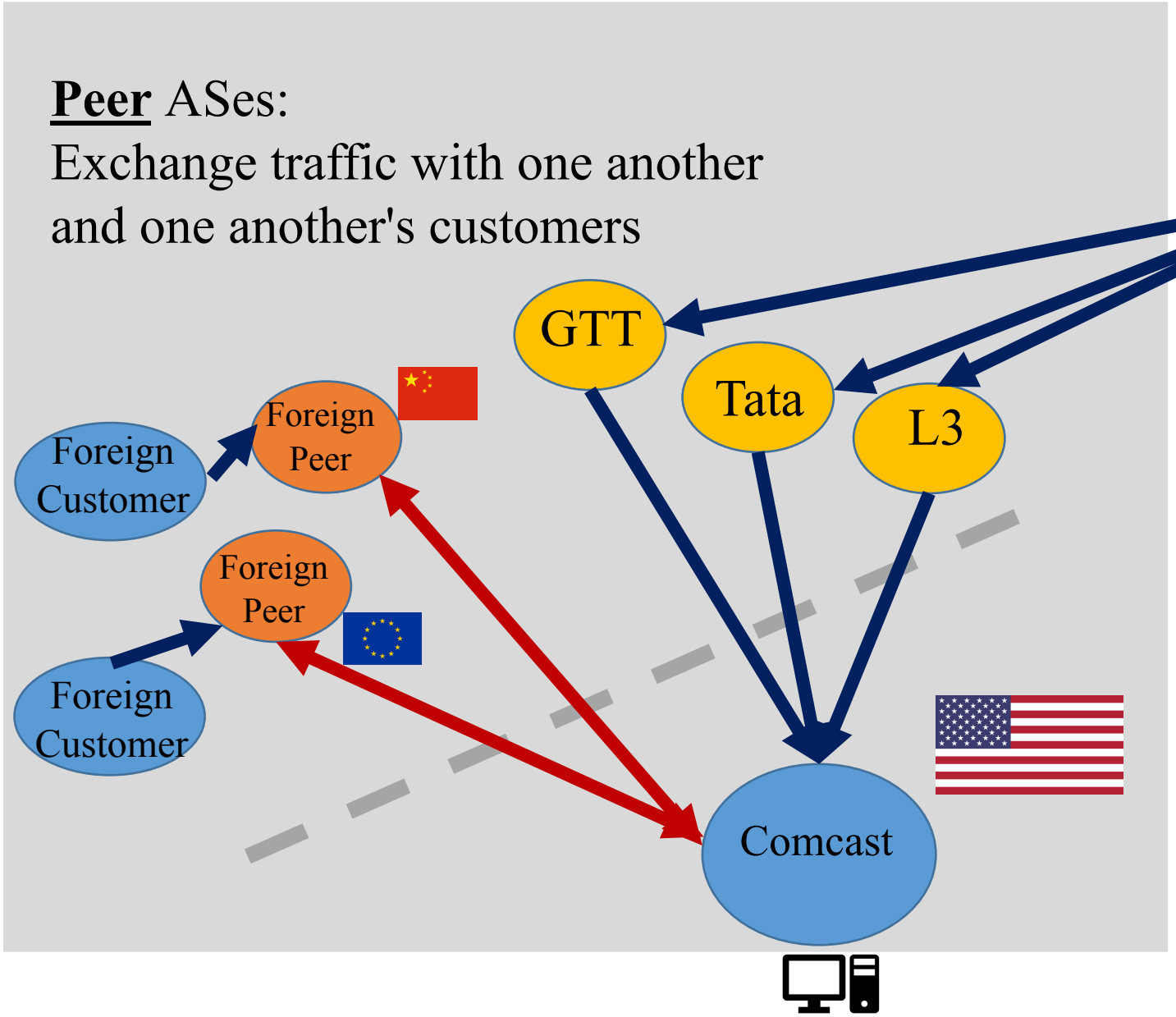
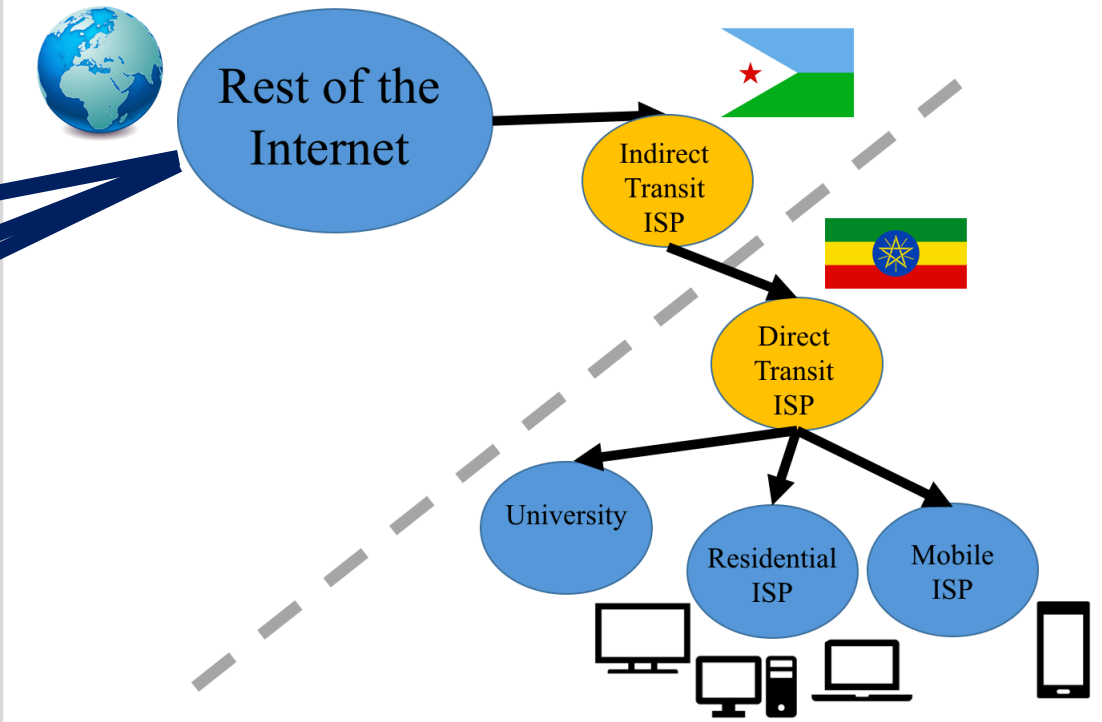


Why Study a Nation's Inbound Route Diversity?

Peer ASes:
Exchange traffic with one another and one another's customers





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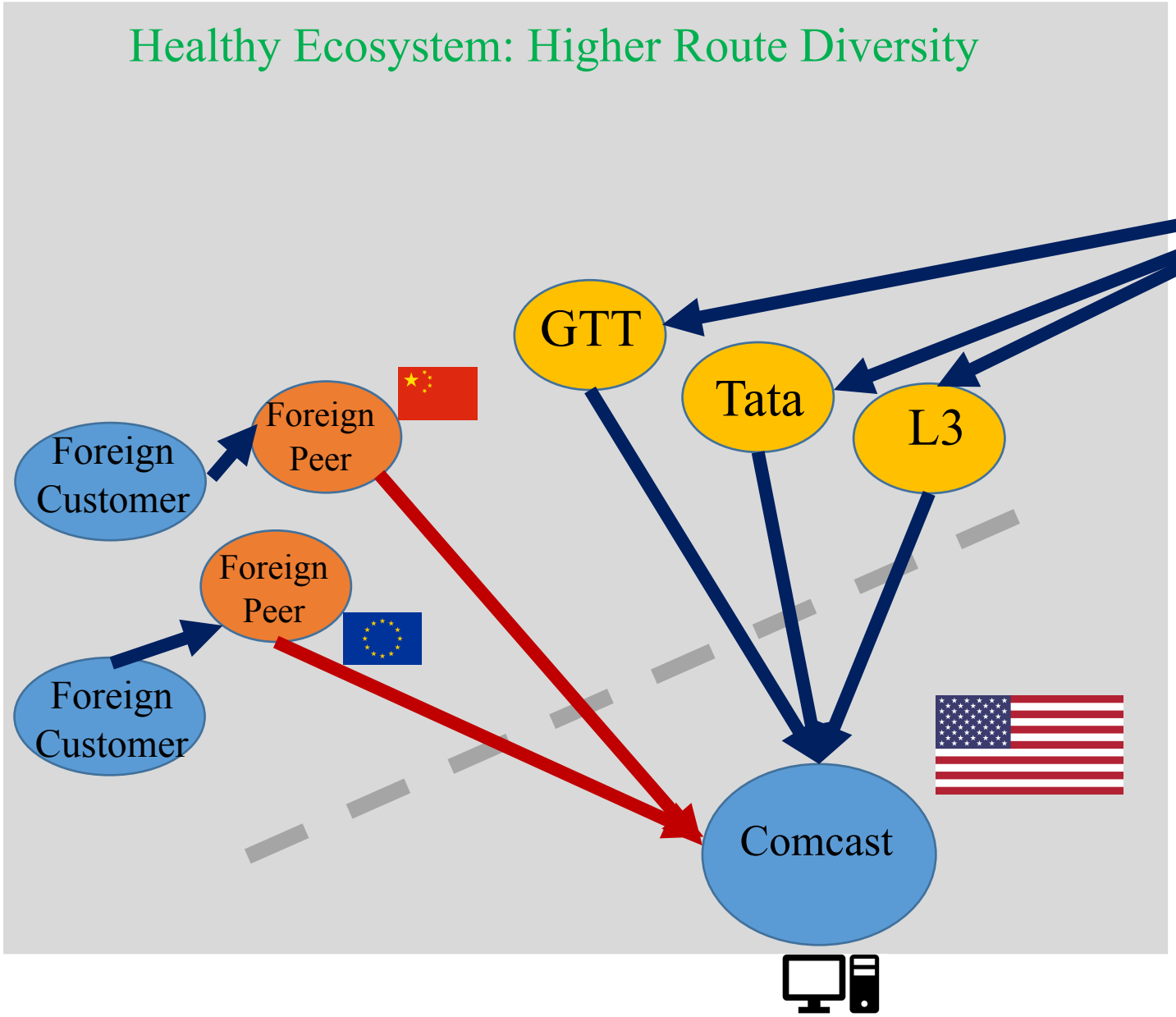
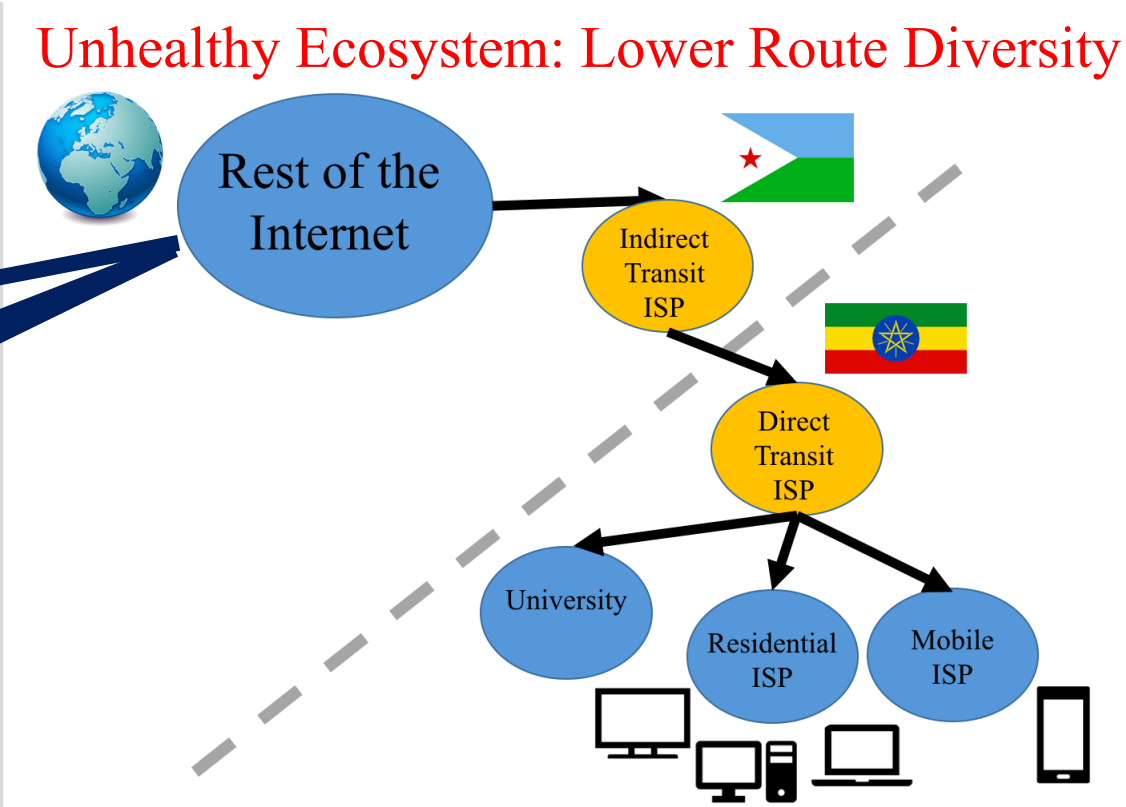
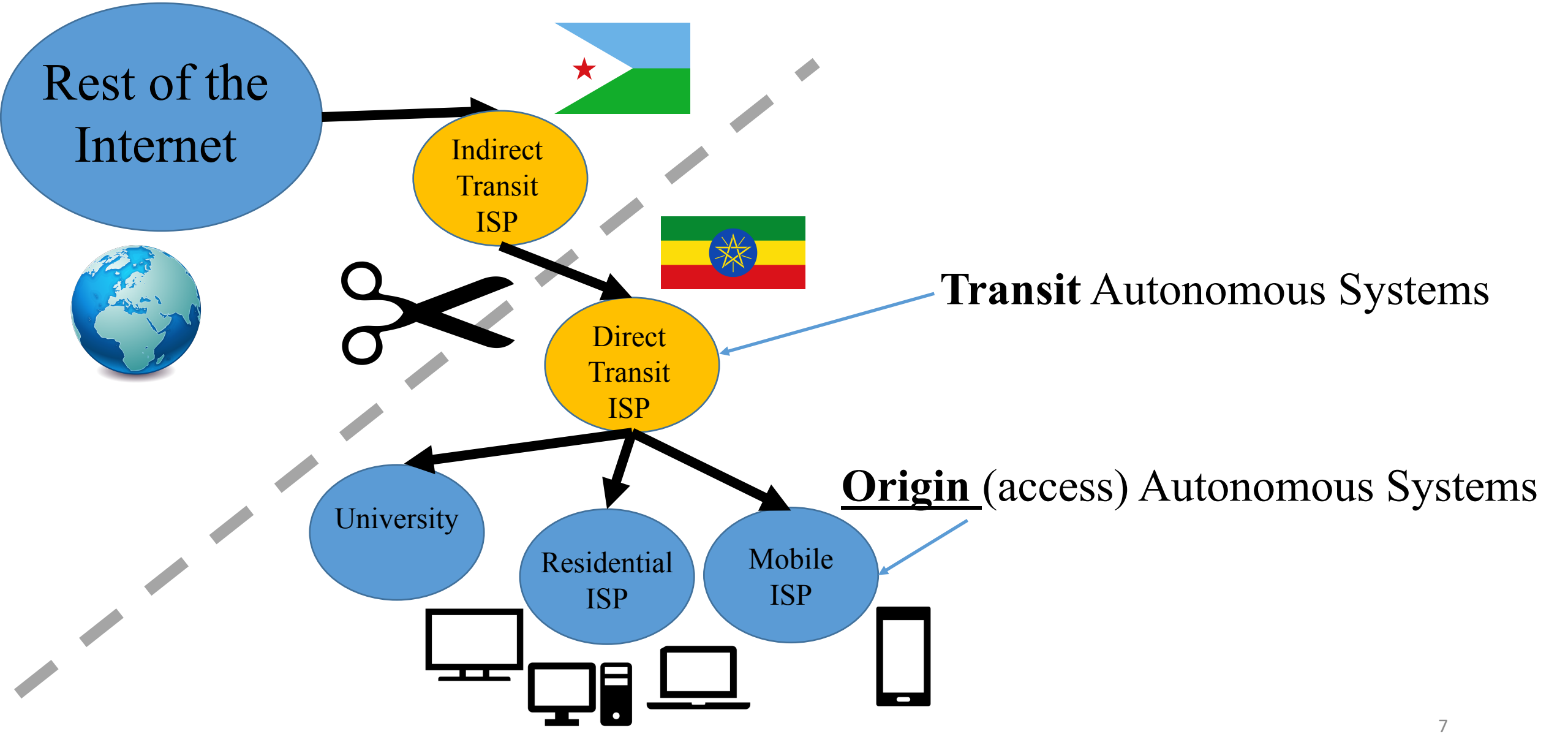


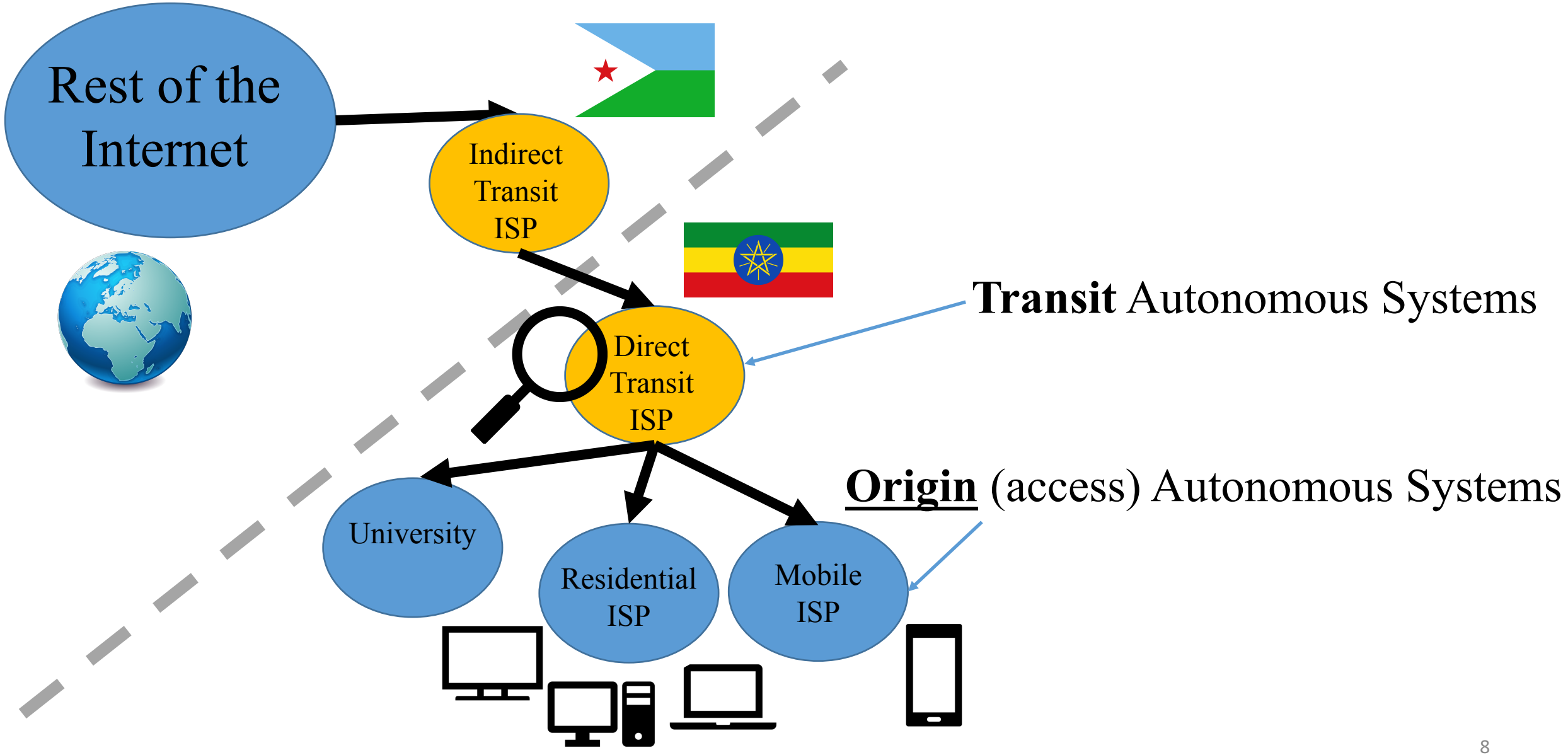


- Identify countries with lower diversity
- Quantify route concentration

Transit Concentration Exposes Country to Disconnections



Transit Concentration Exposes Country to Observation



In countries with concentrated routes, some networks have the potential capability to ***observe, manipulate and disrupt*** Internet traffic flowing towards a country.

Most vulnerable countries from anecdotal evidence are least represented in networking literature (e.g., Africa and Central Asia)

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Security

DDoS attack boots Kyrgyzstan from net

Russian bears blamed

By Dan Goodin 28 Jan 2009 at 19:57 6 SHARE ▼

The two primary Kyrgyzstan ISPs (www.domain.kg, www.ns.kg) have been under a massive, sustained DDoS attack . . . Few alternatives for Internet access exist in Kyrgyzstan. . . . [the attacks] essentially knocked most of the small, Central Asian republic offline.

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Pensioner in Georgia cuts Armenia off from internet

6 April 2011 Share

An elderly woman in Georgia is facing a prison sentence after reportedly causing internet services in neighbouring Armenia to crash.

CNN World LIVE TV

Ethiopia has been offline, and nobody really knows why

By Samuel Getachew, CNN

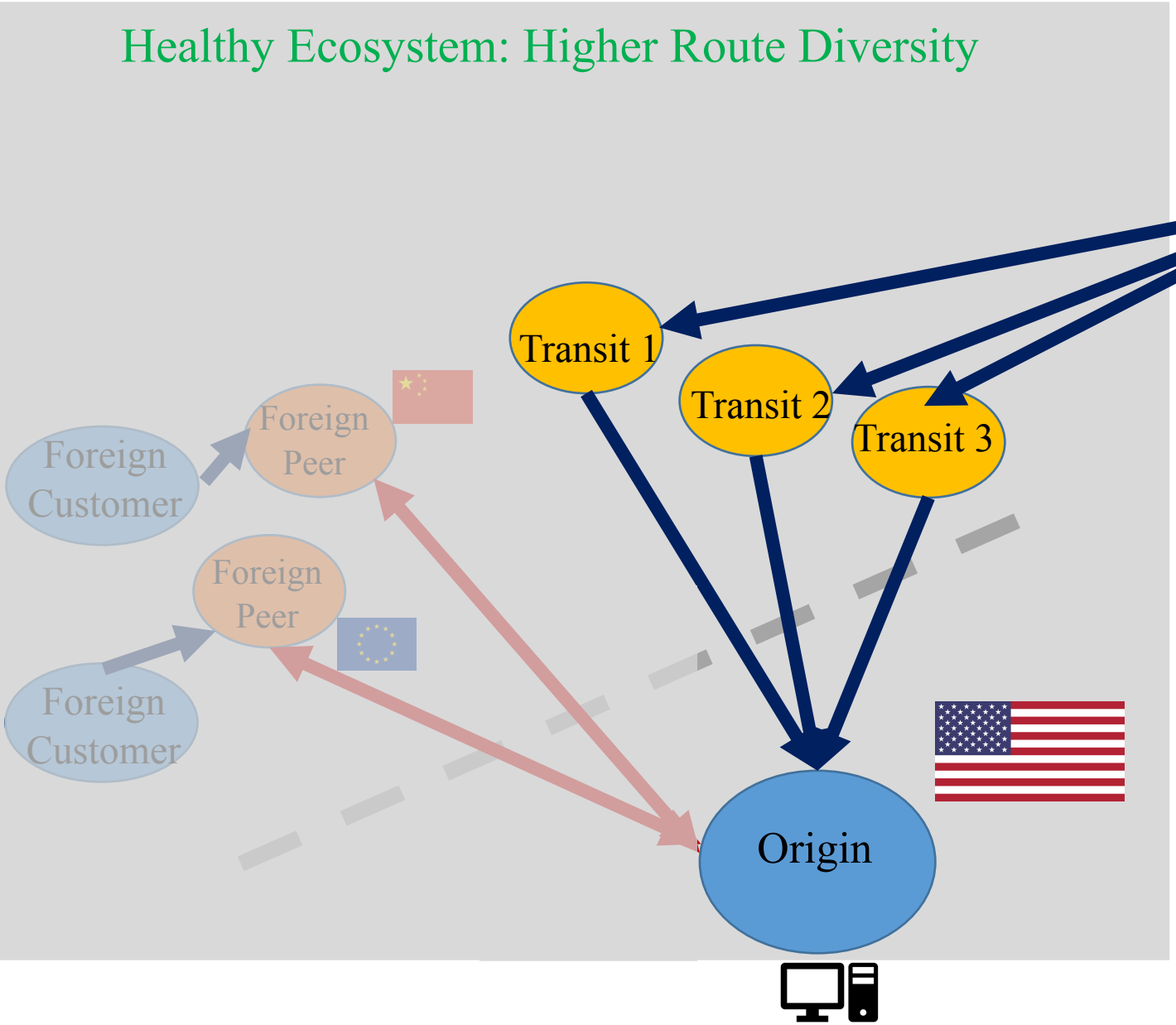
Updated 4:32 PM ET, Mon June 17, 2019

Government control is facilitated by how internet connectivity works in Ethiopia. The country is landlocked and connects to the internet via satellite, a fiber-optic cable that passes through Sudan and connects to the international gateway, and another cable that connects through Djibouti to an international undersea cable.

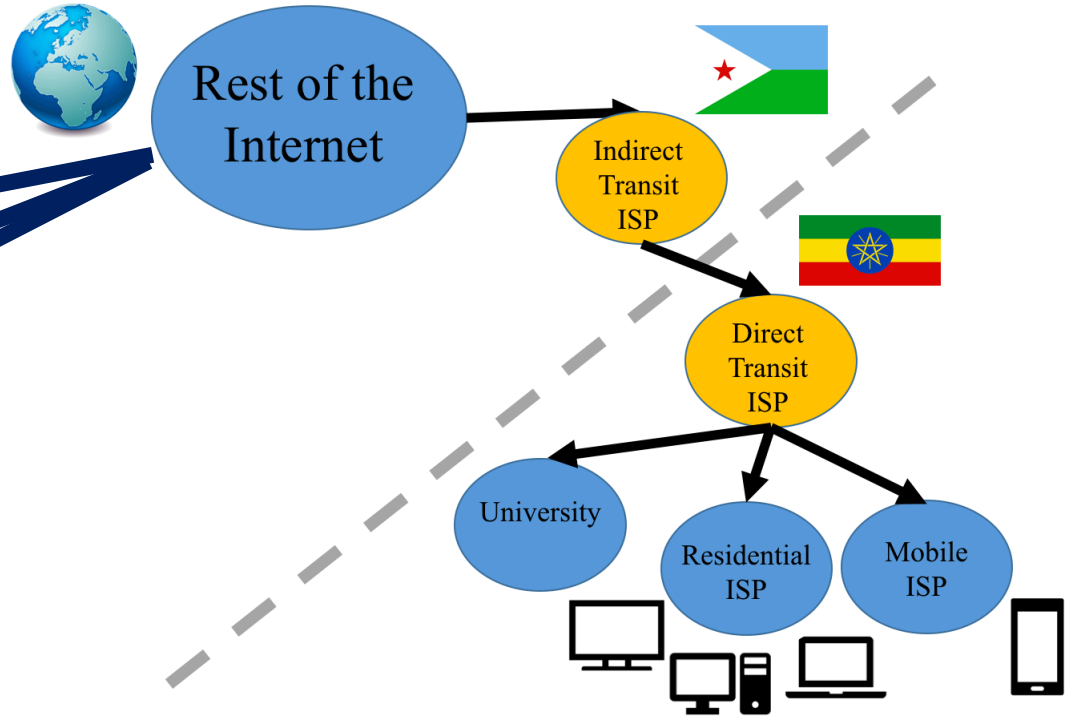
We built tools to identify countries with concentrated inbound routes

First Sign of Concern on Route Diversity: Foreign Peering is Rare

Healthy Ecosystem: Higher Route Diversity



Unhealthy Ecosystem: Lower Route Diversity



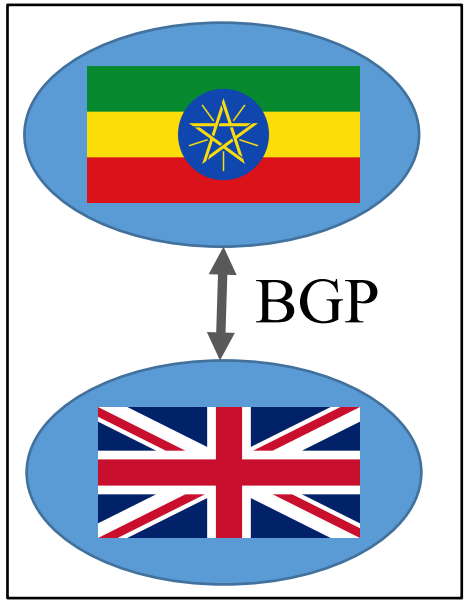
Border Gateway Protocol (BGP): the system relied upon by network operators to announce and implement their routing policies.

We built tools to identify countries with concentrated inbound routes

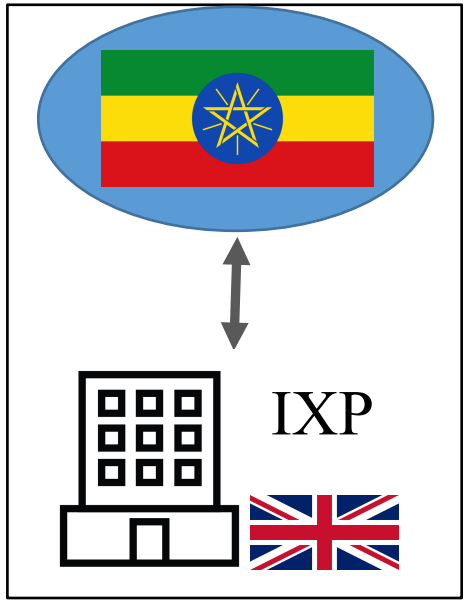
Identify Countries with Lower Route Diversity: origin ASes generally do not have foreign peers and therefore **traffic flows through (often concentrated) transit links**

First Sign of Concern on Route Diversity: Foreign Peering is Rare (Step 1)

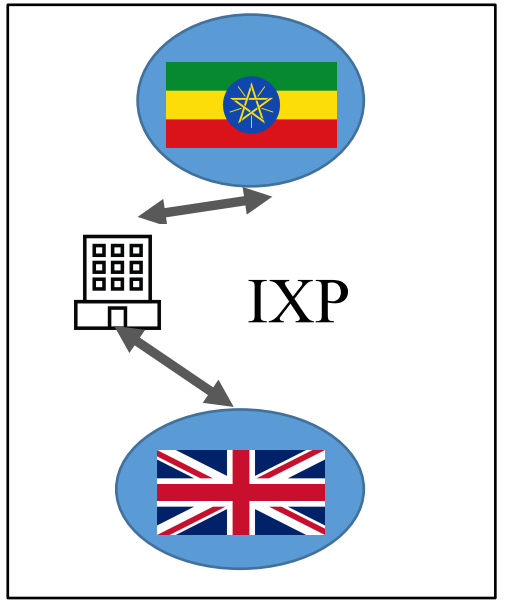
Infer share of country's addresses where lack of foreign peering suggests a **fragile infrastructure without visible opportunities for improvement**



No existing peers



No potential peers



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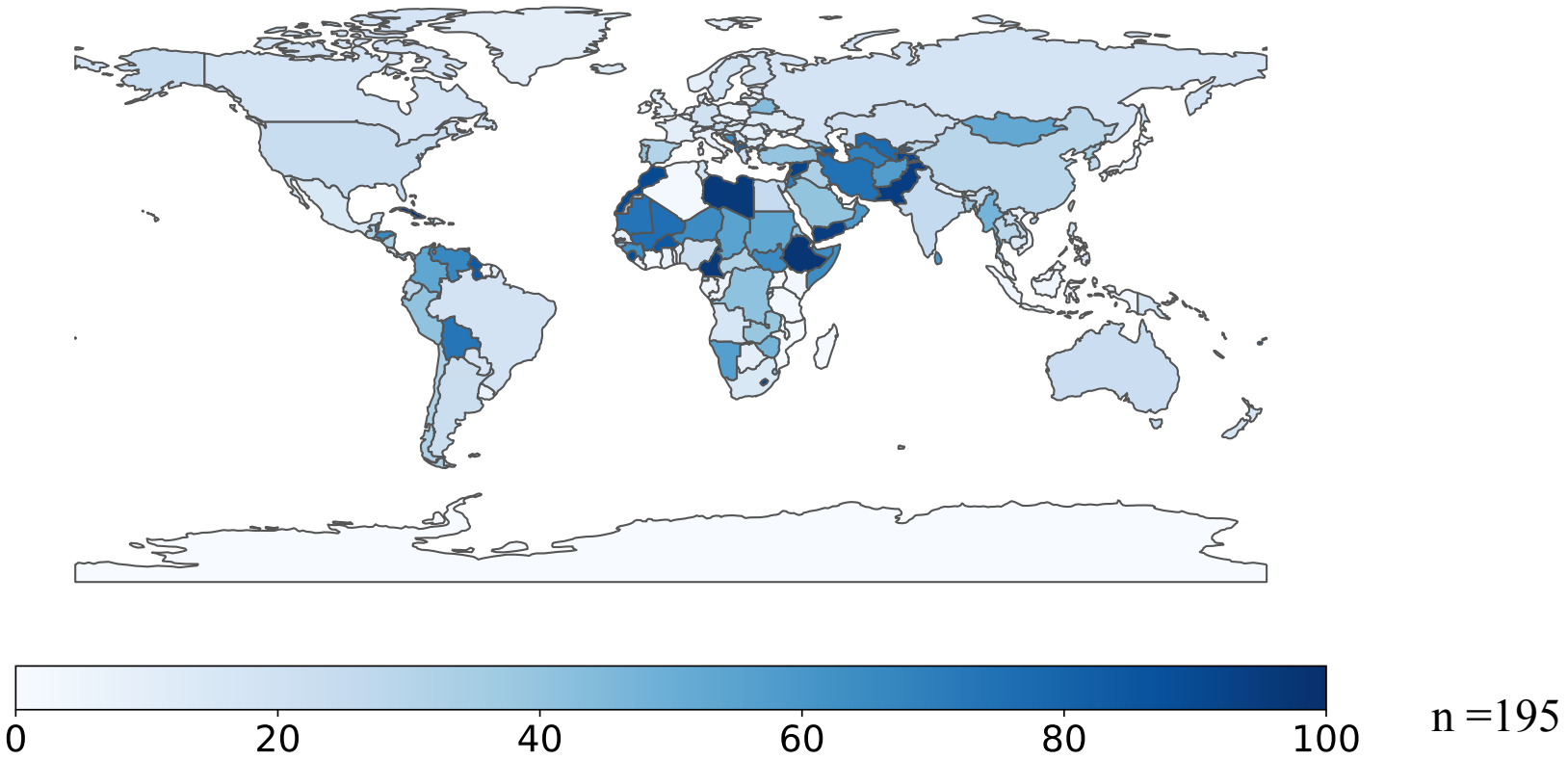
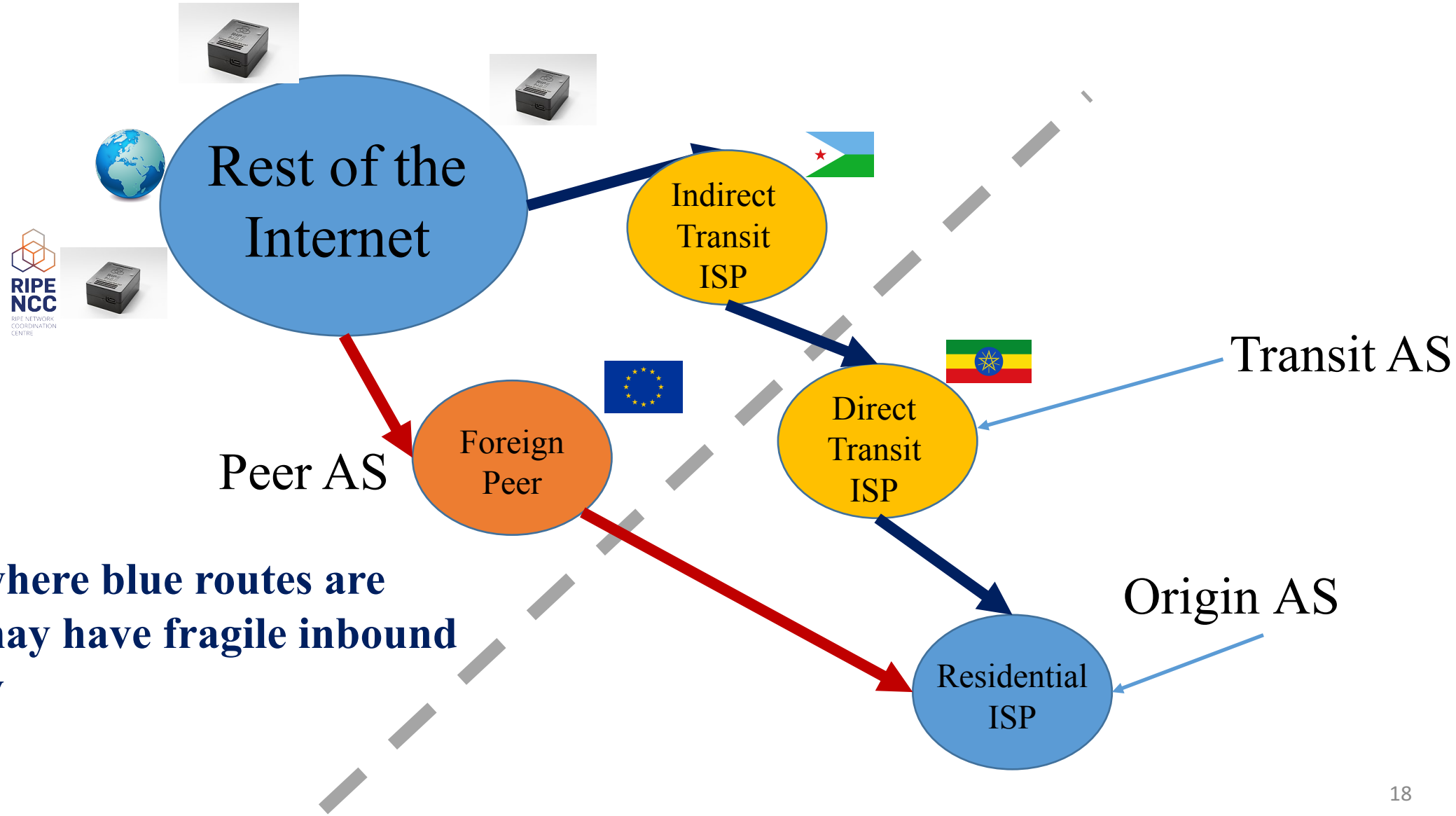


Percentage of each country's address space where we have found no evidence of international peering.

First Sign of Concern on Route Diversity: Foreign Peering is Rare (Step 2)



Countries where blue routes are dominant may have fragile inbound connectivity

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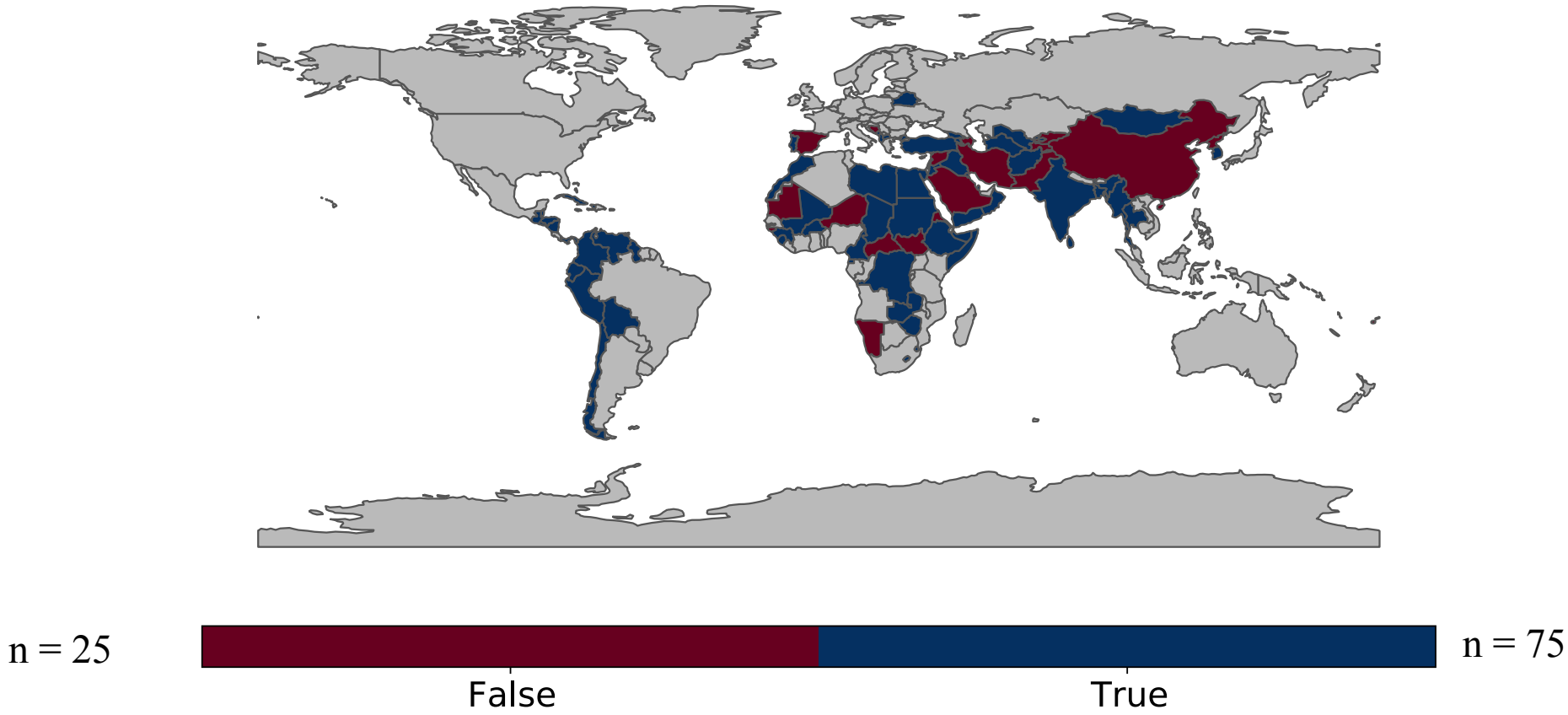
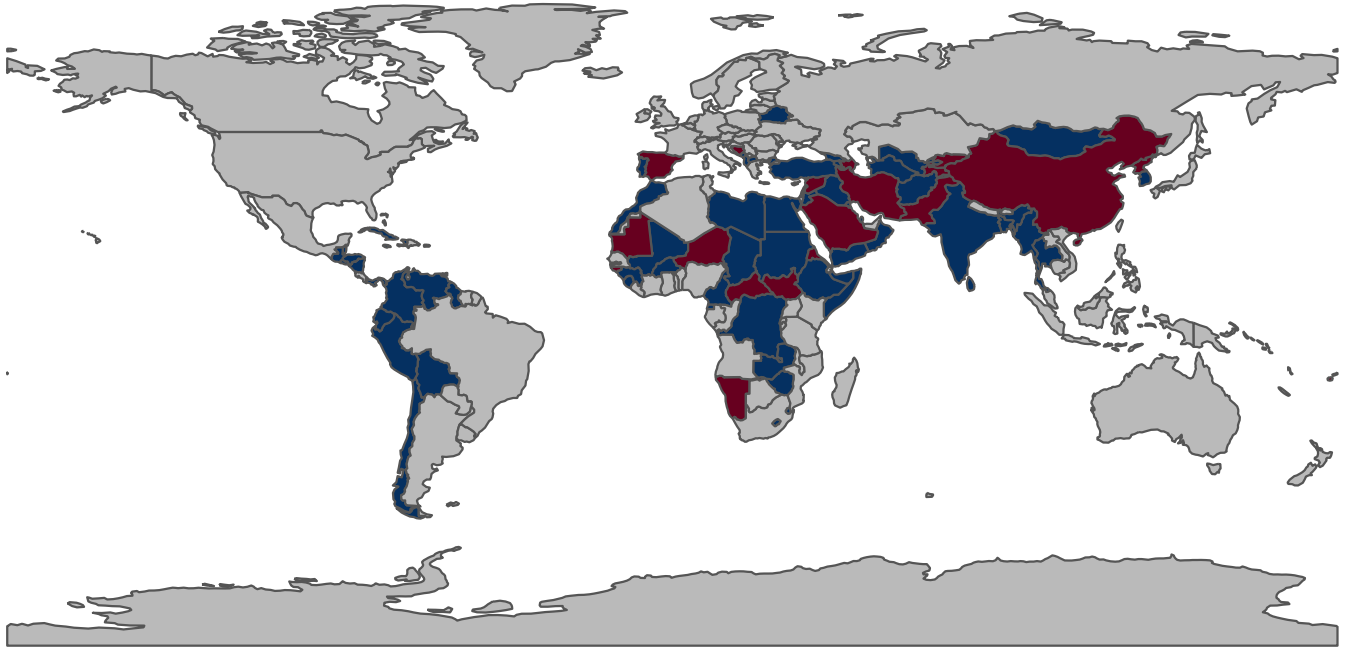


Is this country served primarily by transit ASes?

First Sign of Concern on Route Diversity: Foreign Peering is Rare (Step 2)

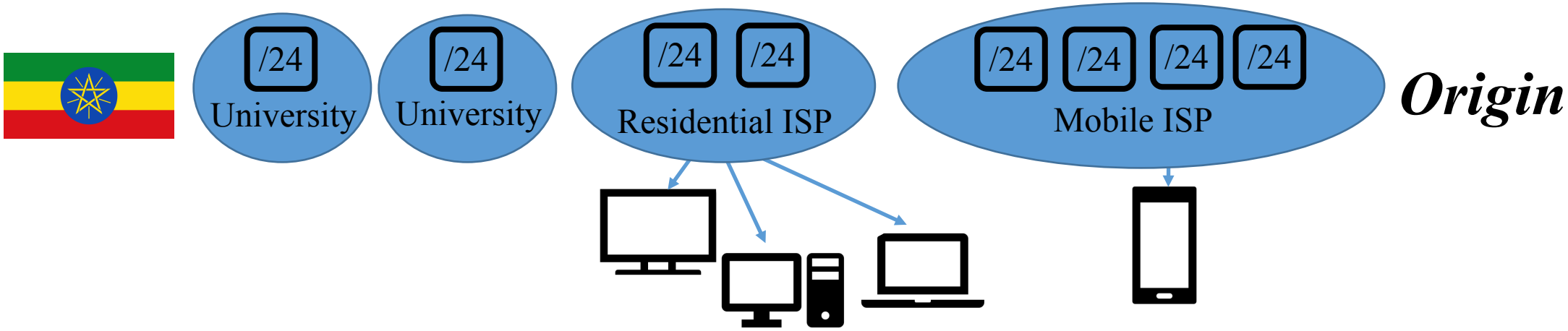
We confirmed these assertions with operators in seven countries:



1. Cameroon
2. D.R. Congo
3. Sudan
4. Zimbabwe
5. Lesotho
6. Ethiopia
7. Venezuela

Is this country served primarily by transit ASes?

Country-Level Transit Influence Defined (1/3)



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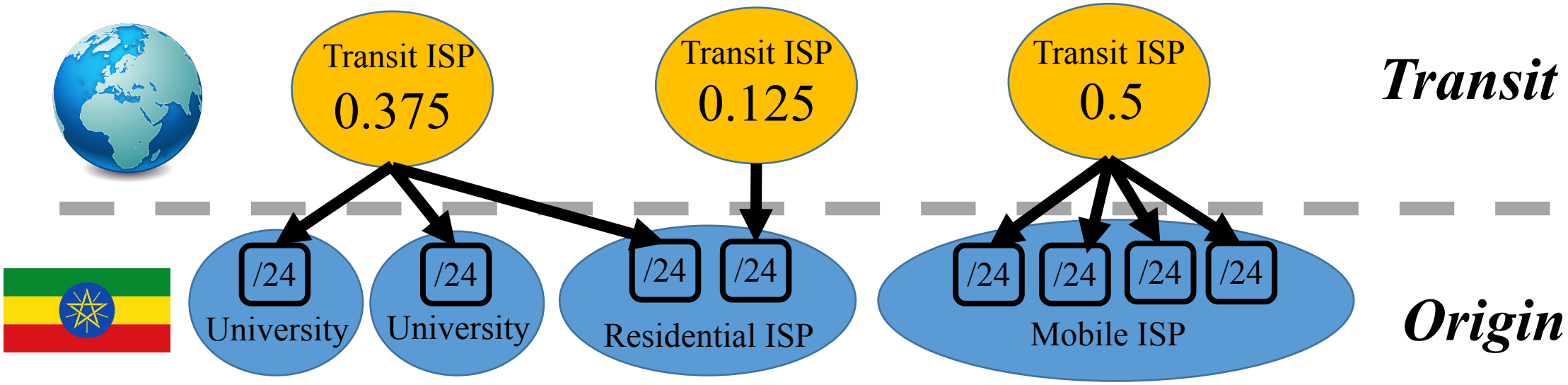


Transit influence of AS_t on country C:
Fraction of addresses originated by any AS_o in country C where AS_t is present as a transit provider **filtered to account for incomplete observations**

$$CTI \sim [0,1]$$

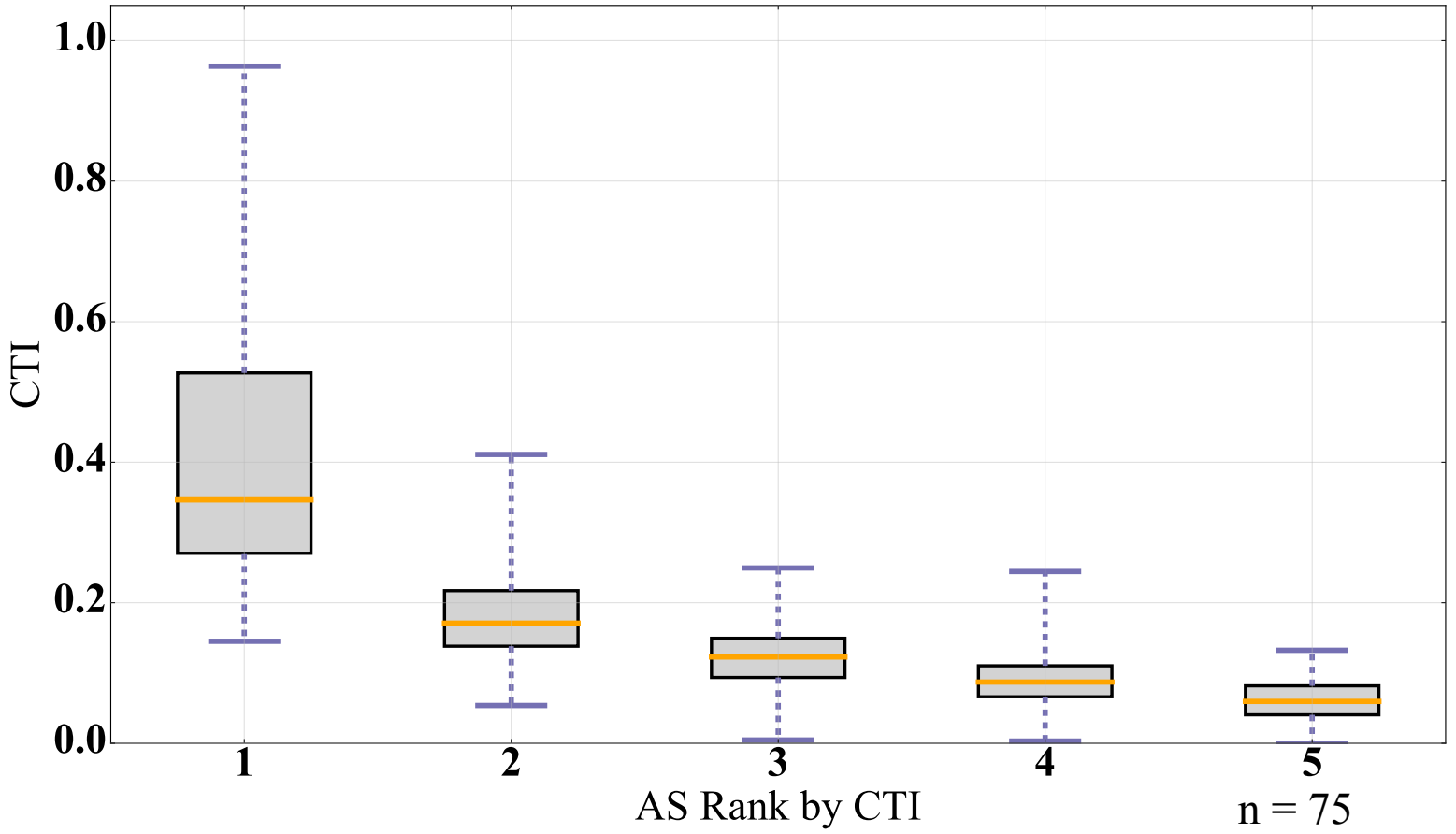
Using CTI to Quantify Inbound Route Diversity

Lower route diversity

Most vulnerable to adverse events affecting a single AS

Higher route diversity

Least vulnerable to adverse events affecting a single AS



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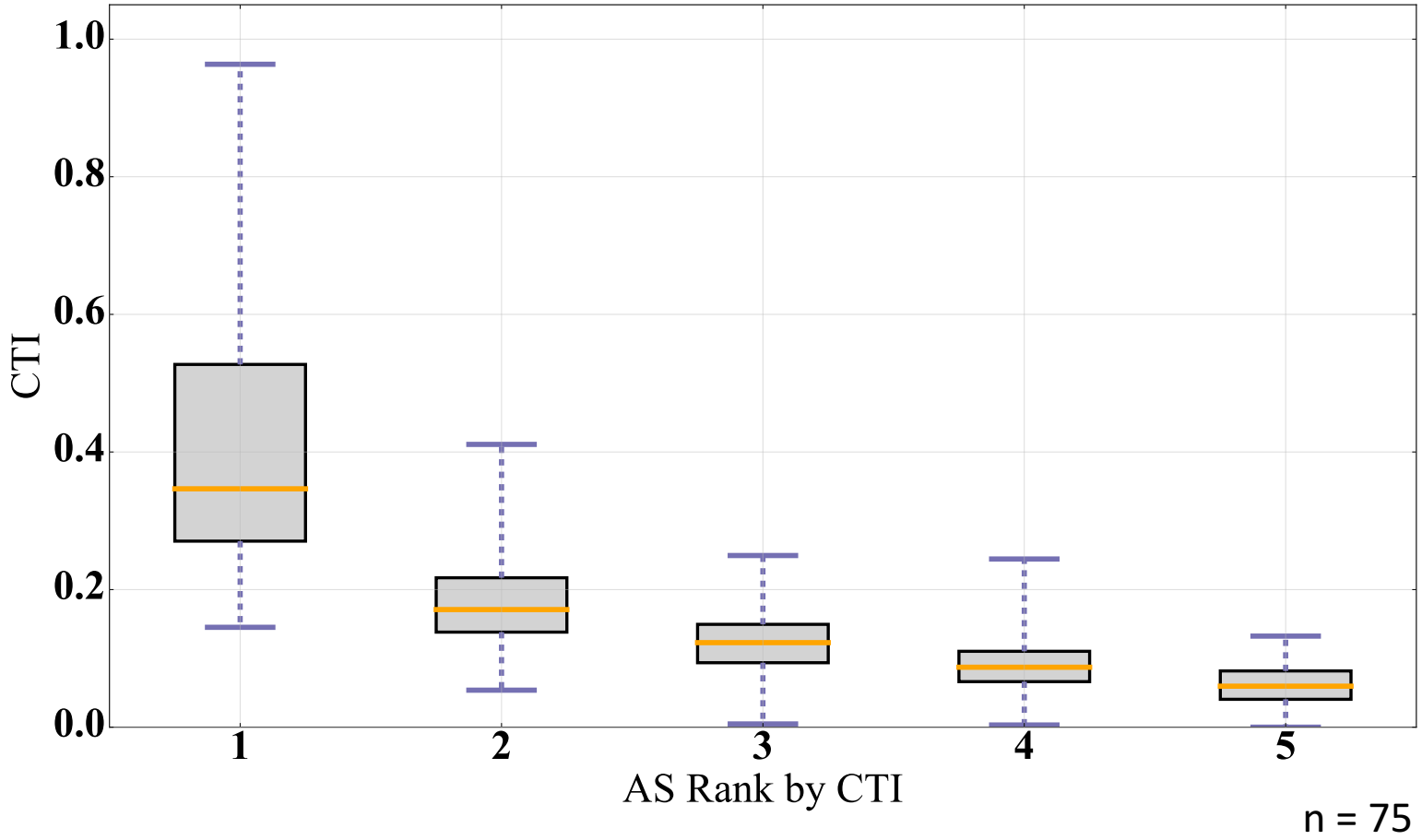

CTI declines quickly: in many countries route are concentrated

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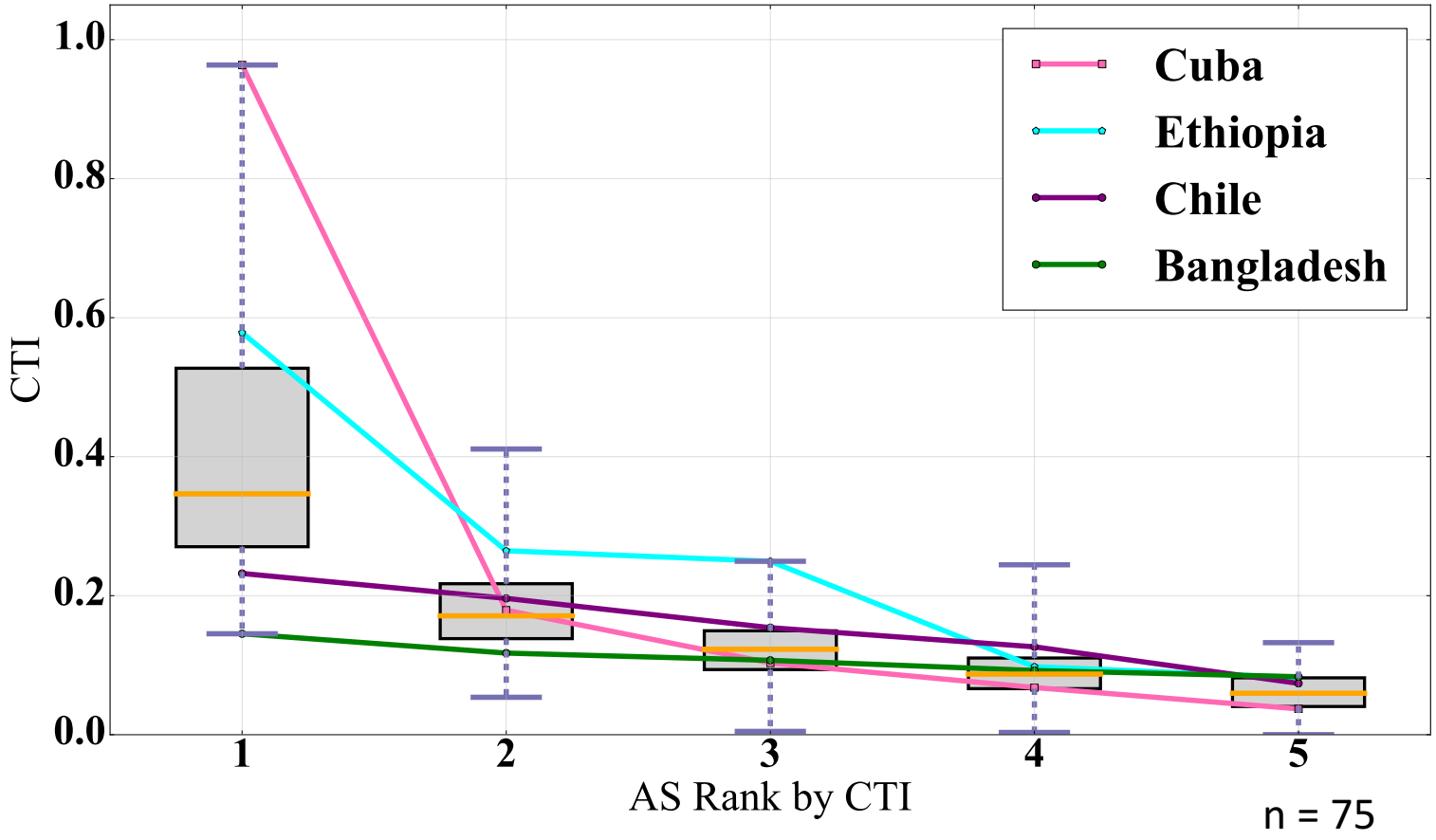

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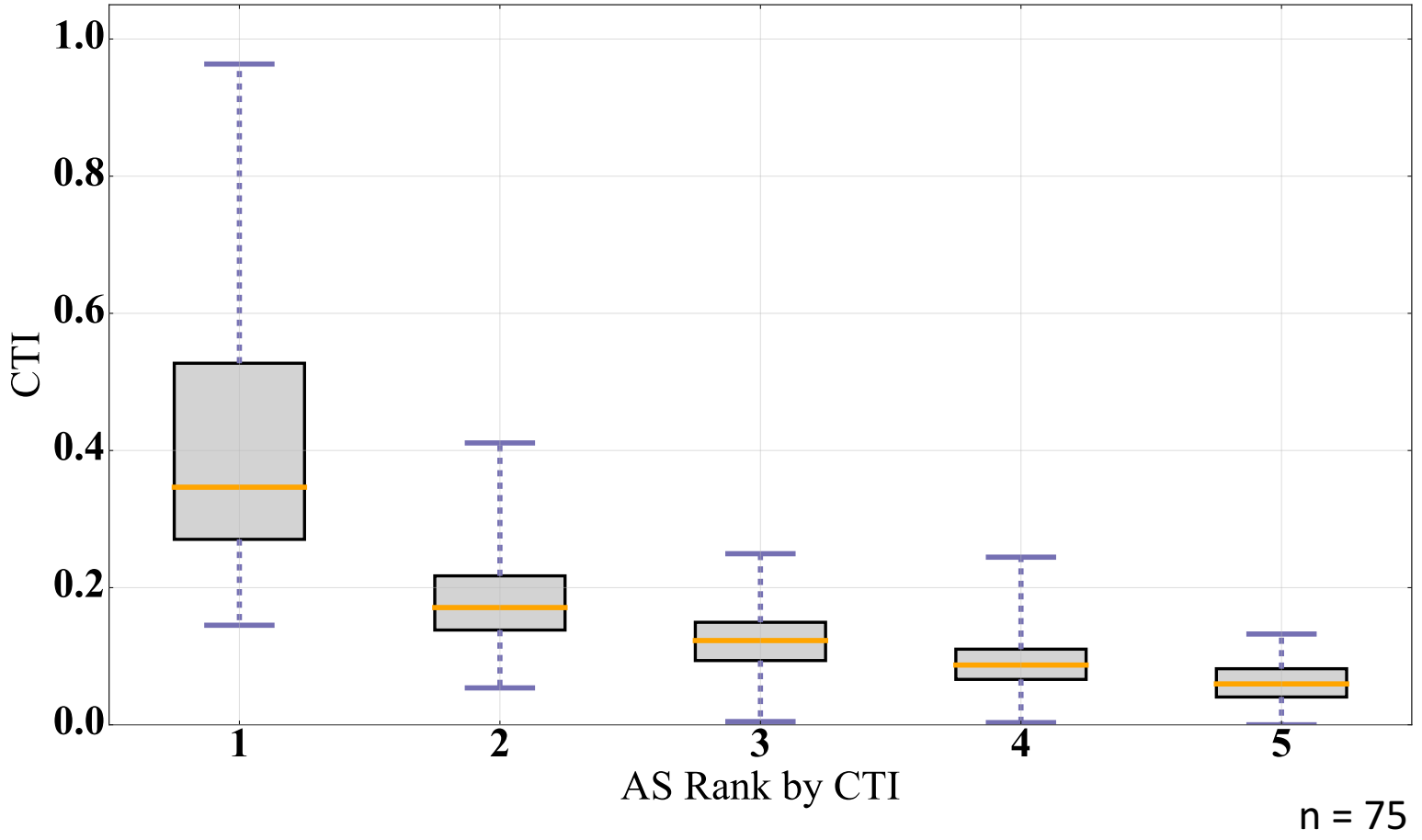
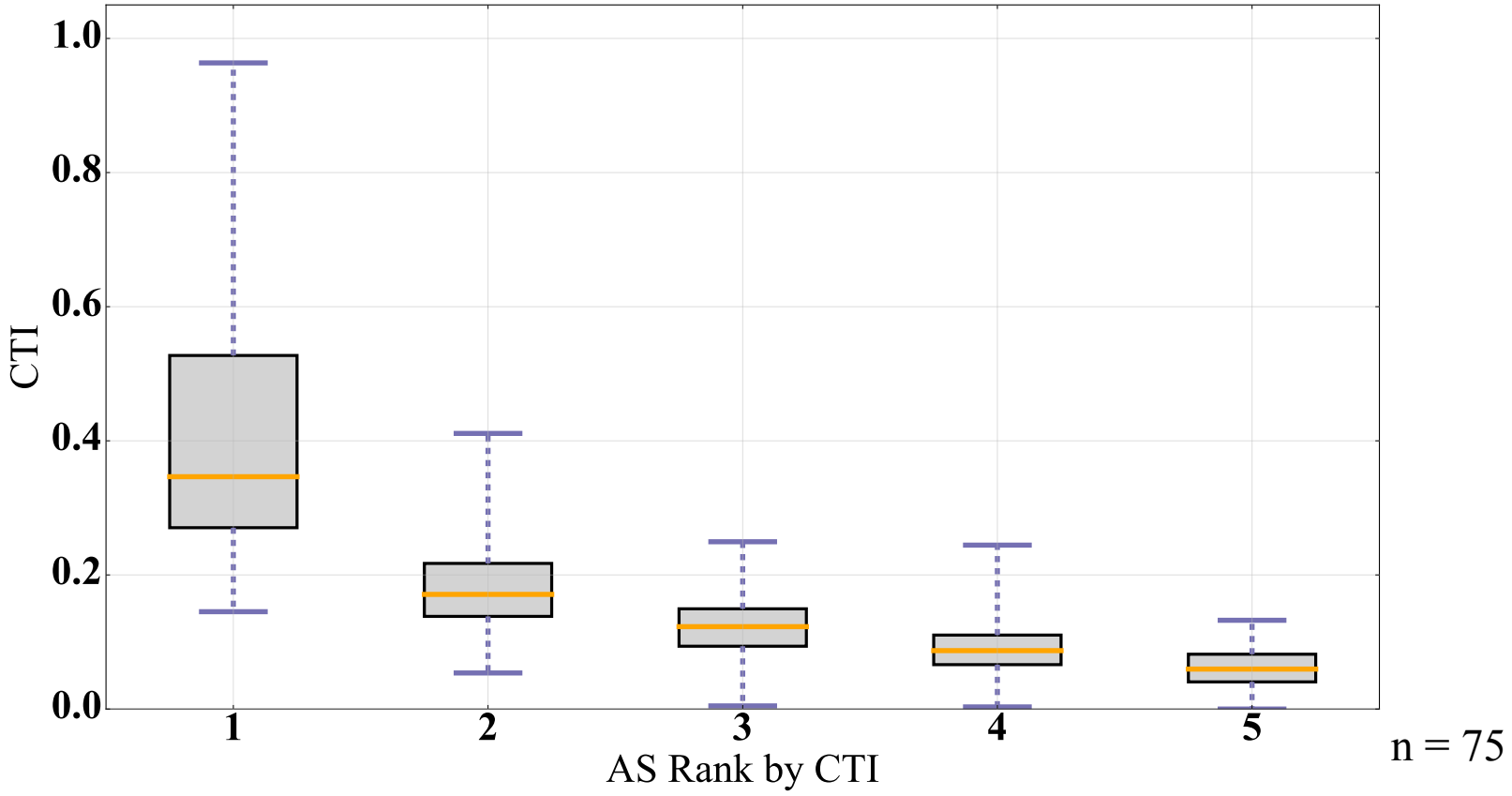


In 49 of 51 non-landlocked countries, a submarine cable operator is ranked in top 5 by CTI

Using CTI to Quantify Inbound Route Diversity

We discussed the set of top ASes by CTI with operators in 5 countries:



1. Ethiopia
2. Zimbabwe
3. Sudan
4. D.R. Congo
5. Cameroon

Telefónica (AS12956) Dominates Transit in Spanish-Speaking Latin America

Solicitamos apoyo validando esta lista de países en LACNIC

Country	Rank by CTI	CTI
Bolivia	1	0.55
Peru	1	0.44
Chile	2	0.24
Colombia	2	0.19
Ecuador	4	0.12
Nicaragua	4	0.08
Guatemala	6	0.04
Belice	8	0.03
Honduras	8	0.04
El Salvador	8	0.02

C&W (AS23520) Dominates Transit in the Caribbean

Solicitamos apoyo validando esta lista de países en LACNIC

Country	Rank by CTI	CTI
Trinidad y Tobago	1	0.58
Belice	1	0.47
Haiti	1	0.40
Guyana	2	0.34
Venezuela	1	0.33
Honduras	3	0.14
Cuba	3	0.11
Ecuador	6	0.06
Nicaragua	8	0.04
Guatemala	8	0.03
El Salvador	10	0.01

Summary

- We built a tool to identify countries served primarily by transit links
- CTI captures concentration of inbound routes towards each of those countries
- Route diversity varies greatly across countries, some are very centralized

Thank you! Questions?

alexander@caida.org cseweb.ucsd.edu/~agamerog

Region	Countries of Concern (Lower Route Diversity)
Central America and the Caribbean	Venezuela, Panama, Haiti, El Salvador, Cuba, Guyana, Bahamas, Nicaragua, Guatemala, Jamaica, Trinidad and Tobago, Honduras, Belize, St. Lucia, Barbados, St. Vincent & the Grenadines, St. Kitts & Nevis
South and Central Asia	India, Mongolia, Thailand, Bangladesh, Sri Lanka, Myanmar, Turkmenistan, Georgia, Uzbekistan, East Timor, Armenia
West and Central Africa	Cameroon, Sierra Leone, Cape Verde, Congo D.R.C., Equatorial Guinea, Guinea, Burkina Faso, Chad, Mali
Middle East and North Africa	Libya, Yemen, Qatar, Oman, Turkey, Egypt, Kuwait, Palestine, Jordan, Afghanistan, Iraq
East Africa	Ethiopia, Zambia, Somalia, Sudan
South Pacific	Tonga, Solomon Islands, Tuvalu, Samoa, Nauru
Andes Mountains (excl. Caribbean)	Bolivia, Peru, Colombia, Ecuador, Chile
Balkans	Albania, Montenegro, Macedonia
Southern Africa	Lesotho, Zimbabwe, Eswatini (Swaziland)
Western and Central Mediterranean	Portugal, Morocco, Malta
Landlocked Countries (excl. above regions)	Luxembourg, San Marino, Belarus
South Korea	South Korea