CSCS
Centro Svizzero di Calcolo Scientifico
Swiss National Supercomputing Centre

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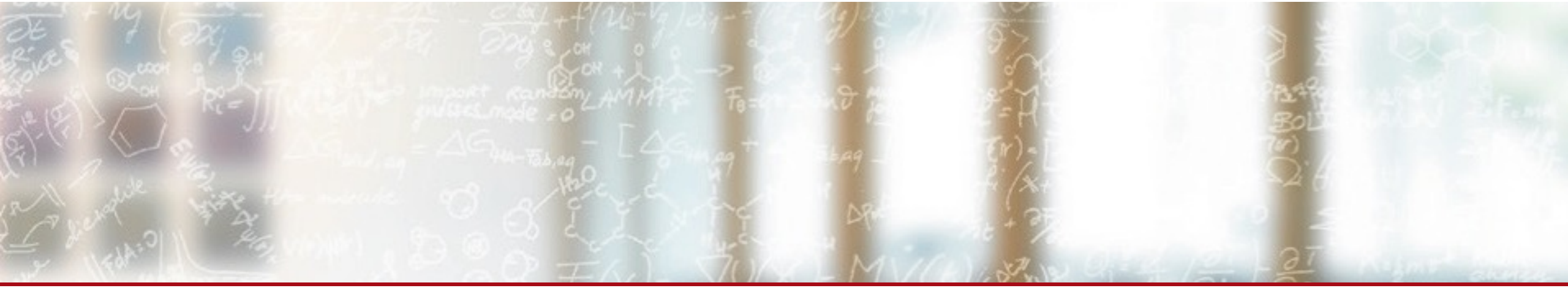

The future of extreme compute and data

Swiss SKA Days 2022

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Extreme compute

- Today's world compute capability?
  - EFlops sum of top 10 systems (~0.5 EFlops/year):
    - Jun 2022 – 2.25 EFlops
    - Nov 2018 – 0.5 EFlops
  - Not listed machines: how many exaflops machines in China or in the industry?

- Technology
  - We are in the silicon era with the use of accelerators
  - Changing era?
    - Nanotechnology, carbon nanotubes instead of silicon transistor
    - Photonics, photons instead of electrons
    - When for large-scale manufacturing?
  - Quantum computing: might be a specific accelerator?

Extreme compute challenges

For most countries sustaining a unique 1-Eflops machine is today's limit

- Power efficiency barrier
  - 1 Eflops ~= 20 MW
    - Large hydropower plant: ~30-50 MW
    - Nuclear plant: ~500-1000 MW
  - Reduce power needs, moving large HPC systems to colder countries
- Money challenge
  - Frontier 1.1 EFlops = $600 Million to build
  - Operational cost over the supercomputer lifetime – 20-30% of building cost
  - Variability of power cost
- Usability and programming
  - Build programming abstraction in scientific software
    - DSL / specialized libraries / hardware-specific back-end
    - Refactoring existing codes takes many years of development
  - Performance engineering

Extreme data

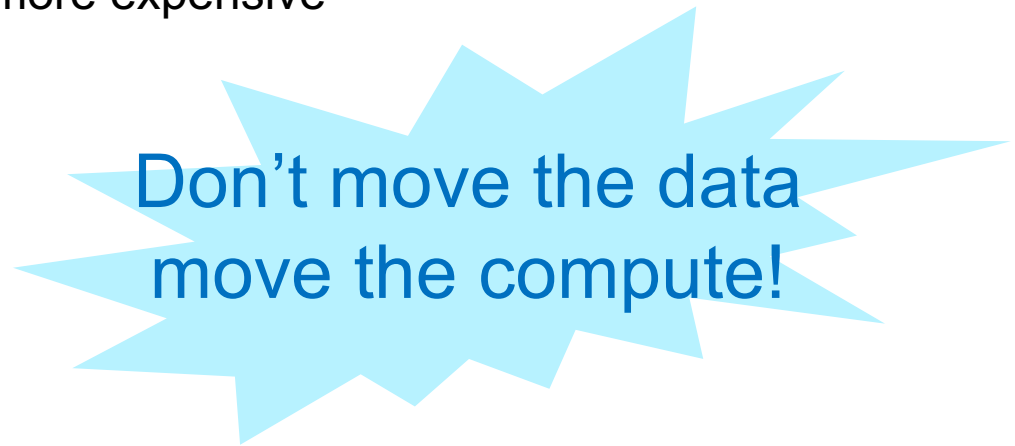
- Scientific data explosion
  - New scientific instrument, more precise
  - International collaboration, distributed instruments, aggregation of data
  - Scientific challenges for finer resolution simulations

- Example of dataset sizes

Insitution	Scientific domain	Workflows	Data size
European Centre for Medium-Range Weather Forecasts (ECMWF)	Weather Forecast	Ensemble forecasts, data assimilation,...	12 PB/year
Paul Scherrer Institute (PSI)	Synchrotron imaging	X-ray spectroscopy, high resolution microscopy,...	10-20 PB/year
CERN	High-energy particle collider	LHC Run 2	1PB/day

Extreme data challenges

- Technology
  - Transfer rate: still orders of magnitude lower than needed
    - 120 TB over internet = 111 days
    - 120 TB sent as discs by Fedex = 1 day
    - Need to build dedicated link with multiple 100Gbps to connect data producers to consumers
    - Transfer only what is relevant for the consumers
  - Storing/presisting PB of data
    - Tapes is still the solution, poor access time
    - Keeping data accessible in near-compute storage is more expensive



Versatile software-defined cluster (vCluster)

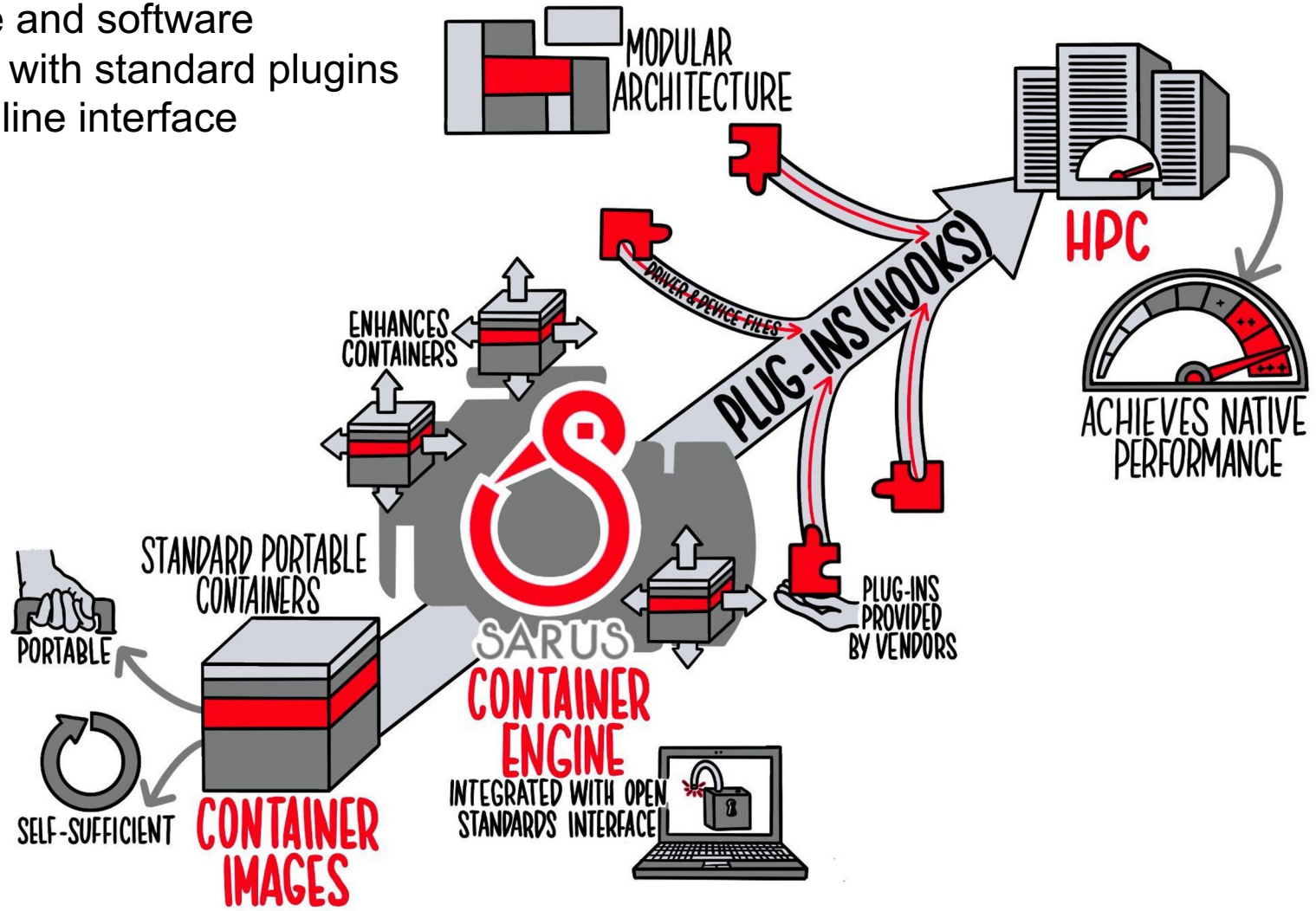
In development

- Deploy an identical platform on several system technologies
  - The platform is defined as a set of config files
    - Each service is a config file (IAM, batch scheduling, data managers, accounting,…)
  - Abstraction layer to be system independant
  - Provide an engine to deploy such software-defined platforms
  - Use Infrastructure-as-Code to implement specific instance of the engine back-end
- Transfer scientific software stack and ensure performance
  - Use containers to store the software stack
  - Use OCI Hooks to expose host HPC-capable stack in the container

- Enable programmatic and web access to the platform
  - Create a RESTful API to access services on the machine
  - Build community portal / scientific workflows using that API

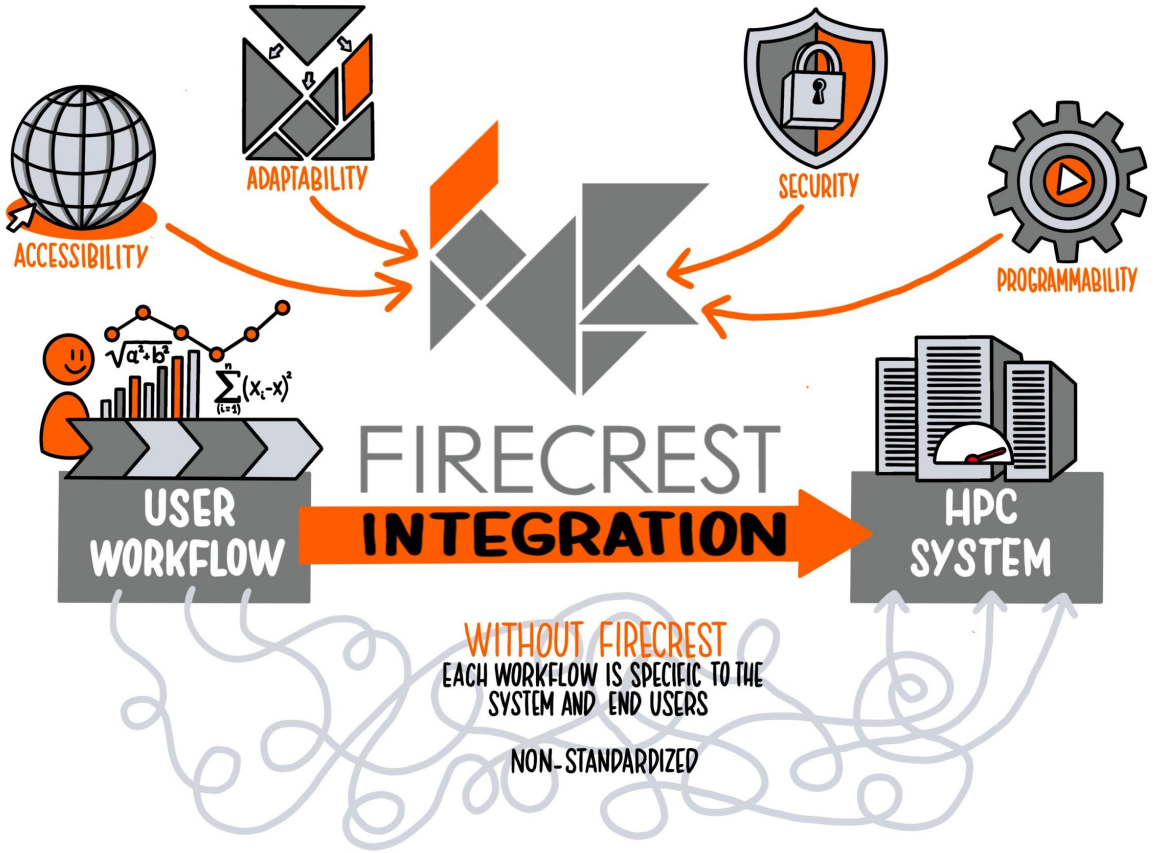
Sarus concept

- Combines container portability with native HPC performance
- Integrates with HPC infrastructure and software
- Customizes containers at runtime with standard plugins
- Provides a Docker-like command line interface



FirecREST concepts

- Accessibility: opens web access to HPC from any device
- Adaptability: modular design to support diverse HPC ecosystems
- Security: provides multiple authorization control layers
- Programmability: uses standard interface for a simplified automation

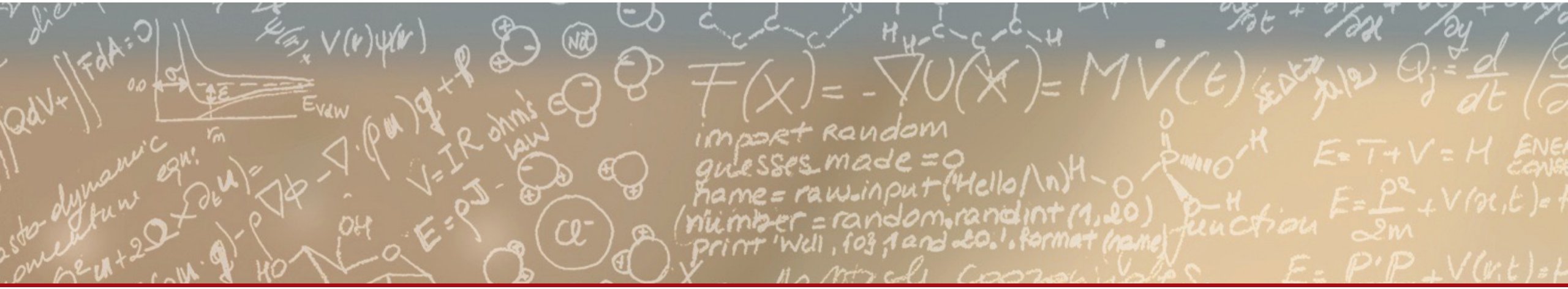


Next steps

- CSCS is commited in the development of the vCluster solution
  - vCluster v1.0, Sarus v2.0, FirecREST v2.0
  - Alps will exclusively use the vCluster technology

- Identify use cases and partners
  - With EPFL/SCITAS looking into the abstraction layer of the vCluster
  - With PSI enhancing vCluster to enable IaaS, tenant-managed vCluster

- Promote and disseminate the vCluster technology
  - Find new use cases and opportunities



Thank you for your attention.