A short introduction to the Worldwide LHC Computing Grid

January 21, 2023

The LHC challenge

- ~100+ PetaByte / year
  - Current total 1.5+ ExaByte
- Data analysis requires at least ~1M typical PC processor cores
- Scientists in tens of countries worldwide
- CERN can provide up to 20-30% of the storage and CPU
- We need a GRID !

What is a grid?

- Relation to WWW?
  - Uniform easy access to shared information
- Relation to distributed computing?
  - Local clusters
  - WAN clusters
- Relation to distributed file systems?
  - NFS, AFS, DFS, …

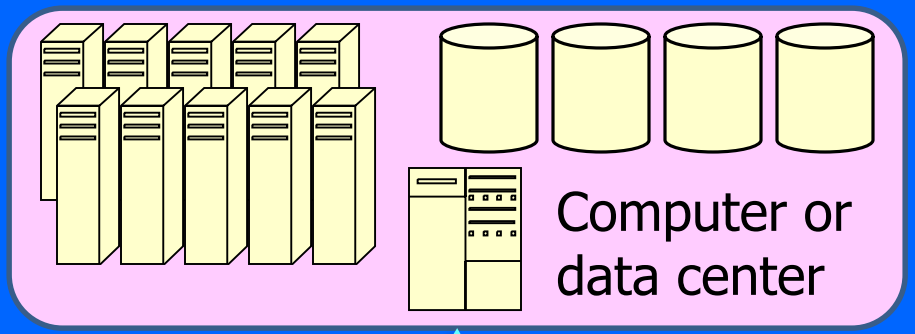
- A grid gives selected user communities uniform access to distributed resources with independent administrations
  - Computing, data storage, devices, …

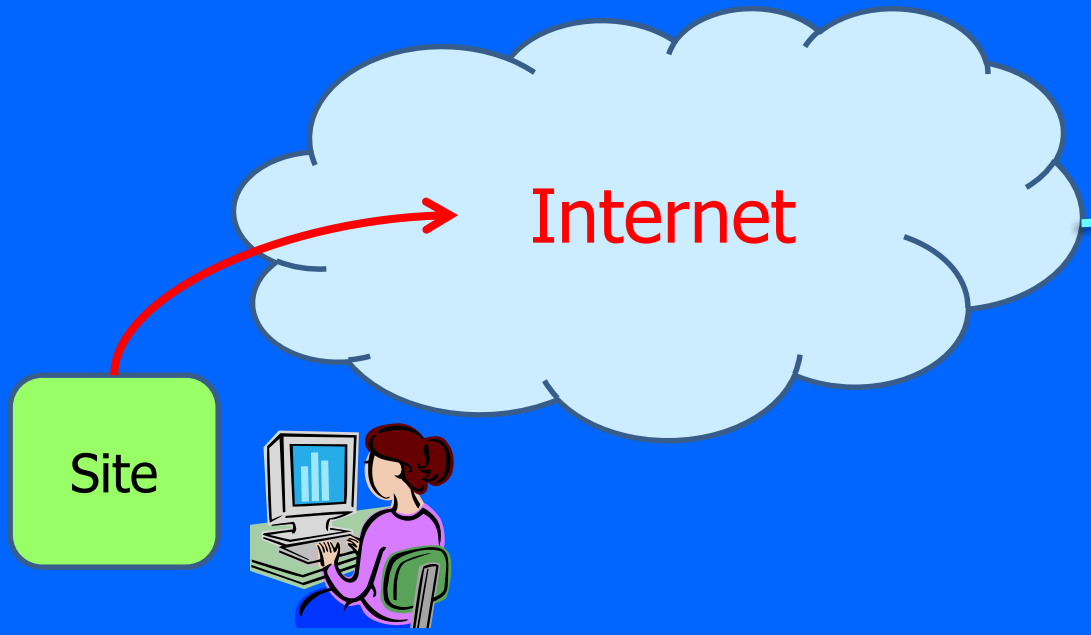
Why is it called grid?

- Analogy to power grid
  - You do not need to know where your electricity comes from
  - Just plug in your devices
- You should not need to know where your computing is done
  - Just plug into the grid for your computing needs
- You should not need to know where your data is stored
  - Just plug into the grid for your storage needs

What is cloud computing?

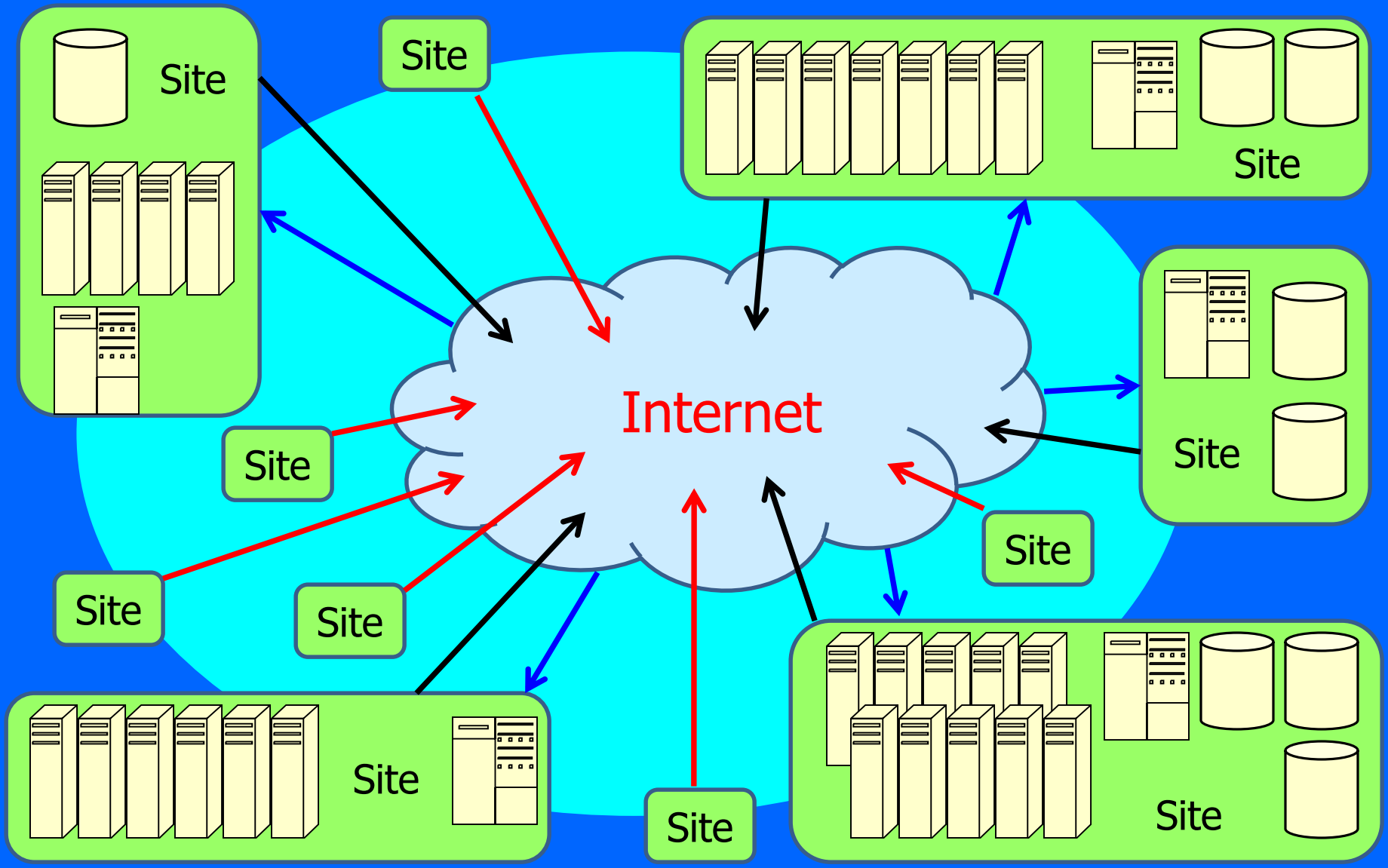
- Transparent use of generic computing resources off-site
  - Dynamically provisioned
  - Metered
- Neutral to applications
  - Rent-a-center





- Amazon EC2, S3
- Microsoft Azure
- Google
- IBM
- Alibaba
- Oracle
- …

What is grid computing?



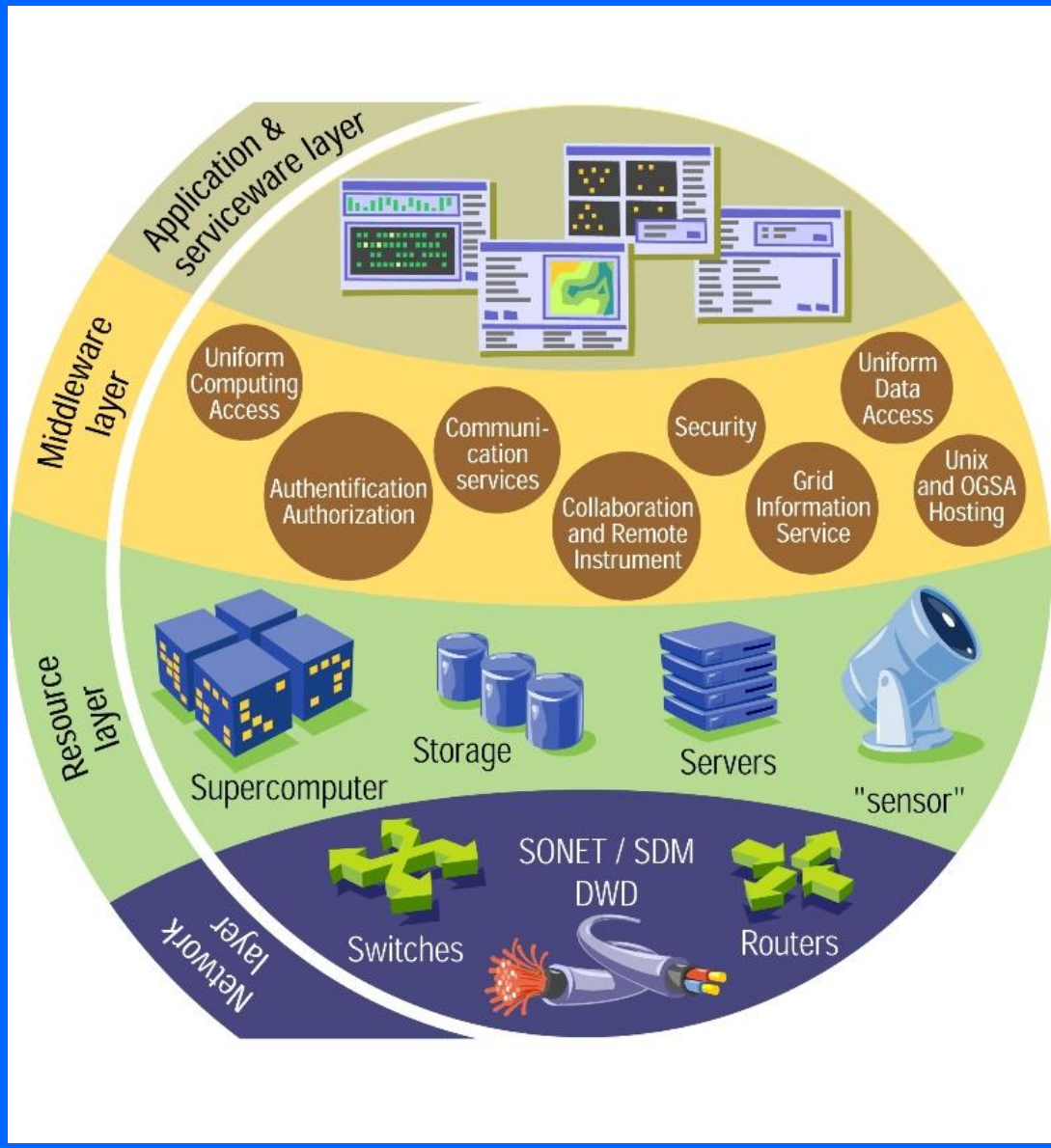
What is grid computing about?

- A grid facilitates collaboration between members of a supported distributed community
  - They can form a Virtual Organization within that grid
- A grid allows distributed resources to be shared uniformly and securely for common goals
  - Computing
  - Data storage
- A grid can support multiple Virtual Organizations in parallel
  - Sites, computer and data centers make selections according to the projects in which they participate
  - The quality of service may differ per VO

How does a grid work?

- Middleware makes multiple computer and data centers look like a single system to the user
  - Security
  - Information system
  - Data management
  - Job management
  - Monitoring
  - Accounting

- Not easy!
  - Independent sites
  - Different systems
  - Local policies/priorities
  - Other users



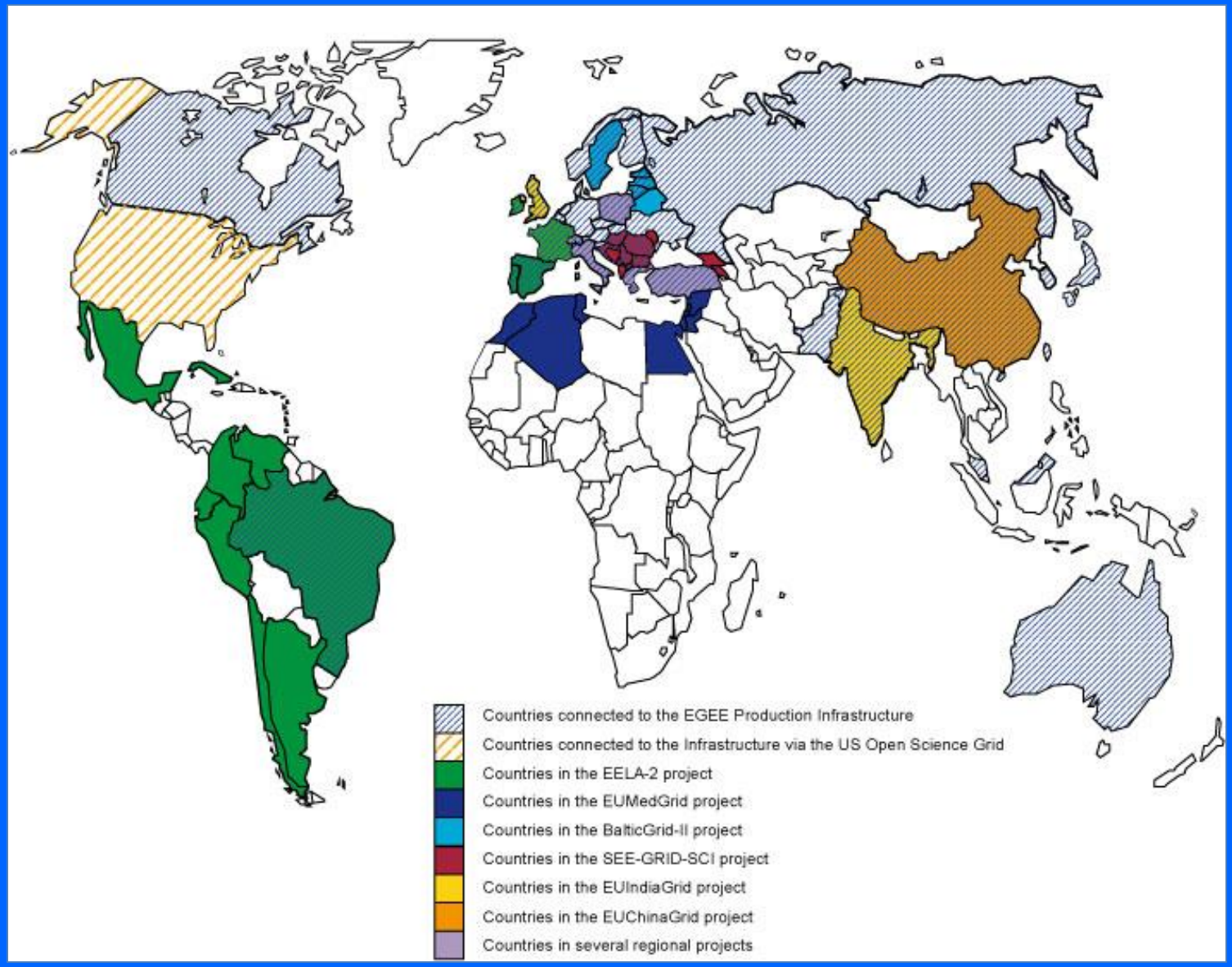
Where can we use grids?

- Scientific collaborations
  - Can also serve in spreading know-how to developing countries
- Industry? Commerce?
  - Mostly cloud computing
- Homes? Schools?
  - Internet Service Providers → cloud computing
  - Secure data sharing technologies?
    - E-learning
    - Social media
- Government? Hospitals? Other public services?
  - Beware of sensitive/private data

Many grids can coexist

- EGI – European Grid Infrastructure
  - Successor of EGEE – Enabling Grids for E-sciencE ← led by CERN
- OSG – Open Science Grid
  - USA and beyond
- National
  - IGI (It), GridPP (UK), DFN (De), France Grilles, …
- Regional
  - NorduGrid (Nordic countries), BalticGrid (Baltic region), SEEGrid (South-East Europe), EUMedGrid (Mediterranean), …
- Interregional
  - EELA (Europe + Latin America), EUIndiaGrid, EUAsiaGrid, …
- WLCG – Worldwide LHC Computing Grid
  - Federation of EGI, OSG, Nordic Data Grid Facility, …

Projects that collaborated with EGEE



Many communities can coexist

- High-energy physics
- Astrophysics
- Fusion
- Computational chemistry
- Biomed – biological and medical research
  - Statistical analysis of anonymized data
  - "In silico" discovery of new drugs and vaccines
  - …
- Earth sciences
- UNOSAT – satellite image analysis for the UN
- Digital libraries
- …

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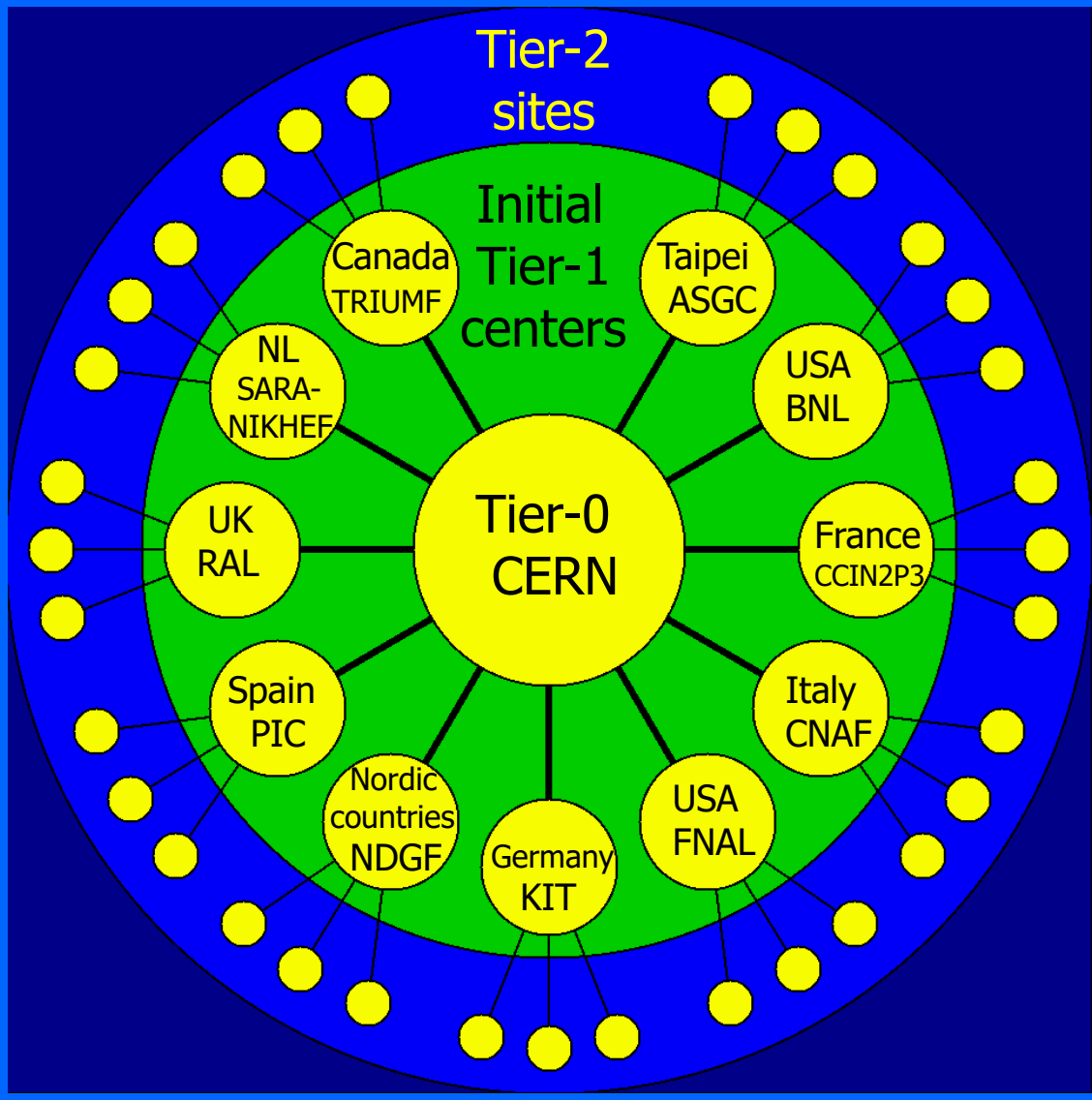
- Scientists in tens of countries worldwide
- CERN can provide up to 20-30% of the storage and CPU
- 70-80% are provided by WLCG partners

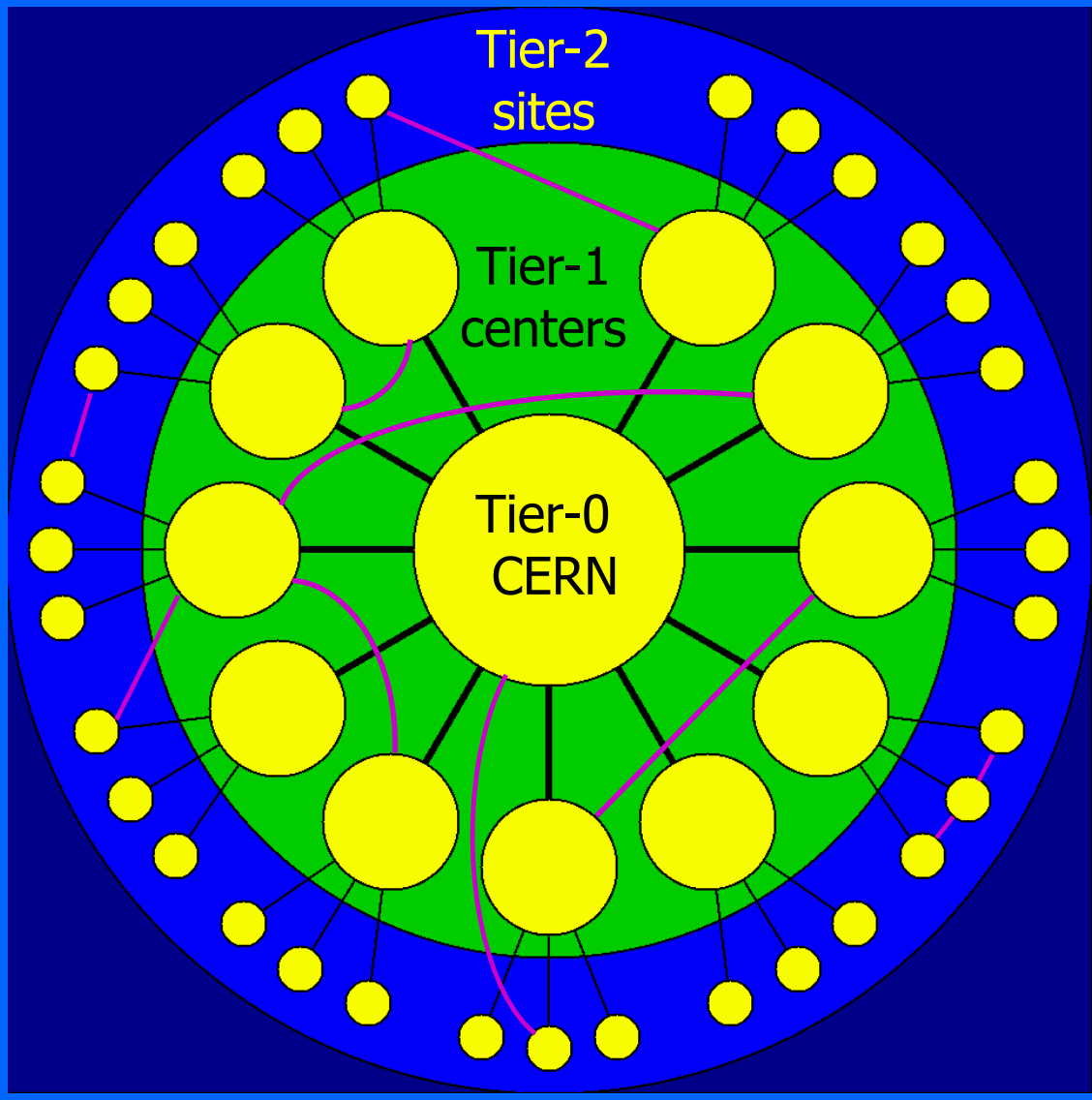
The WLCG answer

- 160+ computing centers
  30+ countries
- Hierarchical and regional organization
- 15 large centers for long-term data management
  - CERN = Tier-0
  - 14 Tier-1 centers
    - South Korea: KISTI
    - Russia: JINR, NRC-KI
  - Fast network links
- 60+ federations of 140+ smaller Tier-2 centers
- Tens of Tier-3 sites
  - Resources outside of WLCG policies



The WLCG evolution

- Fast networks allow for direct transfers between:
  - Tier-1 sites
    - Also providing backup routes since years
  - T2 in the same region
  - T2 and T2/T1/T0 in different regions
- Set of fast network hubs connecting many T2 to many T1 and T0
  - LHCONE = LHC Open Network Environment
- T1 and T2 sites keep their different responsibilities



WLCG Tier-1 centers

WLCG sites

WLCG in action

Conclusions

- Grids facilitate collaboration between members of supported distributed communities
- Grids allow distributed resources to be shared uniformly and securely for common goals
- Grids may have complex infrastructures
- Grids are useful for many scientific disciplines and projects

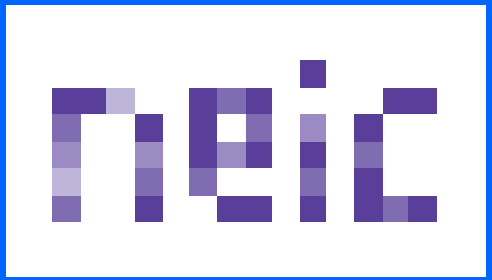
The Worldwide LHC Computing Grid is vital for the success of the LHC experiments !

More information

wlcg.web.cern.ch

www.egi.eu

www.opensciencegrid.org



www.ndgf.org