Hyper-connectivity AMRES status and plans

AMRES

Akademska mreža Srbije

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HPC and AI data centers

- Compute nodes
- Storage nodes
- Network (DC LAN, WAN)
- DC infrastructure (e.g. Power, cooling etc.)
- Software Stack
- Applications
- Security

EuroHPC JU

- The European High Performance Computing Joint Undertaking (EuroHPC JU) is a legal and funding entity, created in 2018 by EC, located in Luxembourg to lead the way in European supercomputing (HPC, AI and Quantum). It is established for a period until 31 December 2033.

- EuroHPC JU coordinate efforts and pools together resources of the European Union (EU), the European participating countries and private partners to develop a supercomputing ecosystem in Europe, to boost European competitiveness, support the digital transformation of its economy, support innovations while ensuring its technological sovereignty.

- The EuroHPC Joint Undertaking (EuroHPC JU) is dedicated to funding the development of high-performance computing (HPC) infrastructure and applications, while also promoting the adoption and advancement of HPC solutions across key sectors vital to scientific progress and economic growth.

- Additionally, it supports education and skills development in the field of supercomputing, fostering a highly qualified workforce capable of leveraging HPC technologies for innovation and competitiveness.

EuroHPC JU

#EuroHPC
Joint Undertaking

The European High Performance Computing Joint Undertaking (EuroHPC JU) will pool European resources to develop top-of-the range exascale supercomputers for processing big data, based on competitive European technology.

Member countries are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Montenegro, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Türkiye and United Kingdom.

EuroHPC

EuroHPC JU and Hyperconnectivity

- One of the mission of the EuroHPC JU is to develop, deploy, extend and maintain in the Europe federated, secure and **hyper-connected** supercomputing, quantum and AI computing, service and data infrastructure ecosystem.

- One of the central parts of EuroHPC's vision is hyperconnectivity:

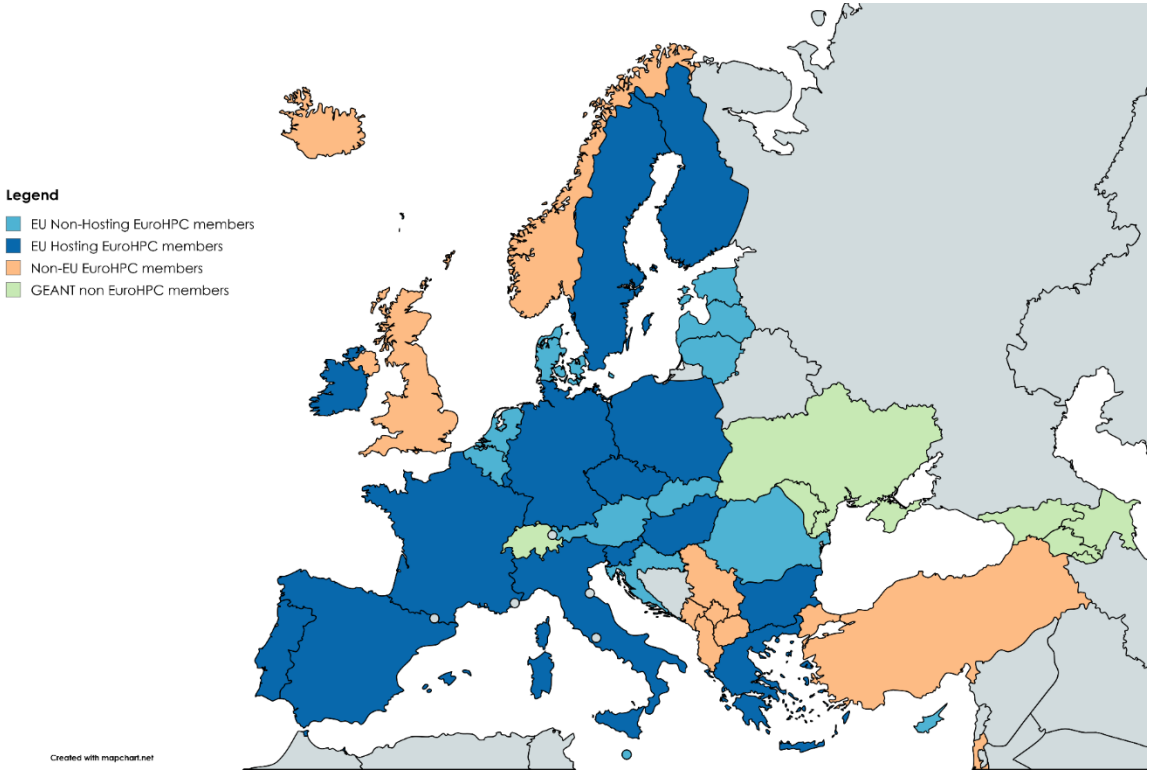
  - The EuroHPC systems themselves must be interconnected with state-of-the-art networking technologies to facilitate collaboration and resource sharing and to make them widely accessible across the EU.

  - Second, these EuroHPC systems need to be integrated into the broader HPC ecosystem, which includes national supercomputers and data infrastructures.

- What does Hyper-connected actually mean?
  - **'hyper-connected'** means a communication capability of transferring data at 10 to the power of twelve bits per second (1 Terabit per second) or beyond;

EuroHPC JU

- **35 Members**
- **All 27 EU countries + 8 Non-EU**
- **15 HPC Hosting countries - with 3 (HPCs) in the Top10***
- Finland – LUMI*
- Sweden – Arrhenius
- Portugal – Deucalion
- Luxembourg – MeluXina
- Italy – Leonardo*
- Czech Republic – Karolina
- Spain – Marenostrum 5*
- Hungary – Levente
- France – Jules Verne
- Bulgaria – Discoverer
- Ireland – CASPIr
- Poland – EHPCPL
- Slovenia – VEGA
- Germany – Jupiter
- Greece - Daedalus



EuroHyPerCon project

- **EuroHyPerCon project -** Study for hyper-connectivity for HPC resources - funded by EuroHPC JU (2023-2024)
- The main scope of the project was to identify and analyze the connectivity requirements of European and national High Performance Computing (HPC) systems and data centers in Europe, and subsequently specify a future-proof connectivity service, along with its implementation roadmap.
- EuroHyPerCon project as a result produced detailed long-term specification of the hyper-connectivity service and laying out an implementation roadmap for the development of the EuroHPC hyper-connectivity infrastructure.
- The solution for HPC hyper-connectivity services proposed in the study leverage the GÉANT and NRENs networks and take into account the complementary connectivity of European activities, including the ongoing Framework Partnership Agreement for Research and Education Networks (GN5-FPA) and related specific grant agreements.

Hyper-connectivity – Call for tender

- The EuroHPC JU has published a call to build a high-speed, secure network connecting European supercomputers and data centers, creating a hyper-connected and federated HPC, AI and quantum computing ecosystem. (Call for Tender to Hyper-connect European Supercomputers (Decembre 2024)).
- This tender aims to create hyper-connectivity and advanced supercomputing network services delivering ultra-fast connections between EuroHPC systems, **while also linking national and regional supercomputing and data centers across Europe, that are not part of the EuroHPC network.**
- The target is to achieve terabits-per-second (Tbps) connectivity, enabling a future-proof infrastructure that supports cutting-edge research, artificial intelligence, and data-driven innovation on a continental scale.

Call for tender - Where is the issue?

- The call is open exclusively to Member States of the European Union (EU) and it is funded by EU CEF program.

- Republic of Serbia is not member of EU and need to find appropriate way to integrate national HPC, AI and Quantum resources to this infrastructure and ecosystem in order to neutralize creation of a new digital divide towards the EU member state countries.

Solution in the case of the Republic of Serbia ?

AMRES institutions and infrastructure

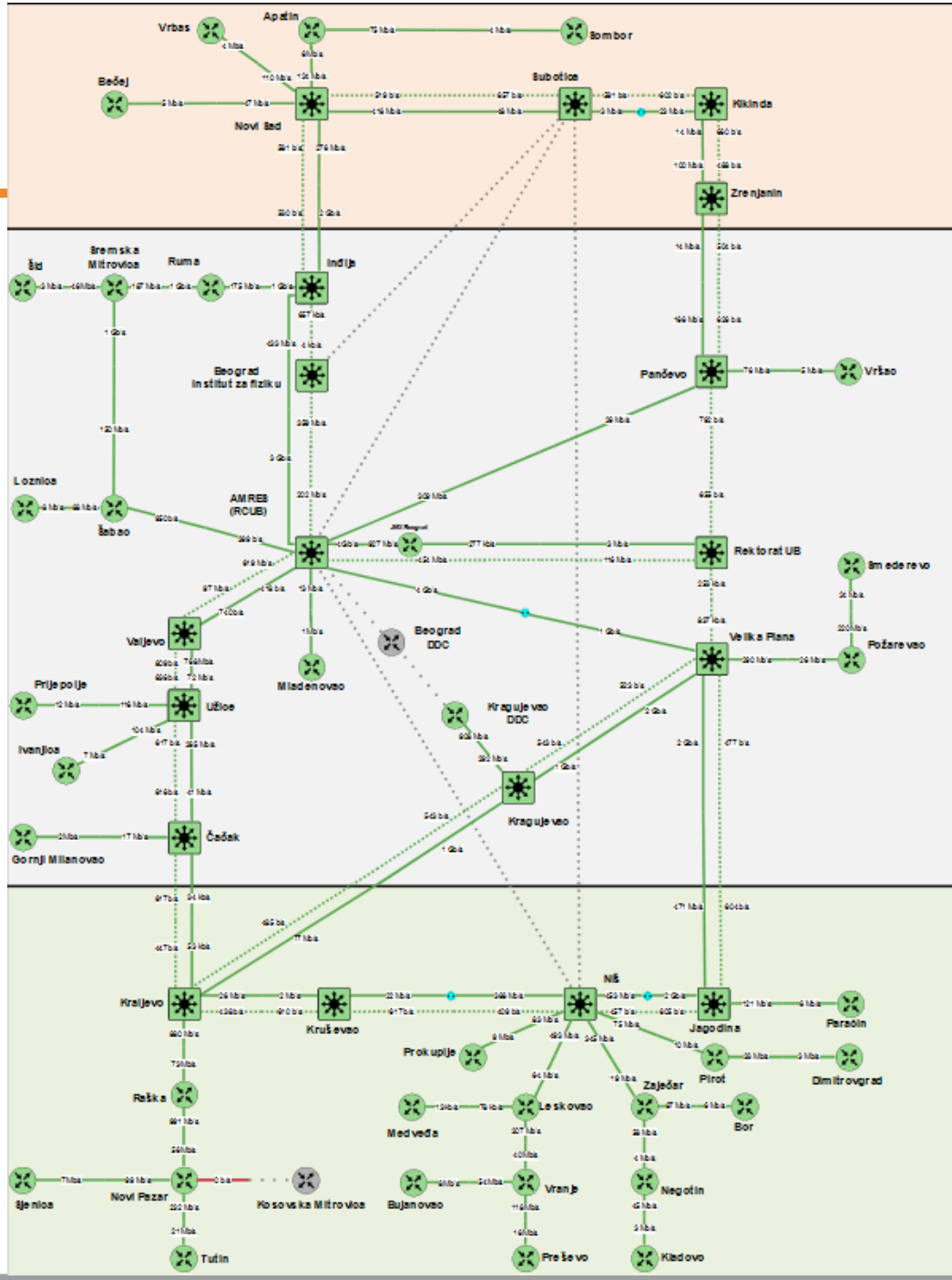
- AMRES connects universities, faculties, institutes, medical institutions (knowledge bases of medical faculties), colleges, secondary and primary schools, libraries, museums, as well as other educational and cultural institutions (approximately 2000 different institutions with around 4100 locations).
- AMRES is fully (100%) funded by the Ministry responsible for telecommunications Goverment of Republic of Serbia and has no independent income.
- AMRES leases around 4200 kilometers of DF optical fibers. The optics are leased through a long-term SeeLight contract (~3800 km of DF optical fibers, the IRU contract is concluded for a period of 15 years, 2011 - 2026), as well as through annual contracts for connecting school locations to TS (~400 km of DF optical fibers).
- AMRES connects all 6 state universities in the Republic of Serbia, but also connect 2 state universities of the Republic of Srpska trough the (SARNET).
- Additionally, AMRES connects the DDC in Kragujevac (AI platform), as well as Institute of physics (HPC and AI) where available supercomputers of the Republic of Serbia are hosted.

AMRES DWDM network

- DWDM and IP/MPLS technologies are implemented on the backbone of the AMRES network.
- DWDM is the key technology to provide capacities needed for hyper-connectivity.
- Current AMRES DWDM transport equipment is installed in 20 nodes with service capacities of n x 100Gbps (Belgrade, Kragujevac, Niš, Subotica) and n x 10Gbps (remainder of the network).
- Lambda DWDM services of the 100Gbps, 200Gbps or 400Gbps can be multiplexed in order to achieve 1,2 Tbps capacity (e.g. 3 x 400Gbps) for data transfers.
- DDC in Kragujevac (AI platform), as well as Institute of physics (HPC and AI) are AMRES DWDM PoPs and support DWDM technology.
- AMRES plan to upgrade central PoP in Belgrade as well as PoP in DDC in Kragujevac in order to increase there capacities and to directly connect AMRES and GEANT DWDM network in Cetin DC in Belgrade during the 2026.

AMRES IP/MPLS network

- The backbone of the AMRES IP/MPLS network consists of approximately 90 links and 75 routers.
- IP/MPLS network equipment is installed in about 70 PoPs in 50 cities of the Republic of Serbia with interface capacities of 10/1 Gbps. Some PoPs include equipment with interface capacities of 400/100/10 Gbps.
- Depending on the specific projects needs MPLS AMRES network support different MPLS VPN services:
  - L3VPN
  - L2VPN
  - VPLS
  - EVPN



AMRES MPLS services for HPC DC

- **L3VPN (Layer 2 Virtual Private Network)** - Provides isolated, secured private IP routing or virtual IP networks over shared MPLS infrastructure. **L3VPNs are ideal for projects that need site-to-site connectivity with robust routing control, privacy, and minimal complexity on their own hardware.**

- L2VPN (Layer 2 Virtual Private Network) over MPLS is a service that **allows geographically distributed customer sites to be connected as if they were on the same local Ethernet or VLAN network.**

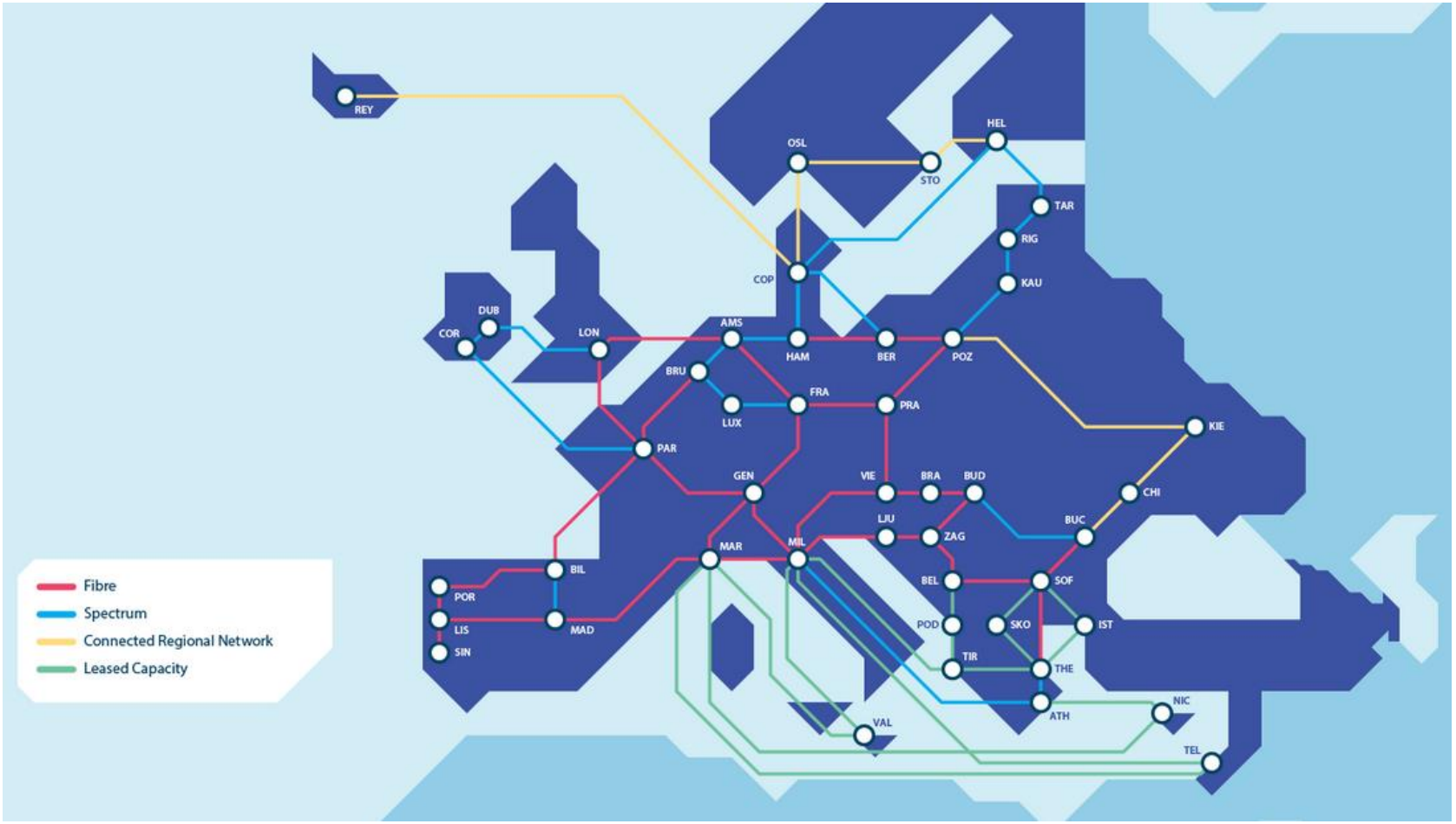
- It works by encapsulating Layer 2 Ethernet frames into MPLS packets using **"pseudowires" which tunnel the frames across the provider's MPLS backbone**, keeping the customer's MAC addresses and VLAN tags intact. This enables transparent Layer 2 connectivity, allowing organizations to run their own IP routing, support legacy protocols, or extend broadcast domains between remote data centers and offices.

AMRES MPLS services for HPC DC

- **VPLS (Virtual Private LAN Service)** is a Layer 2 VPN technology that connects multiple geographically dispersed sites by creating a single, bridged Ethernet domain over an MPLS backbone. It emulates the behavior of a traditional LAN, allowing all connected sites to appear as if they are on the same Ethernet switch, supporting features like MAC address learning, VLAN tagging, and broadcast/multicast traffic.

- **EVPN (Ethernet VPN)** is an advanced Layer 2 VPN technology that uses **BGP (Border Gateway Protocol)** to efficiently manage and distribute MAC address and IP routing information across an MPLS or VXLAN network. It combines the benefits of traditional VPLS with **improved scalability, multi-homing support, and optimized traffic forwarding by using control-plane learning instead of relying solely on data-plane learning.** EVPN enables seamless, flexible, and resilient Ethernet connectivity between multiple sites or data centers, making it ideal for modern cloud and hybrid network environments.

The pan-European research and education network - GEANT



GEANT

- The pan-European research and education network GÉANT has continuously provided high-speed connectivity services over the past 25 years, interconnecting the National Research and Education Networks (NRENs) — or in some cases regional networks— in Europe and beyond.

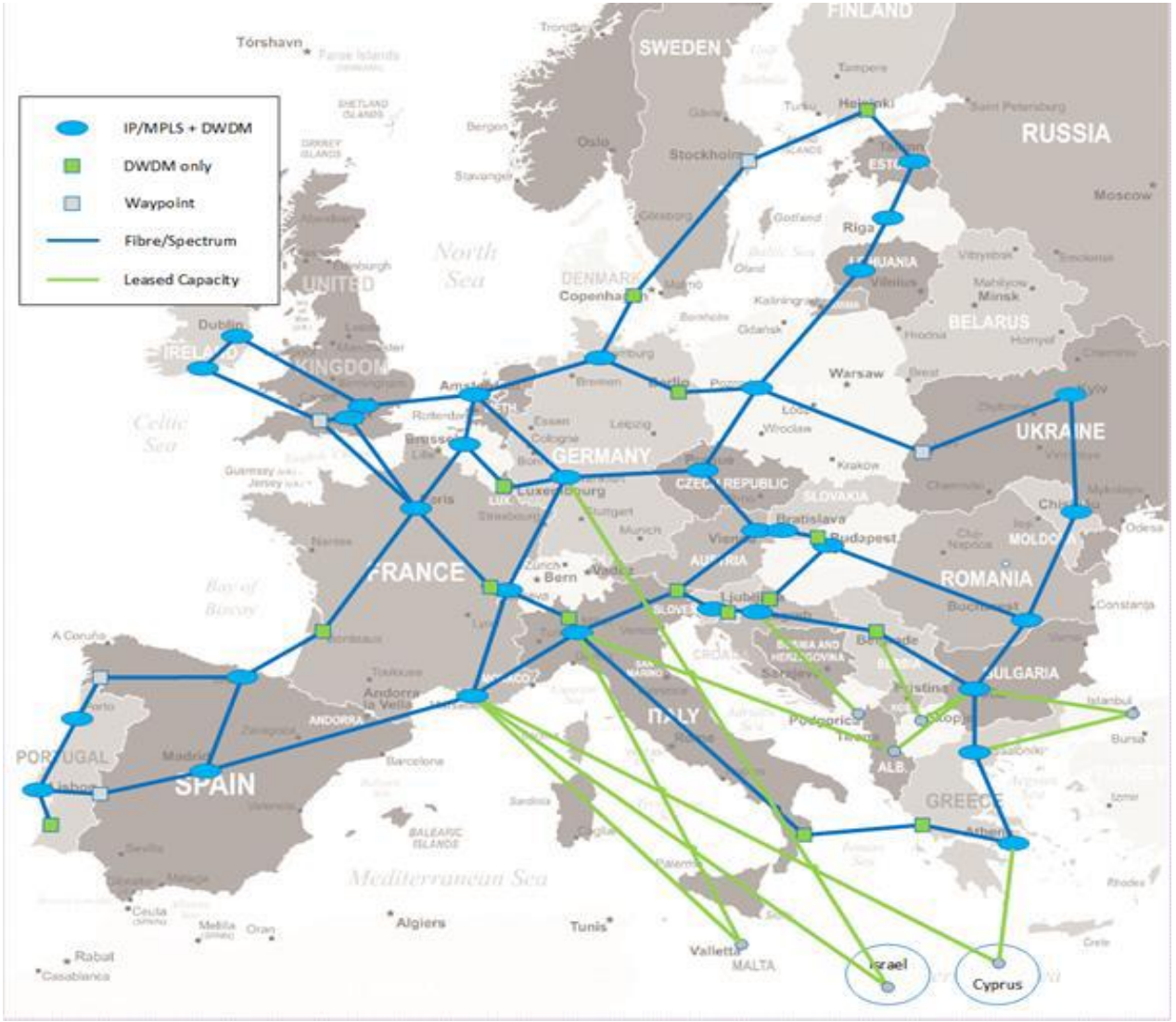
- National Research and Education Networks (NRENs) are specialized internet service providers dedicated to supporting the needs of the research and education communities within their own country.

- GÉANT has Points of Presence (PoPs) inside the NREN countries, while the NRENs have corresponding backbone and access networks in their respective countries that interconnect research, academic and other public institutions and act as national connectivity providers for research, academia, and innovation.

- Through interconnections with more then 35 National Research and Education Network (NREN) partners, the GÉANT network is the largest and most advanced research and education (R&E) network in the world, connecting over 50 million users at 10,000 institutions across Europe and supporting all scientific disciplines.

- During the 2025 GEANT will form IP/MPLS PoP in Serbia and capacity for the AMRES connections to GEANT network will be increased from 2x100Gbps to 2x400Gbps.

GEANT Network



Summary

- AMRES has already implemented appropriate technologies whose features can enable the integration of HPC and AI resources within the Republic of Serbia, as well as their connection with the European infrastructure.

- With the planned infrastructure upgrades, AMRES will be capable of meeting the demands of hyper-connectivity required for all potential future needs of Serbia's HPC and AI community, and will facilitate the integration of national resources with the European infrastructure.

Appendix:

- TCS (Trusted Certificate Service) service - AMPEC, in collaboration with the GÉANT organization, offers a service for issuing digital SSL/TLS certificates to AMRES users who have the right to use domains under "ac.rs", "edu.rs", and "gov.rs".

- iAMRES Identity Federation - The identity federation significantly simplifies inter-institutional access to web services. Within the identity federation, a user has a single digital identity provided by their home institution — where they work or study. By using this digital identity, the user can access services offered through the Identity Federation.

Hyper-connectivity - AMRES status and plans