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NOUS Empowering Europe's Data Future

A Catalyst for European Cloud Services in the Era of Data Spaces, High-Performance, and Edge Computing: NOUS

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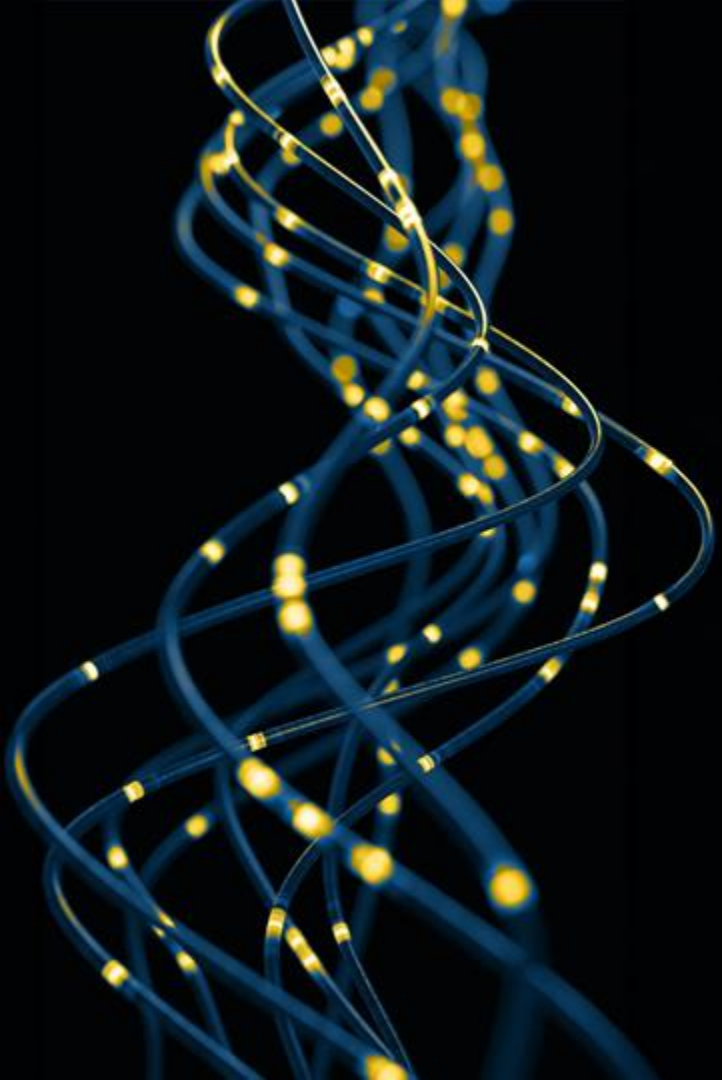
Introduction

- Europe's cloud market is dominated by non-European providers (75%)

- Dependence on foreign cloud services poses risks:
  - Compliance issues with EU laws and regulations
  - Data sovereignty and privacy concerns

- Need for a secure, high-quality, European cloud infrastructure



Background and Motivation

- Europe's digital future depends on secure data processing capacity
- Cloud services are essential both centrally and at the edge
- NOUS aligns with the European Strategy for Data
  - Aims to create foundations for European Cloud Services
  - Addresses EU-specific requirements
  - Leverages various data spaces (Mobility, Energy, Green Deal)

The NOUS Project

- **NOUS:** EuropeaN ClOUd Services in the era of data spaces, high-performance, and edge computing
- Envisions creating a comprehensive blueprint for implementing a European cloud service
- Focuses on interconnected EU platforms rather than hyper-verticalized providers
- Acts as the technological pillar of Europe's Next Generation Cloud

Partners

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Objectives of NOUS (I)

Objective 1: Develop a technological connectivity framework between Europe's HPC network and NOUS

- Extends computational capabilities
- Enables seamless interaction with quantum computers

Objective 2: Develop data processing modules for fusing data from physical assets and digital models

- Addresses computation distribution in the Edge-to-Fog-to-Cloud (E2F2C) continuum

Objective 3: Implement blockchain as decentralized database connected to the edge

- Compare with classical storage models
- Focus on standard and IoT-driven applications within NOUS

Objectives of NOUS (II)

Objective 4: Design an extensible translation-to-standards concept using a data lake

- Develop software components for standards in Mobility, Energy, and Green Deal Data Spaces

Objective 5: Develop architecture for a suite of European cloud services combining computing, edge, and data

- Increases EU's digital sovereignty

Objective 6: Create a collaboration platform based on the Living Labs concept

- Acts as a "Stack Overflow
- for data sharing"
- Allows users to ask questions
- and share data analysis results

Objectives of NOUS (III)

Objective 7:Collaborate and Facilitate Data Sharing within European Data Spaces

- Collaborate with other initiatives and organizations working on European Data Spaces
- Facilitate data sharing within NOUS
- Focus on convergence of ideas around common European cloud services

Objective 8: Enhance Cybersecurity Measures within NOUS

- Investigate darknets and zero-trust security models

Objective 9: Ensure Legal, Ethical, and Environmental Compliance

- Address legal and ethical issues by following the EC's Ethics Guidelines for Trustworthy AI
- Ensure environmental compliance by applying the "Do no significant harm" principle per the EU Taxonomy Regulation

Key Features of Data Spaces

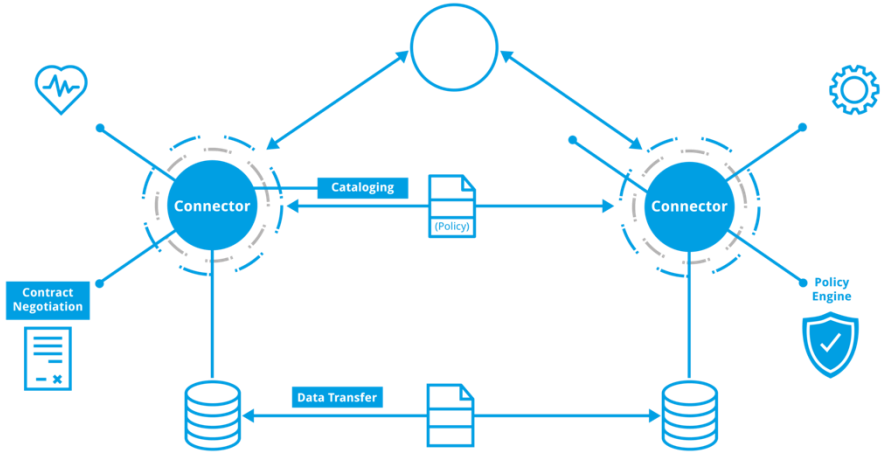
1. Interoperability
- Seamless integration between different data sources and formats
- Facilitates data exchange across diverse sectors

2. Access Control
- Robust mechanisms to manage and control data access
- Ensures only authorized entities can access specific datasets

3. Security and Privacy
- Advanced security measures to protect data
- Compliance with regulations like GDPR

4. Data Sovereignty
- Data providers retain ownership and control over their data
- Determines how and who can access the data

5. Value Creation
- Promotes new insights and innovative products/services
- Enables value generation through collaboration



Source: "Dataspace Protocol - International Data Spaces" (https://internationaldataspaces.org/offers/dataspace-protocol/)

NOUS and Data Spaces

Nous and Data Spaces (Part 1)

- **Integration with Data Spaces:**
  - NOUS acts as a catalyst for a single European data market
  - Promotes technological and business convergence
- **Challenges in Data Spaces:**
  - **Technical:** Data integration, standardization, management
  - **Organizational:** Collaboration across entities
  - **Legal:** Compliance with regulations (e.g., GDPR)
  - **Business:** Sustainable models for data sharing

Nous and Data Spaces (Part 2)

- **Adoption of Gaia-X Principles**
  - Builds upon Gaia-X's federated data infrastructures
  - Ensures interoperability and compliance with EU standards
- **NOUS Contributions**
  - Designs and develops innovative components
  - Provides structured parallel programming environments
  - Enhances data sovereignty, transparency, and trust

NOUS Architecture

- An IaaS/PaaS/MLaaS architecture integrating:
  - Compute Components
  - Edge Components
  - Data Components
- Incorporates connection with HPC network and quantum computers
- Provides federated learning framework as a service
- Utilizes low-consumption Distributed Ledger Technologies (DLT)

NOUS Architecture- Compute Component

Compute Component (Part 1)

- **Integration with HPC and Quantum Computing**
  - Optimizes computational tasks across resources
  - Enables seamless interaction with Europe's HPC network
- **Cybersecurity Measures**
  - Investigates darknets for secure sub-networks
  - Implements zero-trust security models
- **Load Scheduling Optimization**
  - Uses multi-criteria evolutionary algorithms
  - Considers computational requirements, costs, and energy consumption

Compute Component (Part 2)

- **Sandbox Environments**
  - Provides researchers with testing platforms
  - Facilitates the development and execution of complex algorithms
- **Kubernetes and VM-powered Applications**
  - Supports containerization and virtualization
  - Enhances scalability and resource management
- **Parallel Computing Support**
  - Enables high-performance computing tasks
  - Addresses challenges in simulations and digital twins

NOUS Architecture- Edge Component

Edge Component (Part 1)

- **Edge Computing Integration**
  - Enhances capabilities of devices like smartwatches, sensors, connected cars
  - Processes data closer to the source to reduce latency
- **Federated Learning and Inference**
  - Decentralized machine learning to protect privacy
  - Optimizes local learning processes to minimize resource consumption
- **Parallel Computation Programming**
  - Uses frameworks like FastFlow
  - Allows users to instantiate configurable parallel applications

Edge Component (Part 2)

- **Load Balancing**
  - Hierarchical, algorithmic data and computation distribution
  - Intelligent resource allocation between edge devices and cloud/fog data centers
- **Edge-to-Fog-to-Cloud Continuum**
  - Distributes computation among devices
  - Enhances operational efficiency and data processing
- **Privacy and Data Sovereignty**
  - Ensures data remains under control of the data providers
  - Implements robust access control mechanisms

NOUS Architecture- Data Component

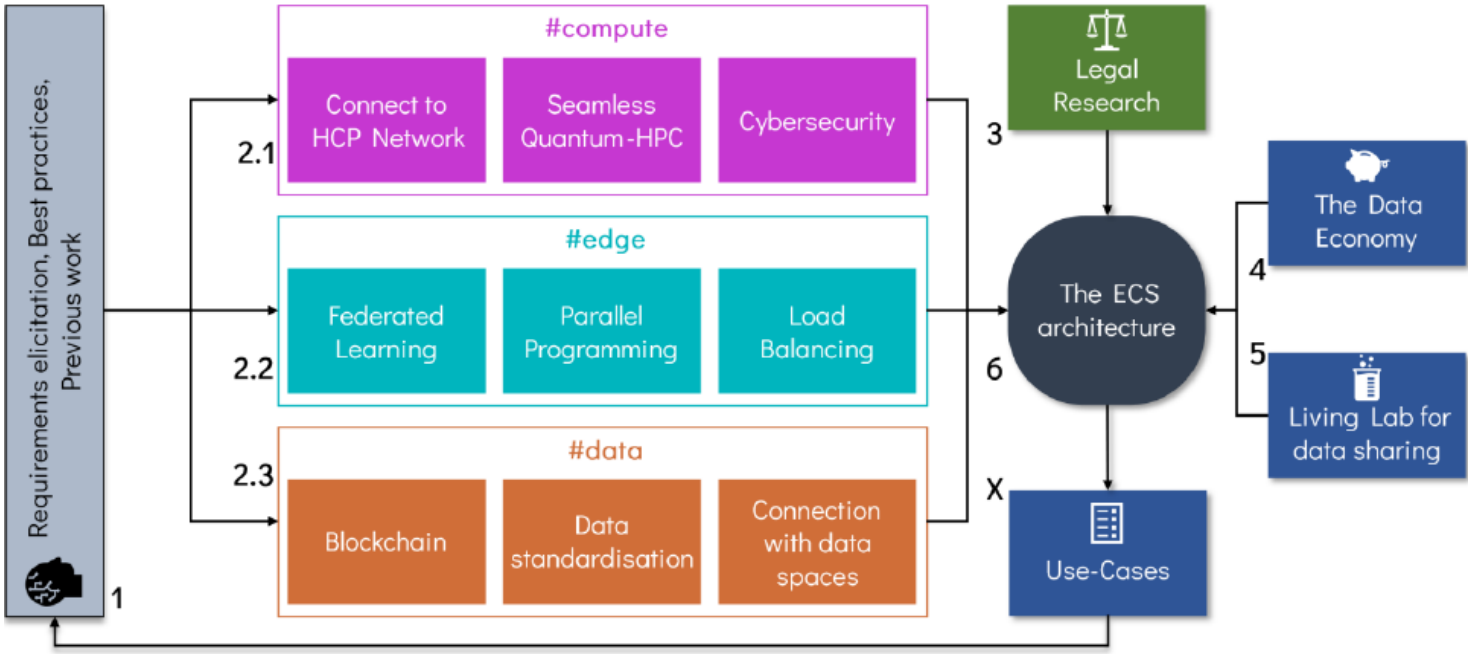
Data Component (Part 1)

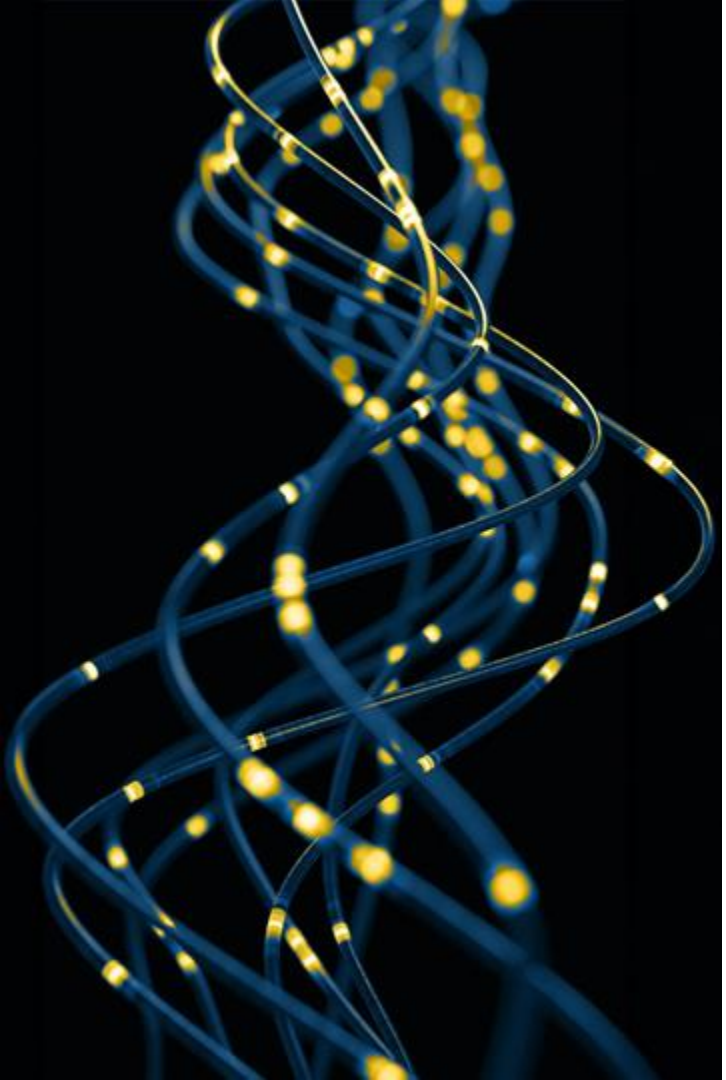
- **Blockchain Integration**
  - Uses green DLTs
  - Manages data lifecycle within datasets
- **Data Lifecycle Management**
  - Ensures transparency and adherence to legal requirements (e.g., GDPR)
  - Provides interoperability with data spaces (DSSC)
- **Data Standardization**
  - Develops an Auto-Standardizer (AS) tool
  - Translates datasets to standards in Mobility (NeTEx, GTFS), Energy (IEC, SAREF), and Green Deal Data Spaces

Data Component (Part 2)

- **Data Sovereignty and Ownership**
  - Data providers retain control over their data
  - Determines access and usage policies
- **Secure Data Exchanges**
  - Implements smart contracts and oracles
  - Manages interaction with data external to the ledger
- **Integration with Data Spaces**
  - Facilitates connection and data flow within European Cloud Services
  - Addresses challenges in creating a single data market

NOUS Architecture





Use Cases

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Demonstrates NOUS applications in real-world scenarios

- **Key use cases:**
  - **Use Case 1:** Perception of Connected Vehicles Using Camera Data
  - **Use Case 2:** Energy Prediction and Energy Data Lifecycle Management
  - **Use Case 3:** Crisis Management and Civil Protection Platform
  - **Use Case 4:** Scientific Data HPC Storage and AI Analytics

Use Case 1

Perception of Connected Vehicles Using Camera Data

- **Objective:** Improve perception of connected vehicles using roadside and car cameras
- **Challenges:**
  - Precise localization of moving assets (pedestrians, vulnerable users)
  - Real-time data processing and communication
- **NOUS Solutions:**
  - Utilizes a network of IoT devices and NOUS edge servers
  - Implements edge computing for low-latency processing
  - Applies federated learning to protect user privacy

Technical Implementation

- **Edge Computing Integration:**
  - Processes data at the edge to reduce latency
  - Enhances responsiveness of connected vehicles
- **Federated Learning Framework:**
  - Trains models locally on devices without sharing raw data
  - Aggregates updates centrally for improved models
- **Blockchain for Data Integrity:**
  - Ensures secure data exchange between devices
  - Maintains data provenance and ownership

Use Case 2

Energy Prediction and Energy Data Lifecycle Management

- **Objective:** Enhance energy prediction tasks and manage energy data lifecycle
- **Challenges:**
  - Processing historical and real-time energy and weather data
  - Forecasting intra-day and day-ahead power consumption and prices
  - Ensuring confidentiality, integrity, and availability of data
- **NOUS Solutions:**
  - Accesses HPC resources for computational tasks
  - Implements data standardization and blockchain services
  - Enhances cybersecurity measures for data protection

Technical Implementation

- **HPC Integration:**
  - Utilizes HPC for intensive data processing and simulations
  - Improves accuracy and reduces computation time
- **Data Standardization:**
  - Harmonizes data formats for better integration
  - Facilitates data sharing across platforms
- **Blockchain and Cybersecurity:**
  - Manages data lifecycle securely
  - Ensures compliance with legal regulations (e.g., GDPR)

Use Case 3

Crisis Management and Civil Protection Platform

- **Objective:** Enhance cloud-based crisis management platform with NOUS
- **Challenges:**
  - Handling large volumes of satellite and geographical data (up to 1TB)
  - Real-time communication between command centers and field units
  - Ensuring data criticality and low latency
- **NOUS Solutions:**
  - Manages heavy data loads efficiently using HPC and edge computing
  - Prioritizes data transmission based on criticality
  - Secures data communication channels

Technical Implementation

- **Data Management:**
  - Efficiently stores and retrieves large datasets
  - Optimizes data flow to reduce bottlenecks
- **Edge Computing for Field Units:**
  - Processes data locally to improve response times
  - Reduces dependency on central servers
- **Secure Communication Protocols:**
  - Implements encryption and authentication mechanisms
  - Protects sensitive information during crises

Use Case 4

Scientific Data HPC Storage and AI Analytics

- **Objective:** Support computationally expensive in silico experiments in engineering and environmental sciences
- **Challenges:**
  - Conducting extensive computational experiments
  - Reducing the number of experimental calculations
  - Accelerating research and publication processes
- **NOUS Solutions:**
  - Provides sandbox environments for researchers
  - Utilizes AI algorithms like active learning and Bayesian optimization
  - Leverages HPC and quantum computing resources

Technical Implementation

- **Sandbox Environments:**
  - Offers secure and scalable platforms for testing algorithms
  - Facilitates collaboration among researchers
- **AI-empowered Algorithms:**
  - Reduces computational costs and time
  - Improves efficiency of experiments
- **HPC and Quantum Computing:**
  - Accesses advanced computational resources
  - Enables complex simulations and modeling

Technical Innovations

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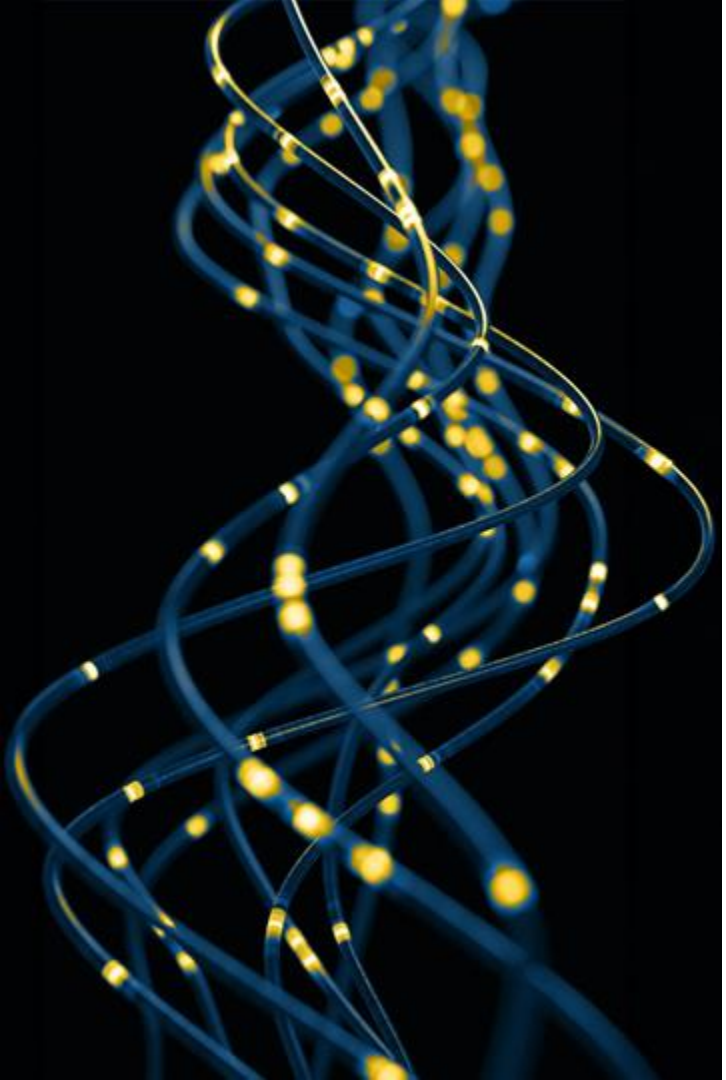
- **Edge Computing Optimization:**
  - Improves capabilities of IoT devices
  - Reduces latency and enhances efficiency
- **Federated Learning Framework:**
  - Protects data privacy during machine learning
  - Enables decentralized model training
- **Low-Energy Blockchain Technologies:**
  - Manages data lifecycle and integrity
  - Ensures transparency and compliance

Benefits of NOUS

- **Strengthening European Digital Sovereignty:**
  - Reduces dependence on non-European cloud providers
  - Enhances control over data and infrastructure
- **Enhanced Security and Compliance:**
  - Aligns with EU laws and regulations
  - Protects data privacy and integrity
- **Fostering Innovation and Collaboration:**
  - Provides a platform for developing new services
  - Encourages cross-sector collaboration



Future Work

Empowering Europe's Data Future

1. **Development of NOUS Components:**
   - Continuous improvement of compute, edge, and data components

2. **Expanded Integration with Data Spaces:**
   - Inclusion of more domains and standards

3. **Fostering Innovation and Collaboration:**
   - Partnerships with organizations working on data spaces

4. **Enhancing Security and Performance:**
   - Ongoing research into cybersecurity measures
   - Optimization of resource allocation and efficiency

Conclusion

- NOUS addresses critical gaps in Europe's cloud infrastructure
- Integrates advanced technologies for a cohesive solution
- Supports EU's vision for a unified and sovereign digital future
- Aims to become the technological embodiment of the EU's vision for data space

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