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MULTI-DOMAIN FEDERATION: SCOPE, CHALLENGES, AND OPPORTUNITIES

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SCOPE

Multi-domain federation

FEDERATION IN ENGLISH DICTIONARIES

- The act of joining states or other groups with an agreement they will be governed under one central authority (e.g., a federation is the United States)
- The act of uniting or of forming a union of states, groups, etc. by agreement of each member to subordinate its power to that of the central authority in common affairs
- An organization formed by such an act; league; specif., a federal union of states, nations, etc.
- The act of federating, especially a joining together of states into a league or federal union
- A league or association formed by federating, especially a government or political body established through federal union
- Act of joining together into a single political entity
- Array of nations or states that are unified under one central authority which is elected by its members
- Any society or organisation formed from separate groups or bodies
- A collection of network or telecommunication providers that offer interoperability

FEDERATION IN ENGLISH DICTIONARIES

Join, Union

- The act of **joining** states or other groups with an agreement they will be governed under one central authority (e.g., a federation is the United States)
- The act of **uniting** or of **forming a union** of states, groups, etc. by agreement of each member to subordinate its power to that of the central authority in common affairs
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- A **league** or **association** formed by federating, especially a government or political body established through federal **union**
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- Array of nations or states that are **unified** under one central authority which is elected by its members
- Any society or organisation **formed from separate groups or bodies**
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FEDERATION IN ENGLISH DICTIONARIES

Organizations, groups, members, collection

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- An **organization** formed by such an act; league; specif., a federal union of states, nations, etc.
- The act of federating, especially a joining together of **states** into a league or federal union
- A league or association formed by federating, especially a government or political body established through federal union **(of their members)**
- Act of joining together **(independent entities)** into a single political entity
- **Array of nations** or **states** that are unified under one central authority which is elected by its **members**
- Any society or organisation formed from separate **groups** or **bodies**
- A **collection** of network or telecommunication providers that offer interoperability

FEDERATION IN ENGLISH DICTIONARIES

Agreement

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FEDERATION IN ENGLISH DICTIONARIES

Authority

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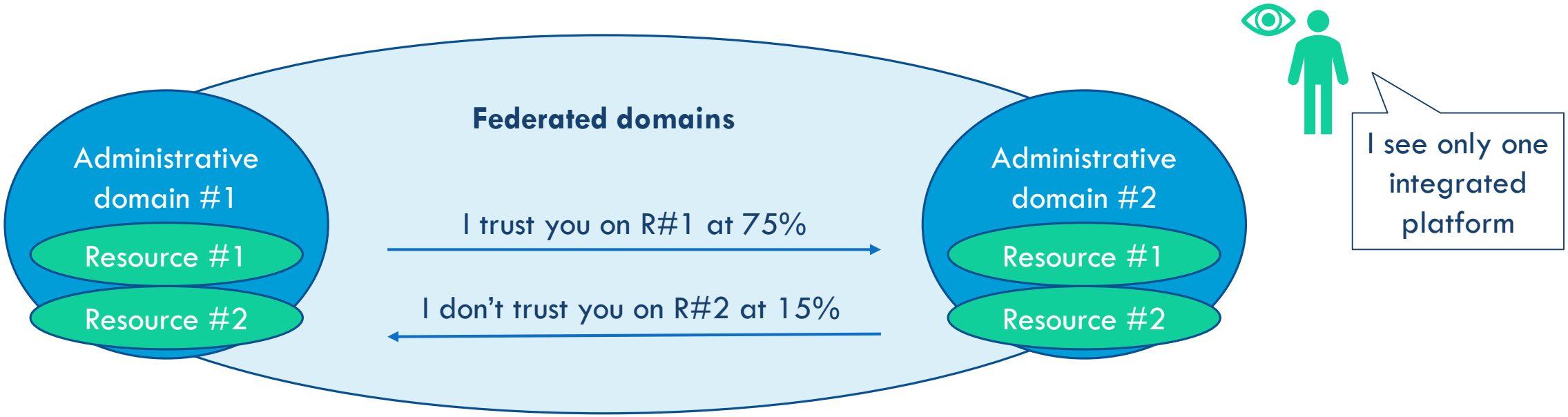
FEDERATION CONCEPTS

Join, Union of Organizations, groups, members, collection subject to Agreement under Authority

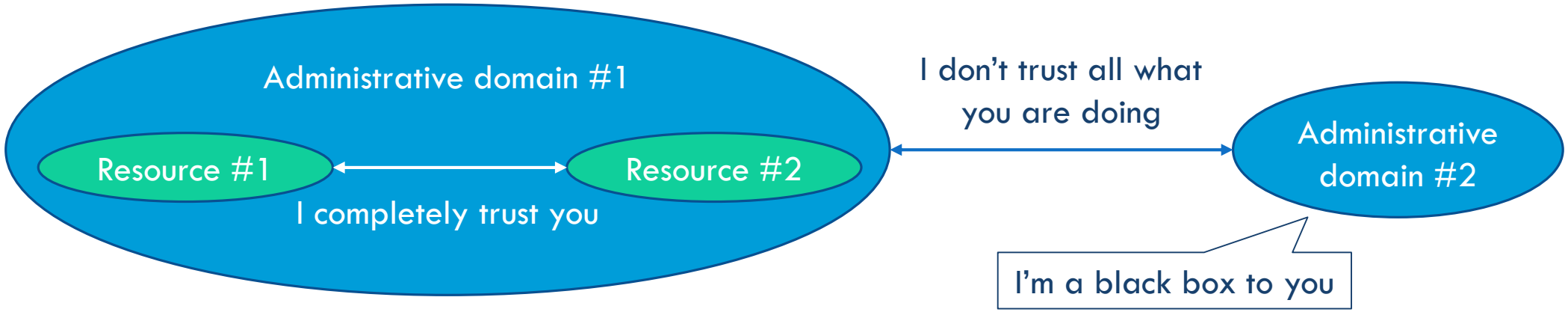
WHAT IS MULTI-DOMAIN FEDERATION?

- Federation is a **mechanism for integrating multiple administrative domains** at different granularity into a unified open platform where the federated resources can **trust each other at a certain degree**



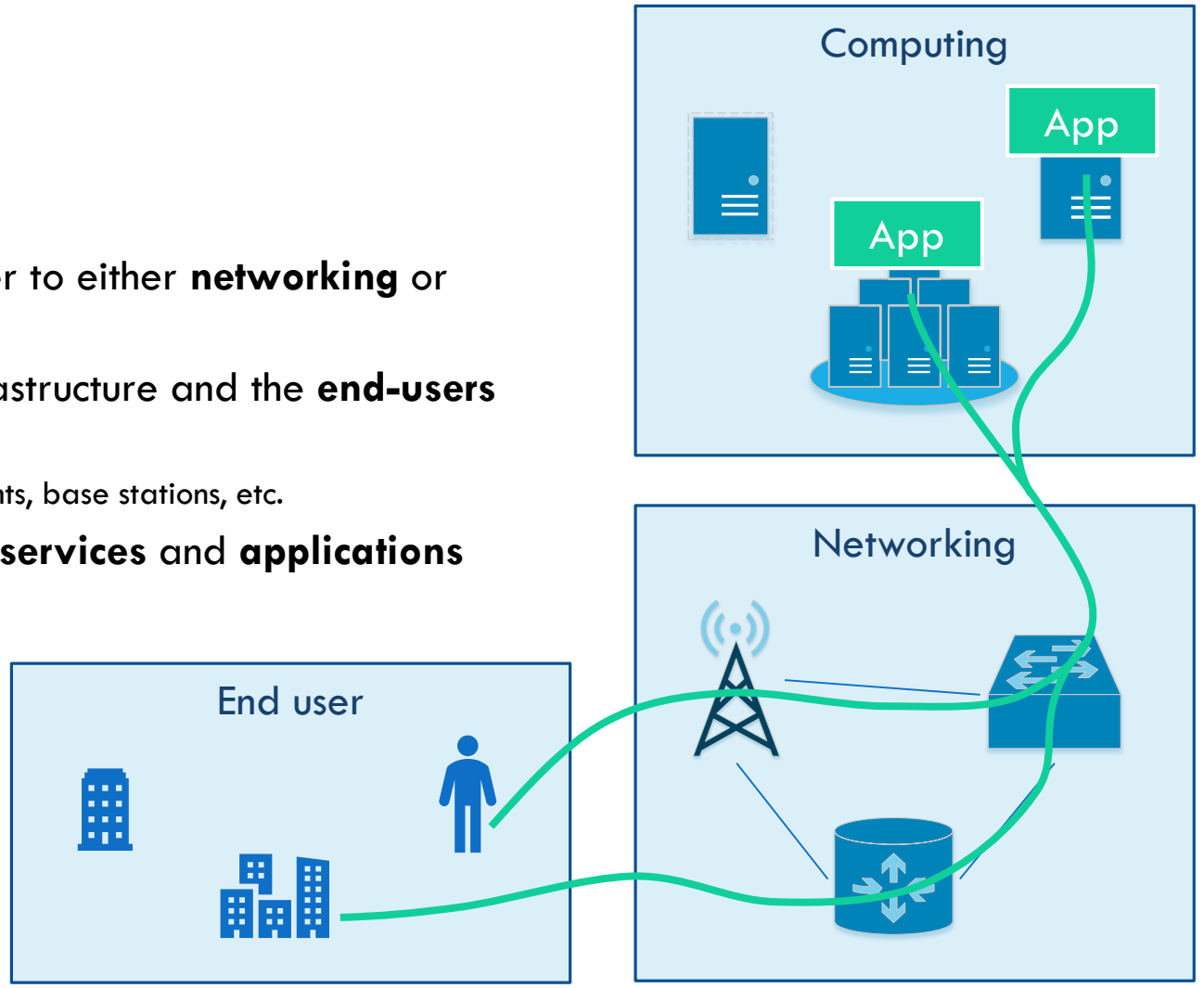
WHAT IS AN ADMINISTRATIVE DOMAIN?

- An administrative domain is a **collection of resources** operated by a **single organization**
- It is viewed as a cohesive entity and its **internal structure is unimportant** from the outside
- The domain's resources are assumed to interoperate with a significant degree of **mutual trust among themselves,** but interoperate with **other administrative domains** in a **mutually suspicious manner**



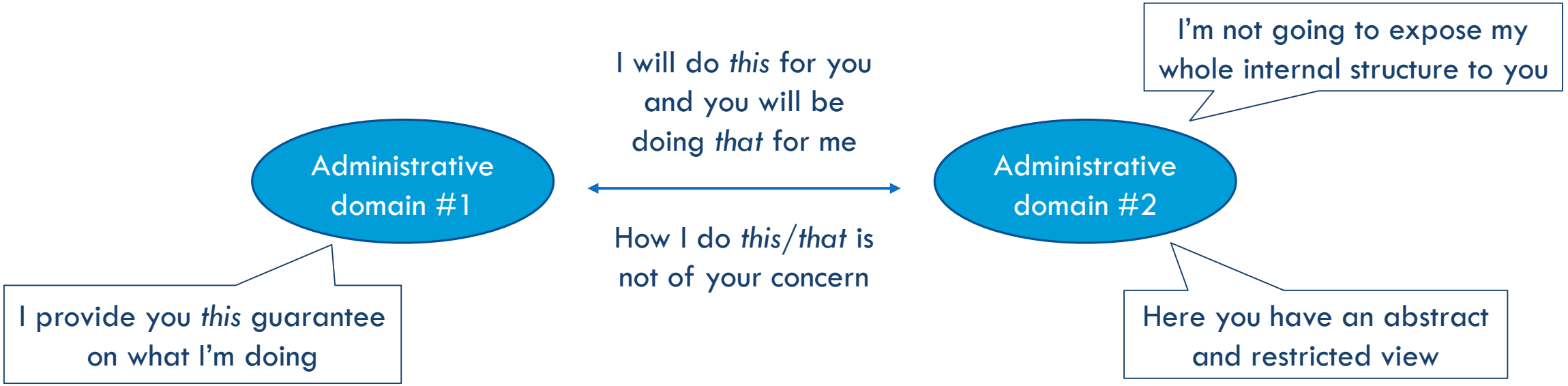
WHAT IS A RESOURCE?

- In the scope of this presentation resources refer to either **networking** or **computing** domains
- Networking resources enable the network infrastructure and the **end-users** to **communicate**
  - E.g., LAN, WAN, RAN, Core, switches, routers, access points, base stations, etc.
- Computing resources enable the **execution** of **services** and **applications** consumed by the end-users
  - E.g., servers, data centres, cloud, fog, etc.
- Resources can be either physical or virtual



WHAT IS FEDERATION TRUST?

- A federation trust is the embodiment of a **service/business-level agreement** or **partnership** between two organizations



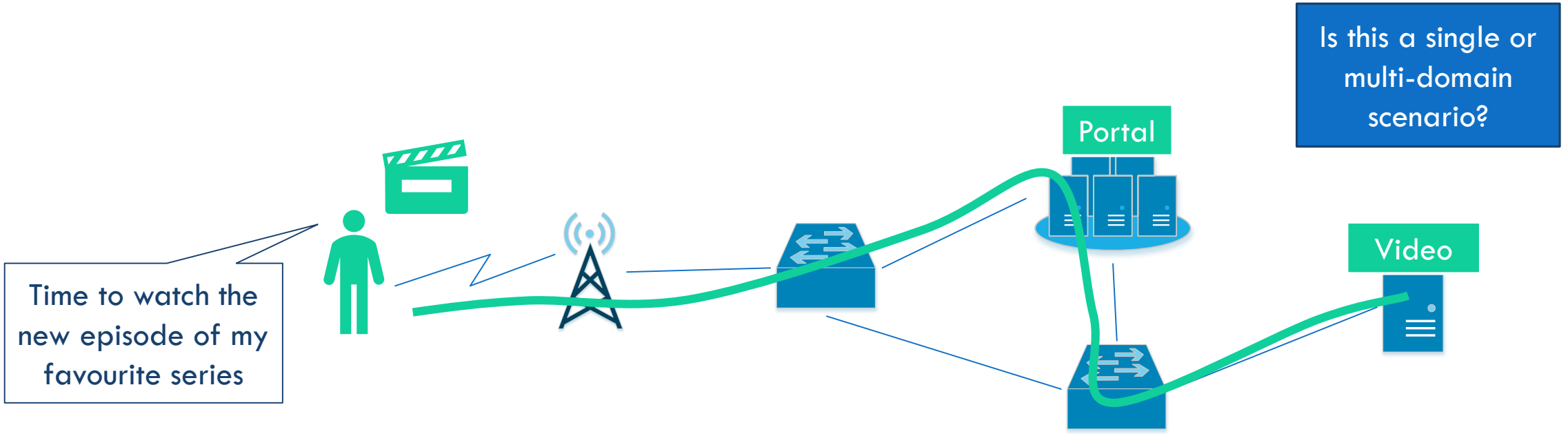
EXAMPLES

Multi-domain federation

FEDERATION SCOPE AND EXAMPLES

This presentation focuses on scenarios involving the following federated resources:

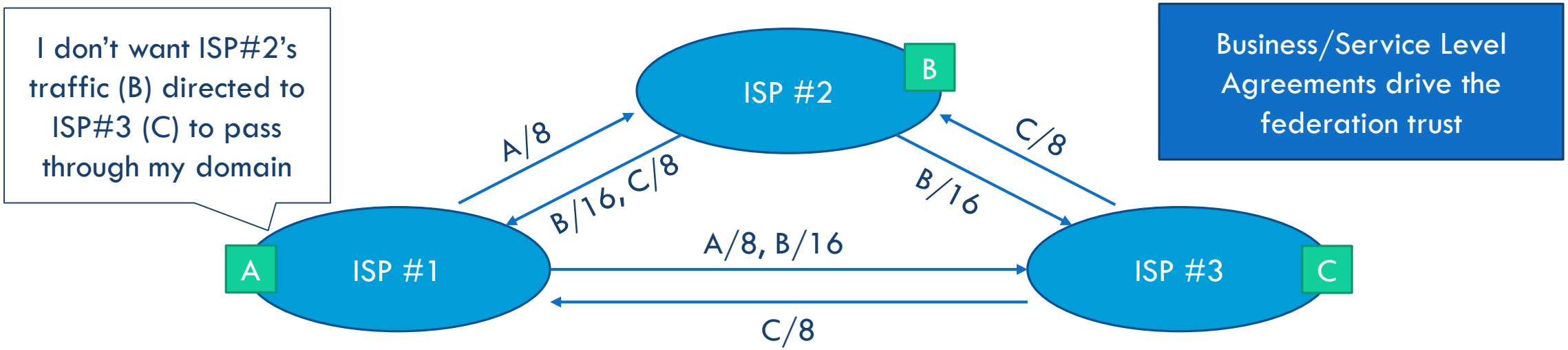
- Connectivity, Computing, Storage, Identity



CONNECTIVITY – INTERNET EXCHANGE POINT

An **Internet Exchange Point** (IXP) is a physical infrastructure through which Internet Service Providers (ISPs) exchange Internet traffic between their networks

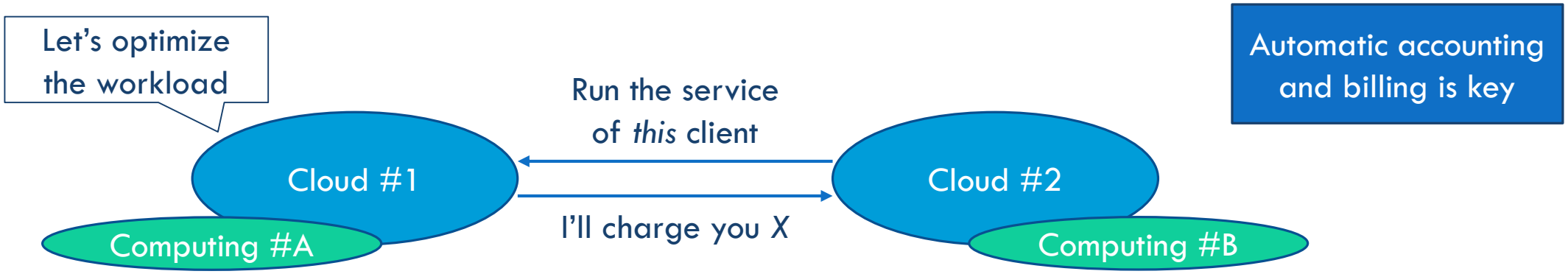
- Each network is an **autonomous system** and acts as an independent **administrative domain**
- **IP prefixes,** which can be seen as federated resources, are advertised via BGP protocol
- BGP sessions are established in a peer-to-peer fashion according to different **federation trust** levels



COMPUTING – CLOUD FEDERATION

Cloud Federation refers to the integration of software, infrastructure and platform services from disparate networks that can be accessed by a client via the Internet

- Possibility for a client to choose the best cloud services provider, in terms of flexibility, **cost** and **availability of services**, to meet a particular **business** or **technological need** within their organization
- Distribution of workloads around the globe and move data between disparate networks



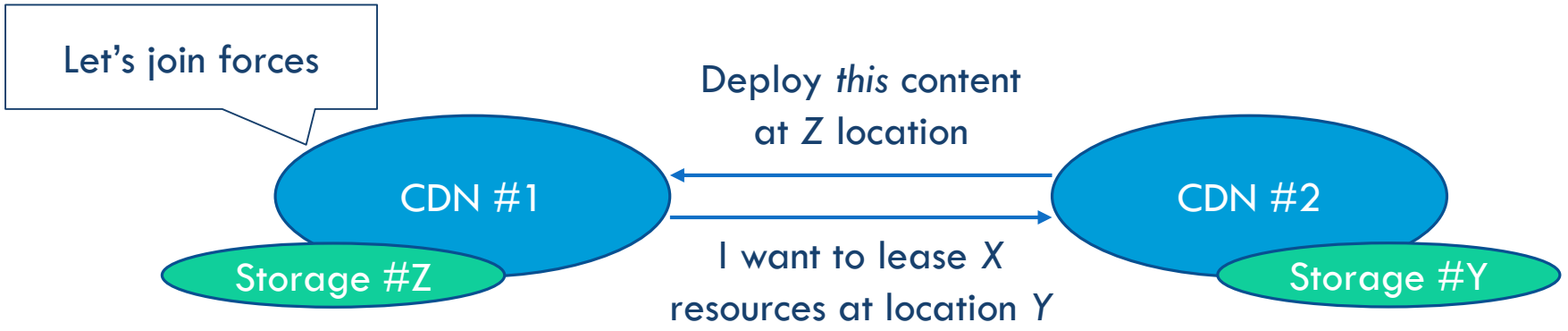
STORAGE – CONTENT DELIVERY NETWORK

Content Delivery Networks (CDNs) provide numerous benefits for cacheable content

- Reduced delivery cost, improved QoE for end-users, and increased robustness of delivery

Small CDN providers can **combine** their infrastructure to **aggregate** content and users or **lease** infrastructure at certain geographic regions on-demand basis

- Standalone CDNs interoperating as an open content delivery infrastructure



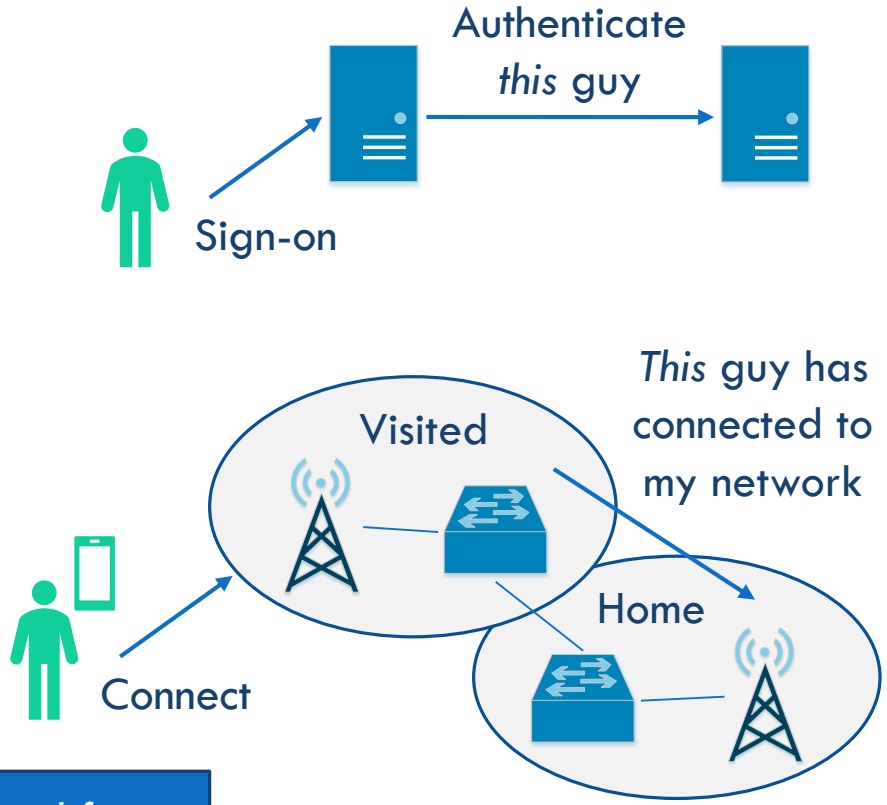
Federation requires a common interface and a shared federation model

IDENTITY – FEDERATED IDENTITY MANAGEMENT

A **Federated Identity Management (FIdM)** allows to link a person's electronic identity and attributes stored across multiple distinct identity management systems

FIdM requires a common set of policies, practices and protocols in place to manage the identity and trust into users and devices across organizations:

- **Single sign-on (SSO)** is a property of access control of multiple related, yet independent, systems
- **Mobile roaming** is the ability of a end-user to access services (e.g., voice, data) when travelling outside the geographical coverage area of the home network, by means of using a visited network



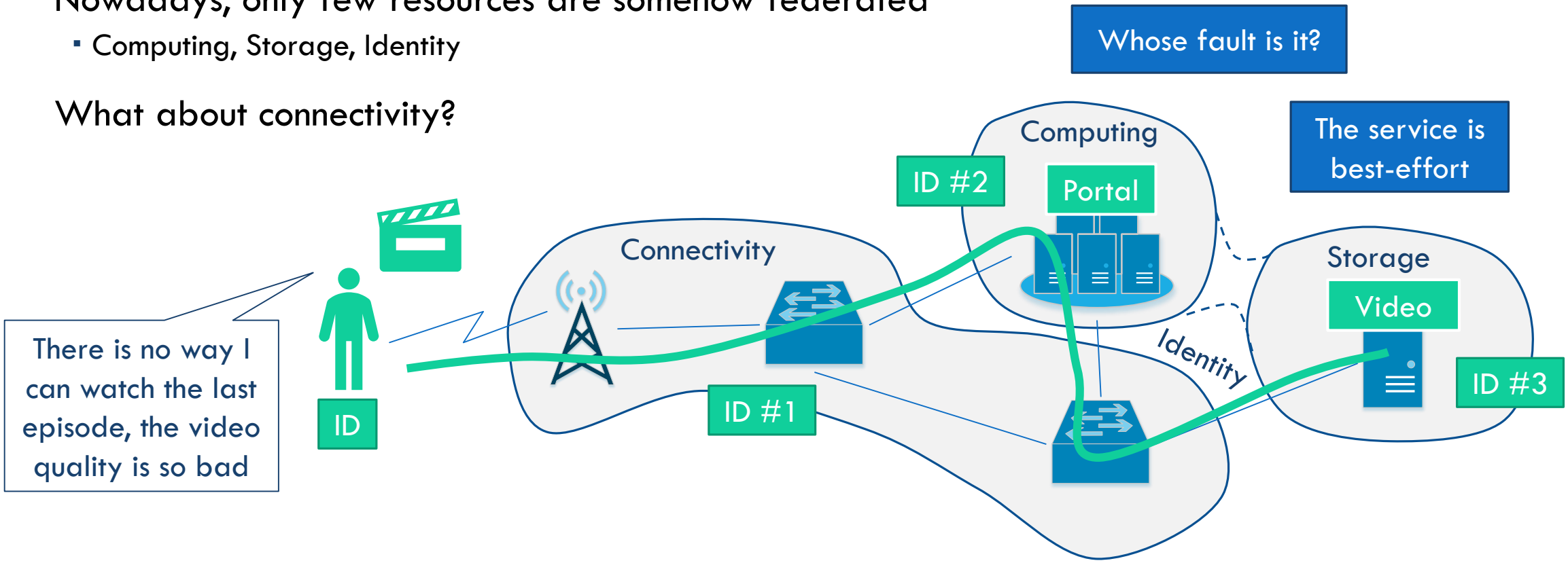
Identity is fundamental for establishing federation trust

STATUS OF NOWADAYS FEDERATION SCENARIOS

Nowadays, only few resources are somehow federated

- Computing, Storage, Identity

What about connectivity?



RELEVANCE IN 5G

Multi-domain federation

5G NETWORKS – 5G-PPP KEY CHALLENGES

Compared to 4G networks, 5G will:

- Provide 1000 times higher wireless area capacity and more varied service capabilities compared to 2010
- Save up to 90% of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the RAN
- Reduce the average service creation time cycle from 90 hours to 90 minutes
- Create a secure, reliable and dependable Internet with a "zero perceived" downtime for services provision
- Facilitate very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people
- Ensure for everyone and everywhere the access to a wider panel of services and applications at lower cost

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Federation concept can be transversally applied to all these challenges

5G NETWORKS – 5G-PPP KEY CHALLENGES

Let's focus on the 90 minutes challenge

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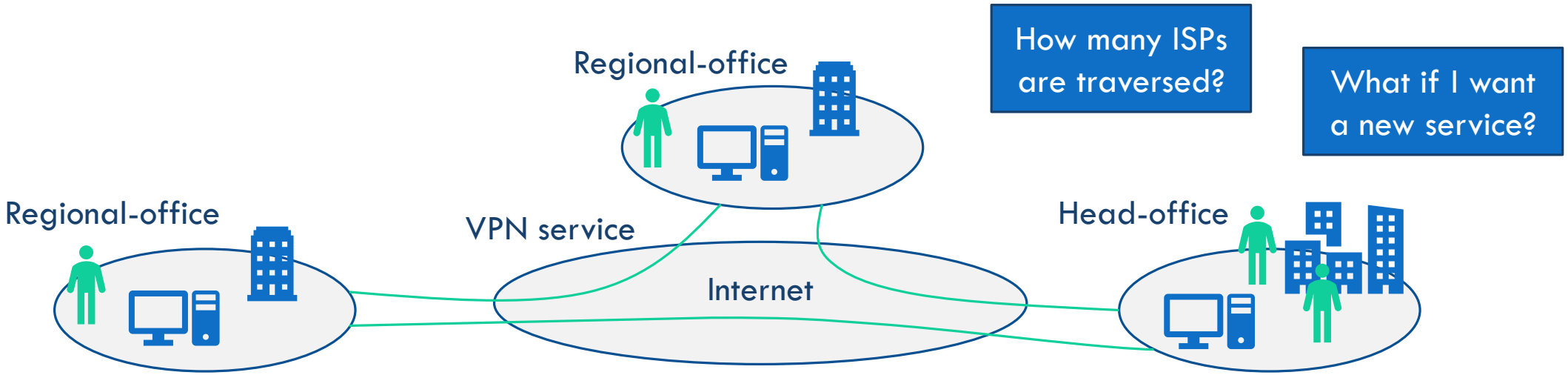
FROM **90 HOURS** TO 90 MINUTES

Nowadays, service provisioning heavily leverages on manual interaction between the actors (e.g., service provider and client) and requires a considerable amount of manual configuration of the underlying infrastructure

- E.g., an E2E VPN service usually requires up to 3 months. In case of multi-domain scenarios, service provisioning could also take longer



FROM 90 HOURS TO **90 MINUTES**

90 minutes target requires services to be

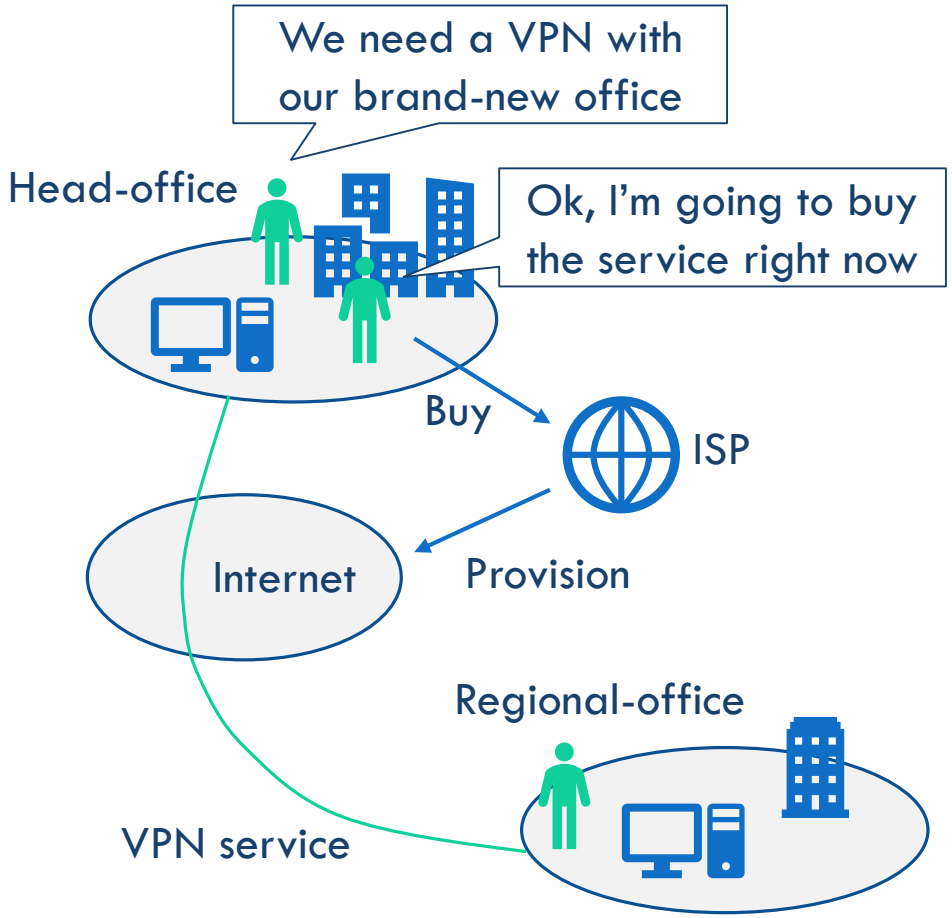
- Easily created through a streamlined common tool
- Automatically provisioned across all the involved domains

This requires 5G networks to provide

- Extremely flexible and highly programmable connect-and-compute infrastructure
  - Softwarization of the network and computing infrastructure
- Scalable management framework
  - Softwarization and integration of management and control

SDN + NFV

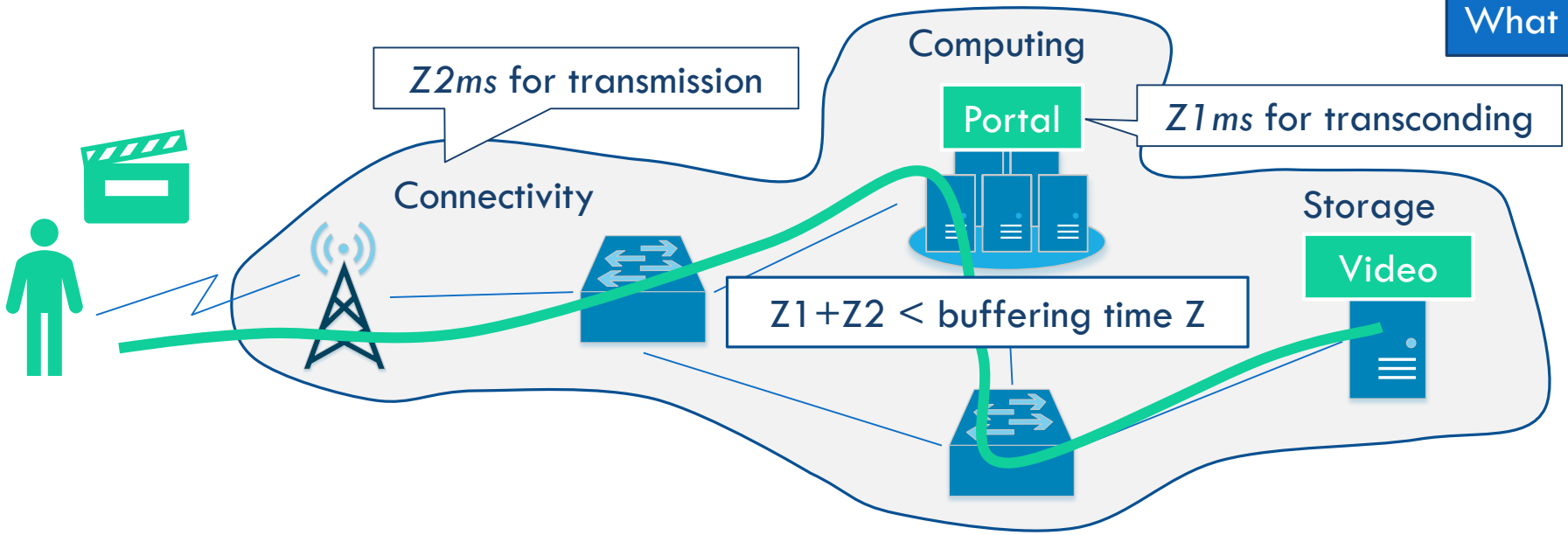
Is this enough to enable E2E service and application provisioning across multiple domains?



THE ROLE OF FEDERATION IN 90 MIN TARGET (1)

Provisioning an E2E service across multiple domains requires full visibility of the service state in each of the involved domains

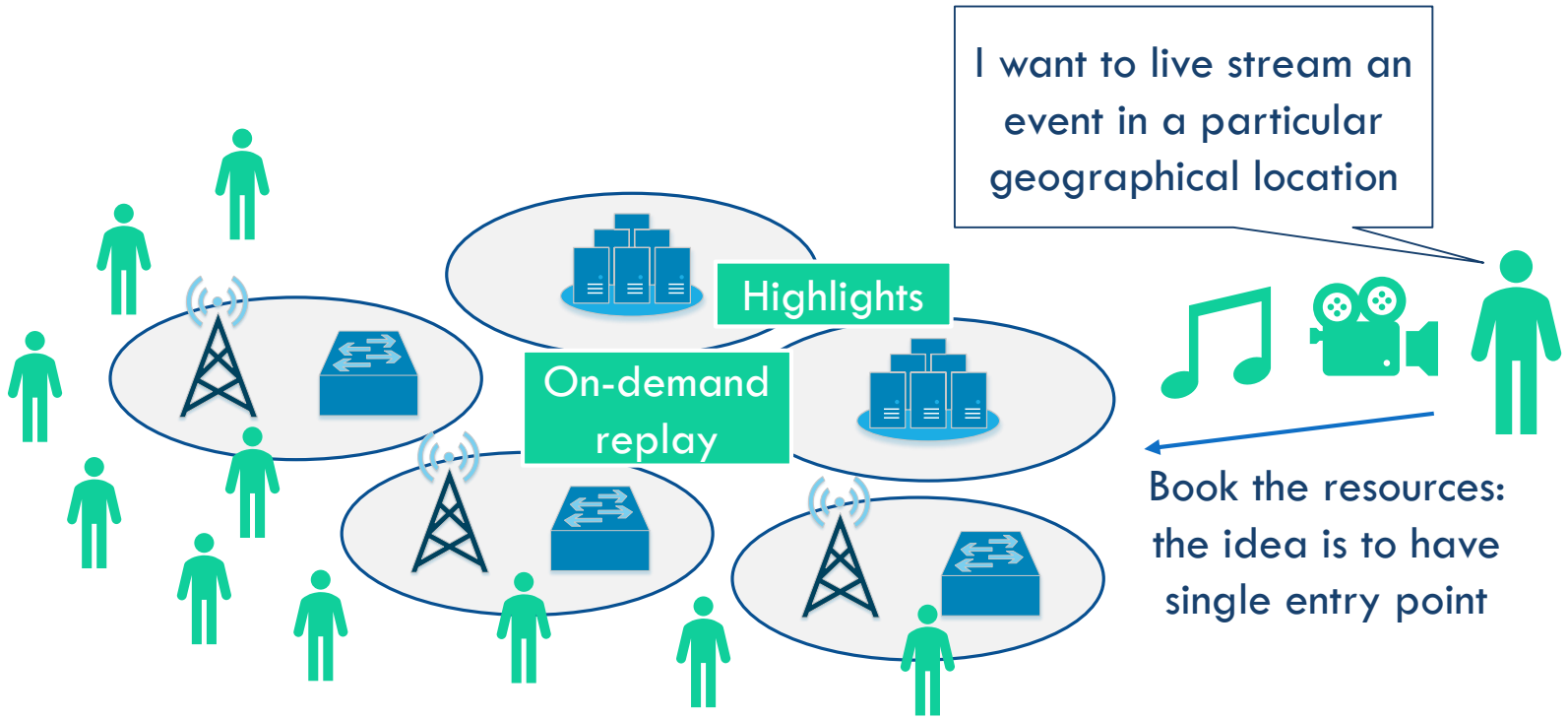
What is an E2E service?
What are its characteristics?
What should be monitored?



Need for a federation trust

THE ROLE OF FEDERATION IN 90 MIN TARGET (2)

Fast deployment of novel applications requires automatized reservation and access to networking and computing resources



What resources do I need?
How many?
How long?
Is there a single provider offering all what I need?

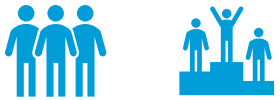
Need for a federation trust

CHALLENGES

Multi-domain federation

FEDERATION CHALLENGES

Federation models
- Bilateral agreement, Exchange

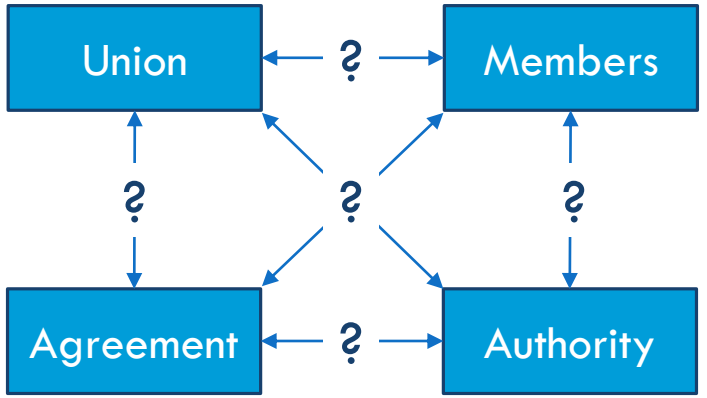


Orchestration
- Single-domain, Multi-domain

Service Level Agreement
- Design, Negotiation

Service catalogue
- Taxonomy, Packages

Multi-domain service delivery
- Resource abstraction, Information model



Challenges are both technological and business

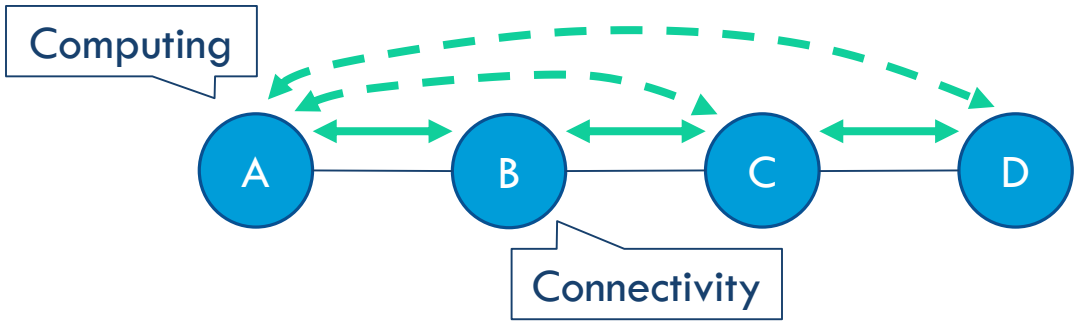
FEDERATION MODELS

Pricing management is key

Bilateral agreement

Each provider has long-lasting agreements with its neighbors

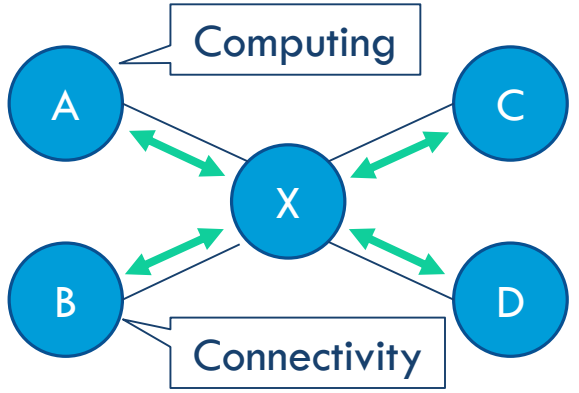
- Services are built on top of these agreements and service offerings are propagated
- Dynamic service offerings and pricing over long-term agreements



Exchange point

Providers have access to a common exchange point

- Either for profit or non-profit exchange points
- Dynamic contracting, invoking and settling for the wholesale consumption of resources



Authority?

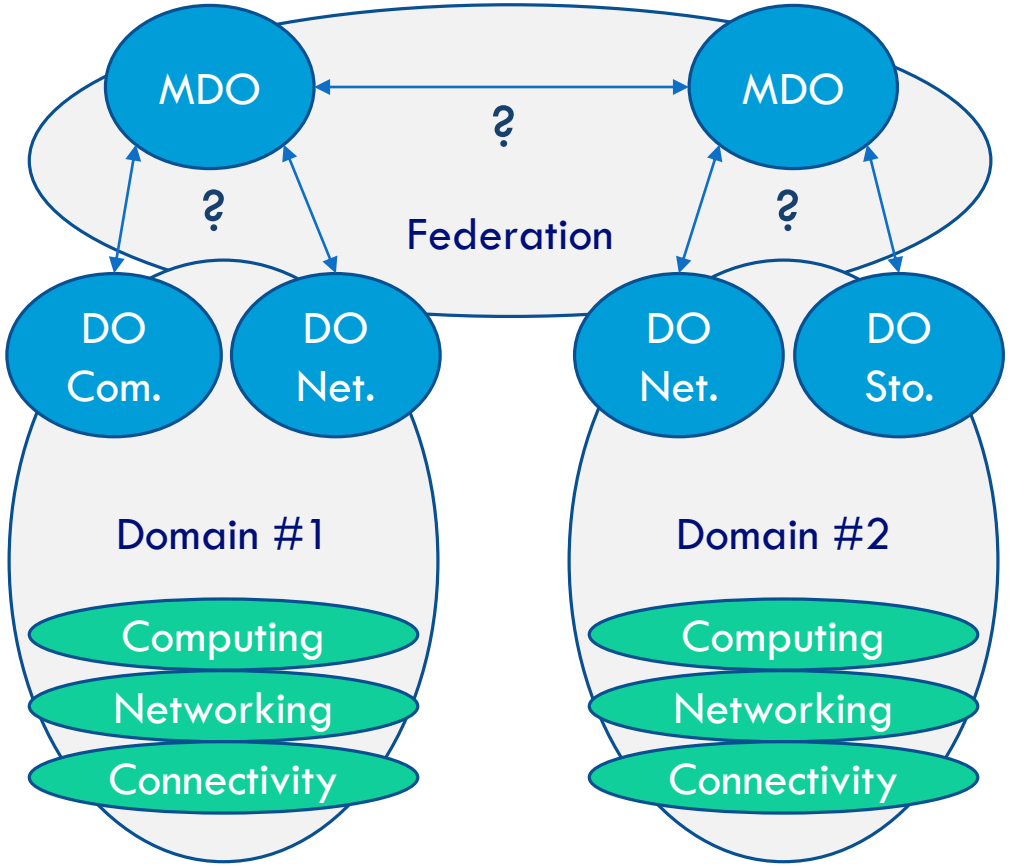
ORCHESTRATION

With no standard interfaces there is no interoperability

E2E service provisioning requires proper orchestration of the federated resources

- Joint orchestration of computing, storage and networking resources across administrative domain boundaries, in a common service offering
- One **Domain Orchestrator (DO)** per technological domain and one (or more) **Multi-domain Orchestrator (MDO)** per administrative domain in the federation

The definition of a **standard interoperable interface** among MDOs and/or between MDOs and DOs is of crucial importance to allow the extension of service provisioning beyond a single administrative domain



SERVICE LEVEL AGREEMENT (1)

A service level agreement/federation trust is an **official commitment** that prevails between different providers and usually consider aspects like:

- Type of resource and service to be provided
- The resource and service's desired performance level, reliability, and responsiveness
- Monitoring process and service level reporting
- The steps for reporting issues with the resource or service
- Response and issue resolution time-frame
- Repercussions for provider not meeting its commitment

SLA design and negotiation belong to both technical and business dimensions

The **SLA structure** should be flexible to allow for **multiple domain-specific metrics**

- Networking, Computing, Storage, Identity, etc.

SLA negotiation is currently done by humans and should be **automated**

- The management of responsibility resolution is critical (i.e., detect the specific failing domain)
- Resource monitoring and SLA assurance with appropriate time-scales (months vs. days) in the federation

SERVICE LEVEL AGREEMENT (2)

A common monitoring system is required across the multiple domains to fulfil the service level agreement

- Without knowing the status of the federated resources is hard to take and enforce any meaningful decision on the system

Monitoring features may vary depending on the service, e.g.:

- **Type**: Network status, Computing load, Storage availability, etc.
- **Granularity**: flow, link, network segment, server, data centre, etc.
- **Visibility**: full-visibility, aggregated, anonymized, etc.
- **Mode**: polling, push, hybrid, etc.
- **Privacy**: confidential data, expose only if anonymized, etc.

Monitoring is an enabler for SLA enforcing

SERVICE CATALOGUE

Multi-domain orchestrated services should be easily accessible and consumable by end-users (e.g., single entry point for booking resources and services)

- Services should be stored in some sort of catalogue where they can be traded and purchased

A common taxonomy is required to associate service elements to resources to be instantiated in the different domains

- A service taxonomy is a framework for organizing, labelling, and managing services

A common set of service packages is required for SLA negotiation

- E.g., connectivity + computing package

A common taxonomy and interface is required for service catalogue management

MULTI-DOMAIN SERVICE DELIVERY

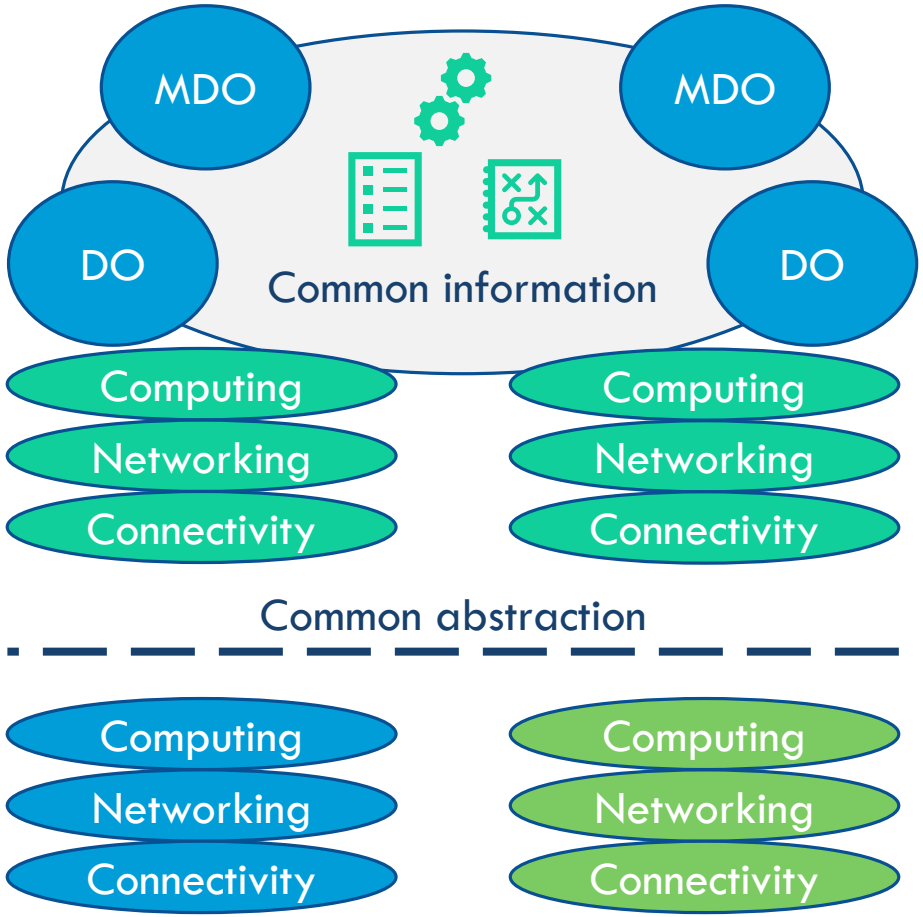
A set of heterogeneous resources spread across multiple domains need to cooperate in order to provision multi-domain orchestrated services

A common abstraction of resource description across domains is critical

- Services should not depend on the physical implementation of the single providers → Hide internal structure of the provider

A common information exchange and handling description is also required

- Providers should have a common information modelling with respect to resource repositories, pricing, SLA, service catalogues, etc.



CHALLENGES RECAP

A federation model involves both technical and business dimensions

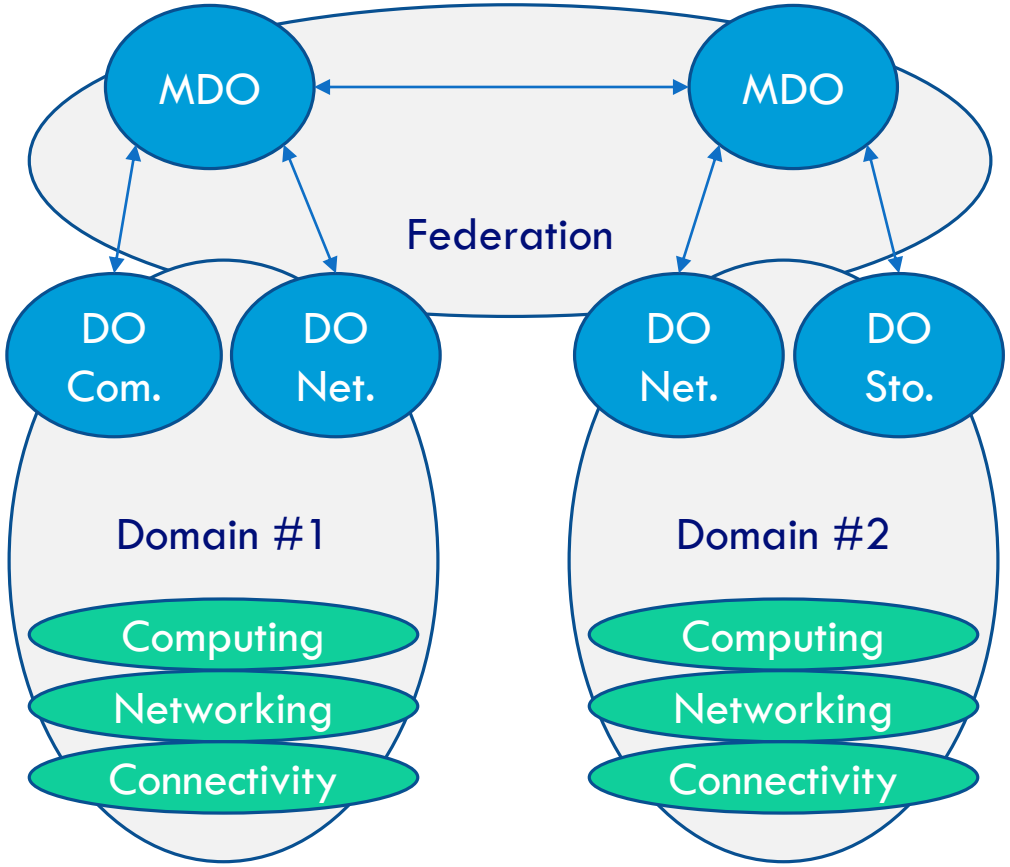
- A trade-off is required and a balance between the domains forming the federation should be achieved

90 minutes target cannot be met without automatization

- A common set of interfaces and abstractions is of paramount importance for multi-domain federation

An effective multi-domain service provisioning is key for the federation

- Service description, negotiation, management, monitoring, charging, responsibility resolution, etc.



OPPORTUNITIES

Multi-domain federation

FEDERATION OPPORTUNITIES

Full-fledged service offering

- Keeping under control all the components of the service

New service offerings

- Capacity of trading resources and service catalogue

Rapid footprint expansion

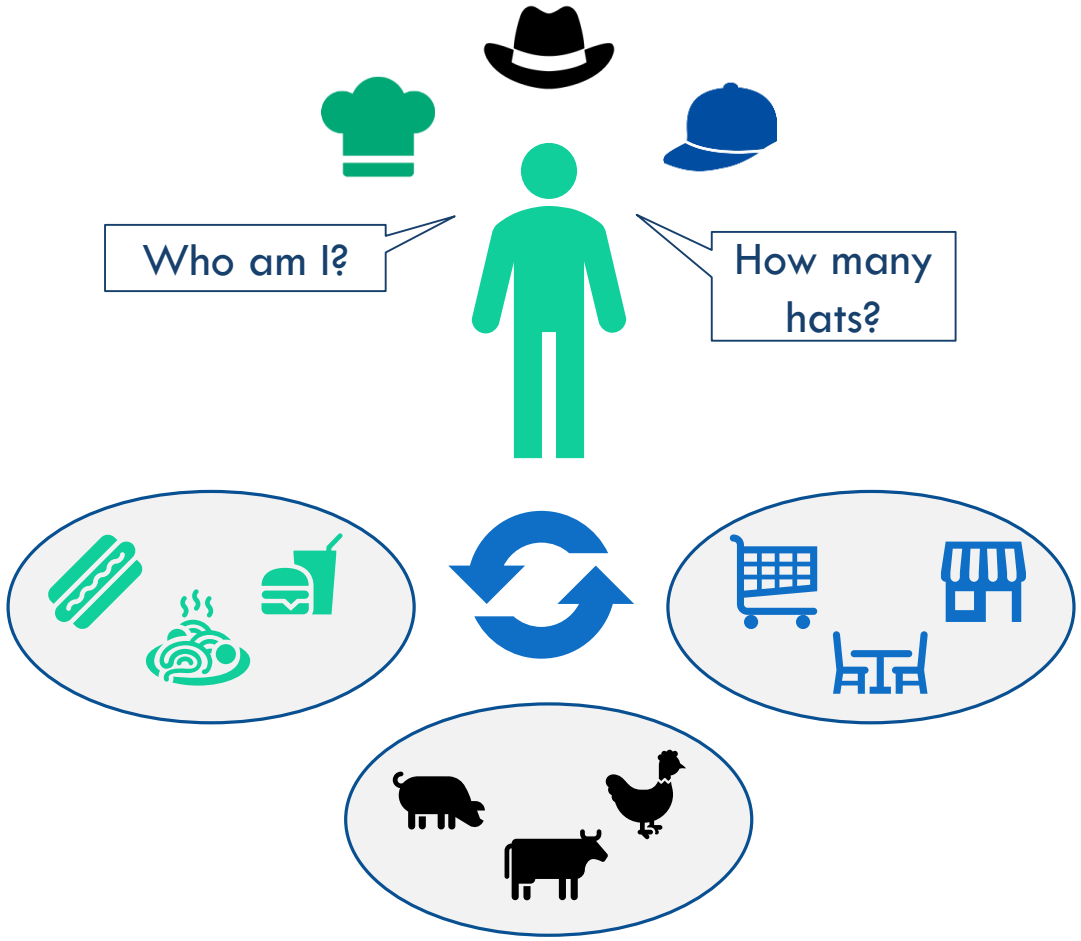
- Dynamic federation and pervasive presence

Faster market adoption

- Standardized interfaces and models

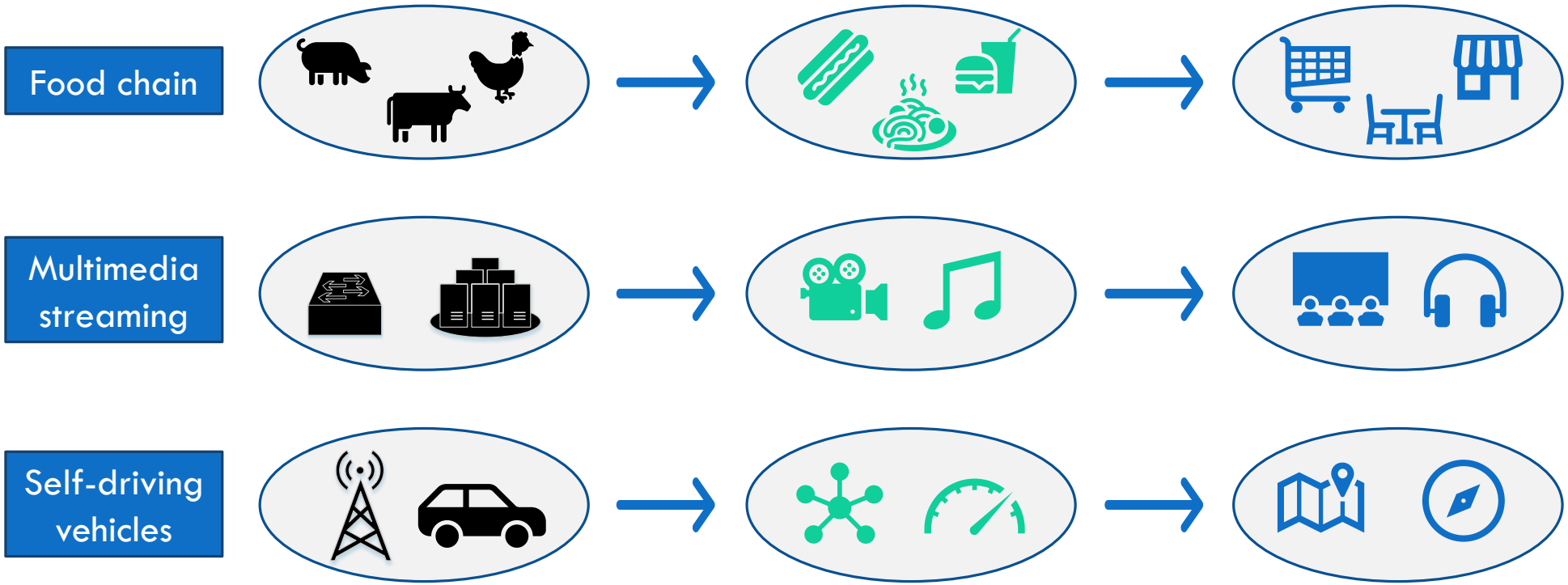
New business mechanisms

- New actors and roles



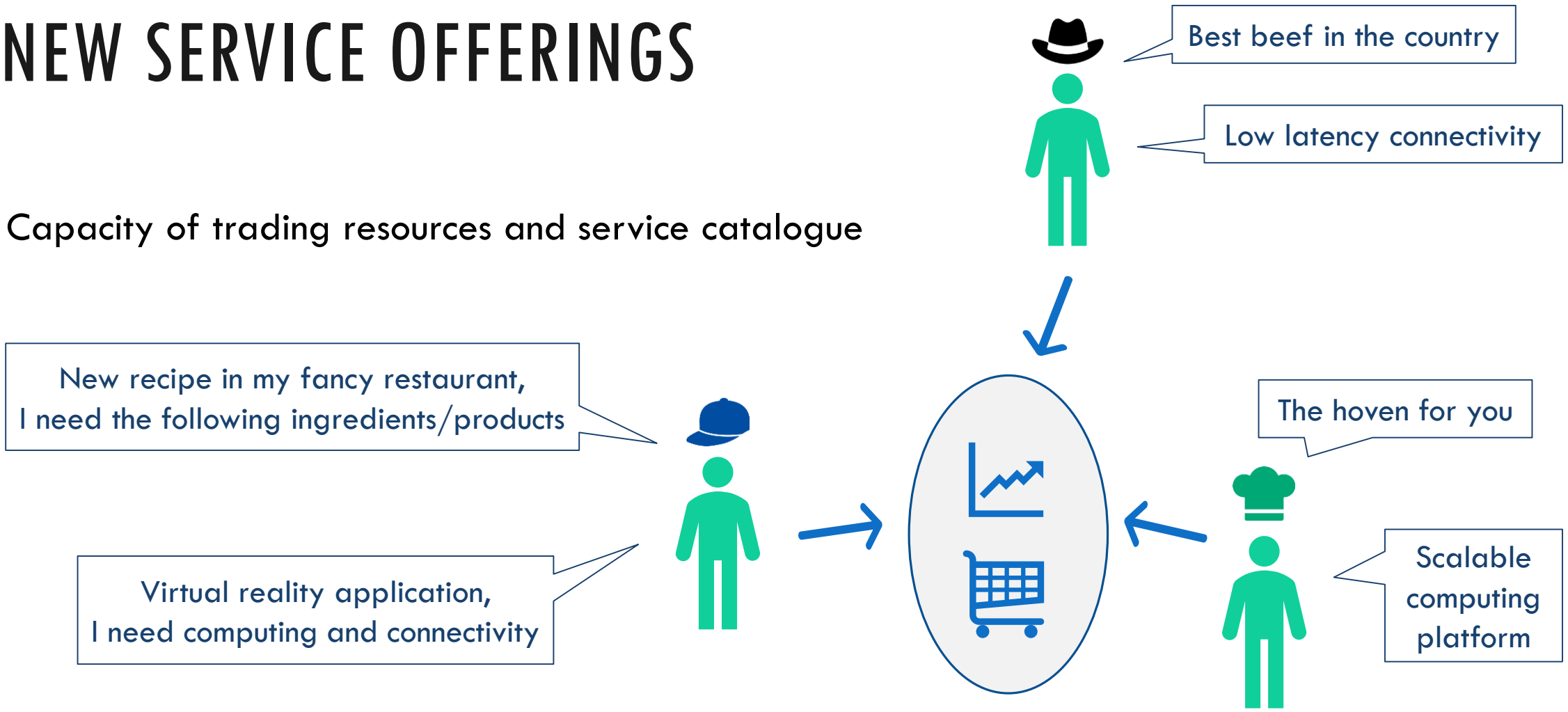
FULL-FLEDGED SERVICE OFFERING

Keeping under control all the components of the service



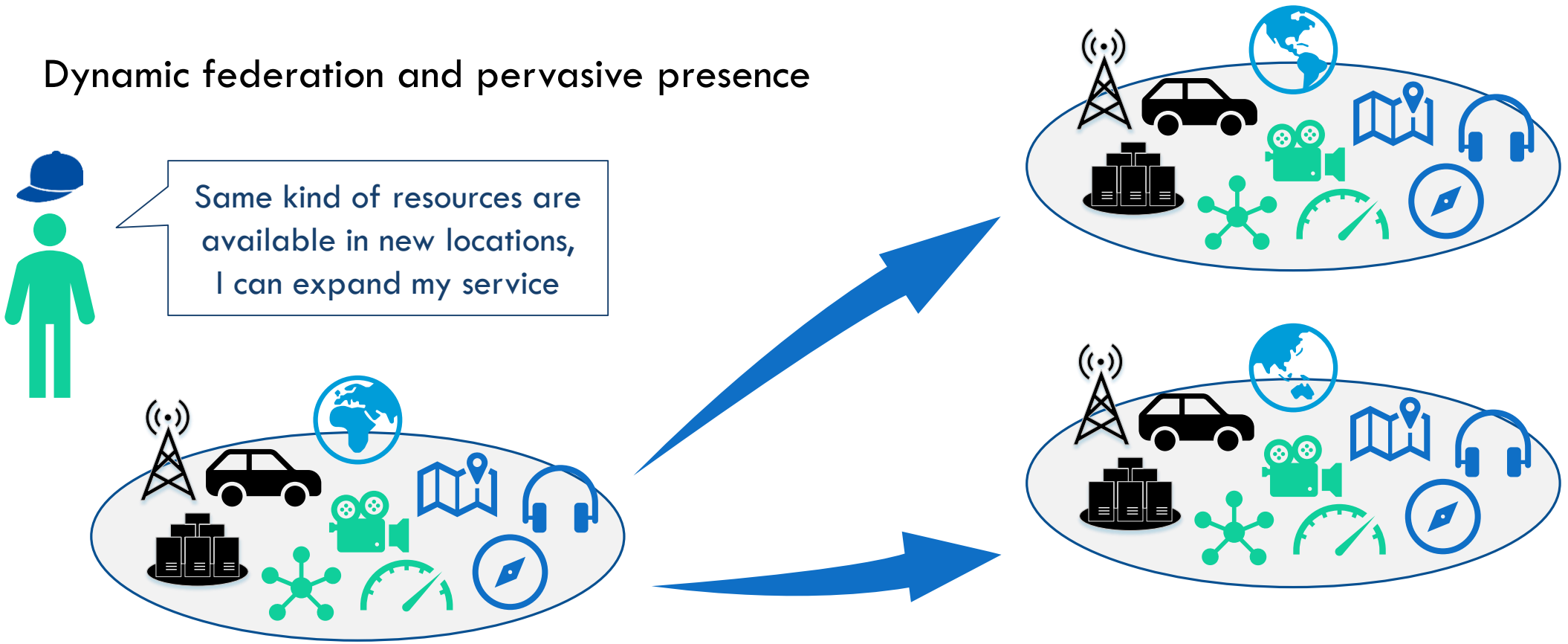
NEW SERVICE OFFERINGS

Capacity of trading resources and service catalogue



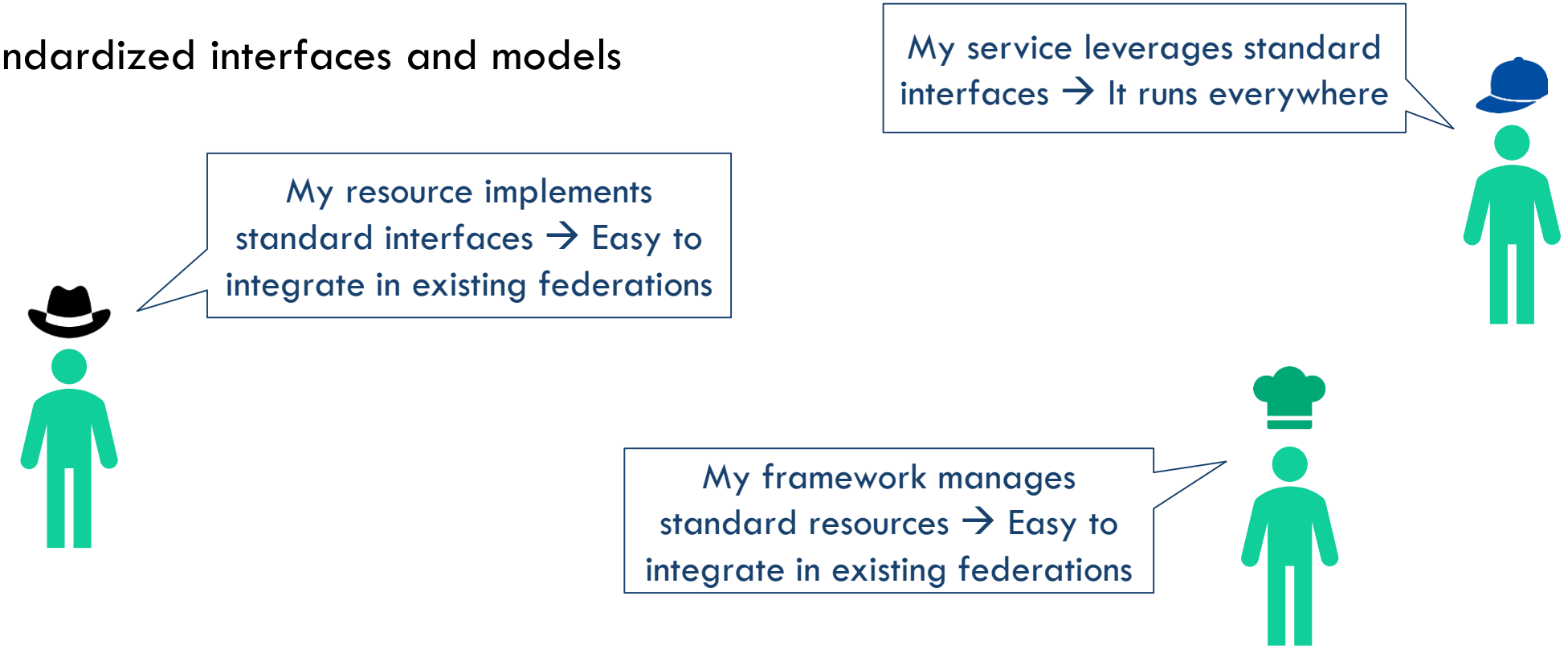
RAPID FOOTPRINT EXPANSION

Dynamic federation and pervasive presence



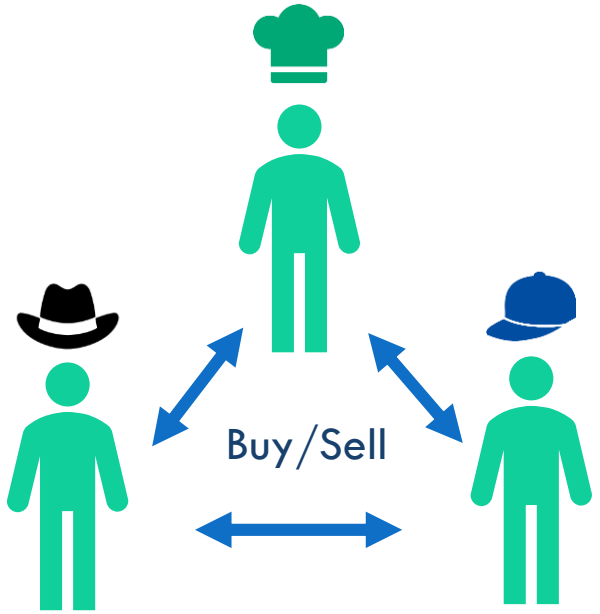
FASTER MARKET ADOPTION

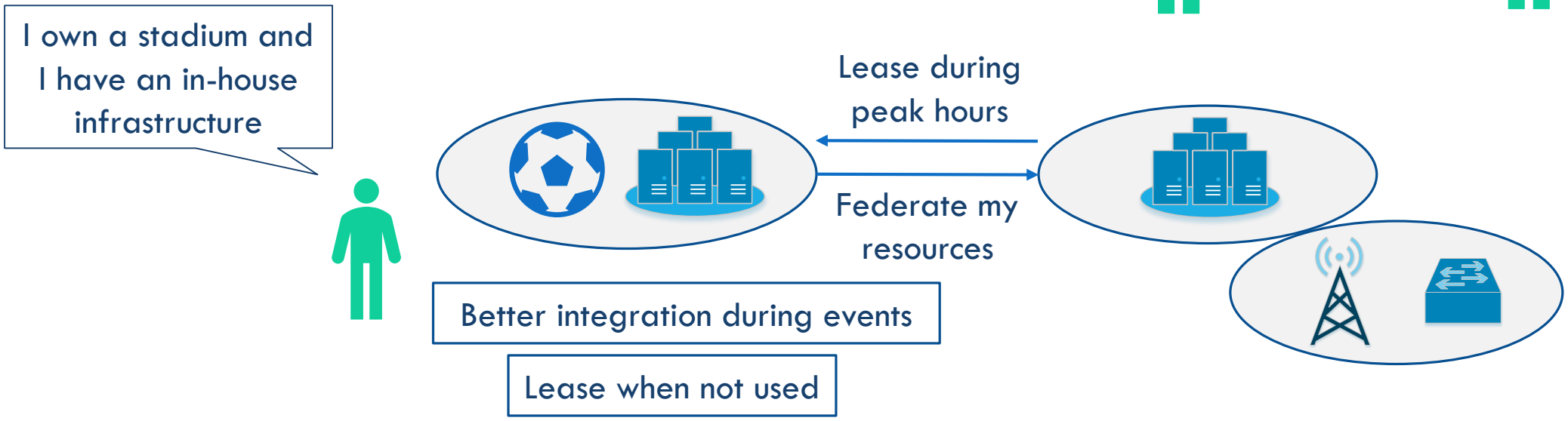
Standardized interfaces and models



NEW BUSINESS MECHANISMS

New actors and roles





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