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Developing infrastructures for FAIR data in plant biology

Cyril Pommier, Guillaume Cornut, Michael Alaux, Windpouire Esther Dzale Yeumo, Raphaël Flores, Thomas Letellier, Célia Michotey, Nacer Mohellibi, Sophie Durand, Erik Kimmel, et al.

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Developing infrastructures for FAIR data in plant biology

A-F Adam-Blondon, URGI, INRA



ALIMENTATION
AGRICULTURE
ENVIRONNEMENT



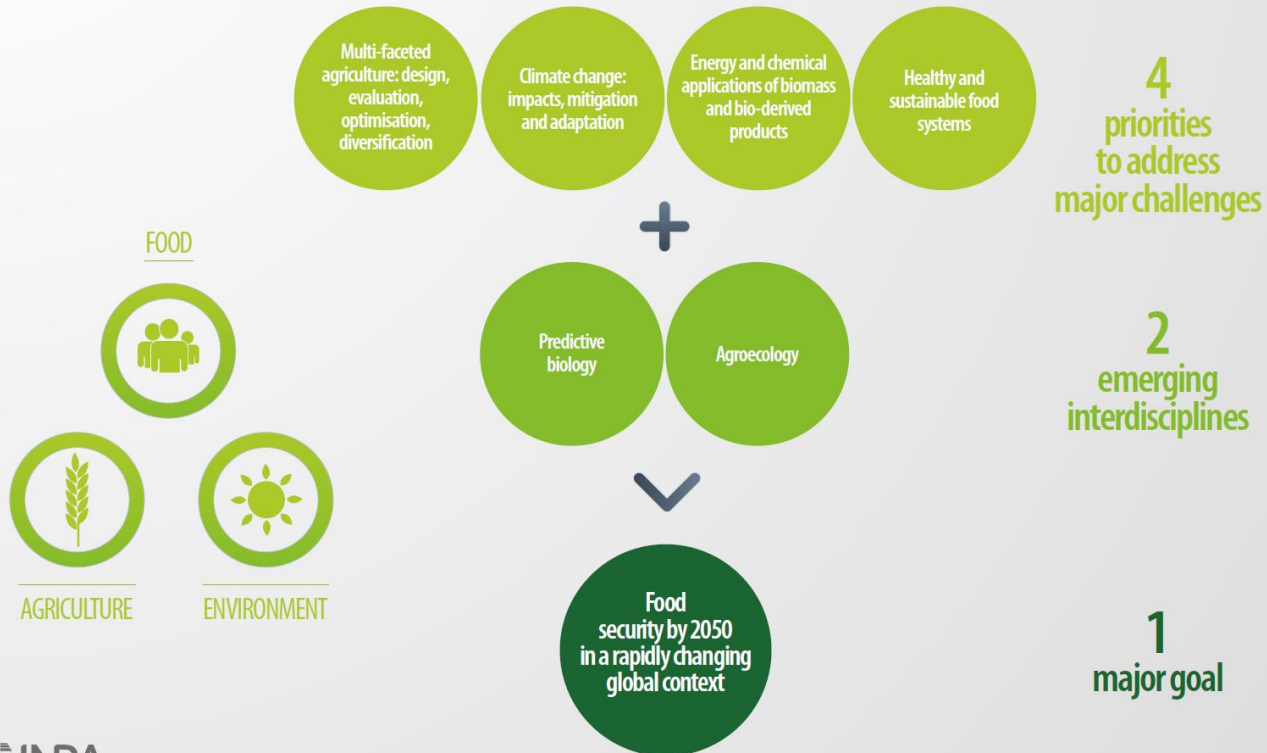
Context



- Genetic resources
[Genetic resources](#)
- Taxons
[Taxons](#)
- Genetic analyses
[Genetic analyses](#)
- Phenotypes
[Phenotypes](#)
- Polymorphisms
[Polymorphisms](#)



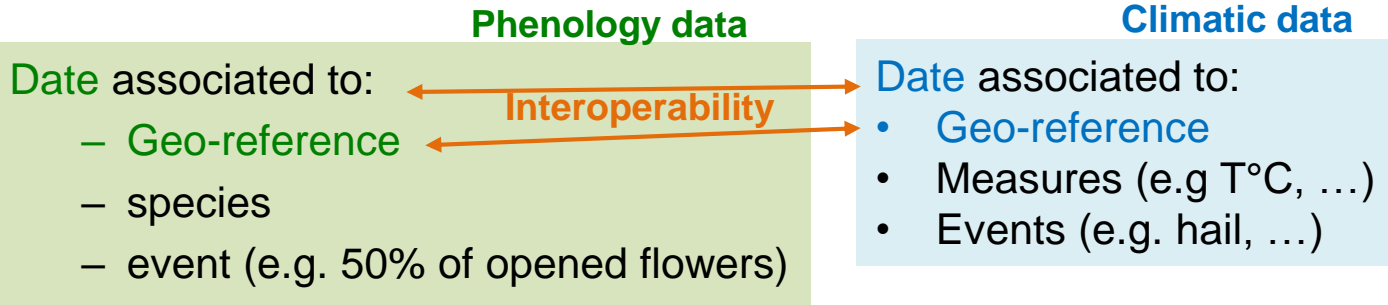
INRA's objectives necessitate interdisciplinary researches and data re-use



Example: modelling the impact of climate change using plant phenology

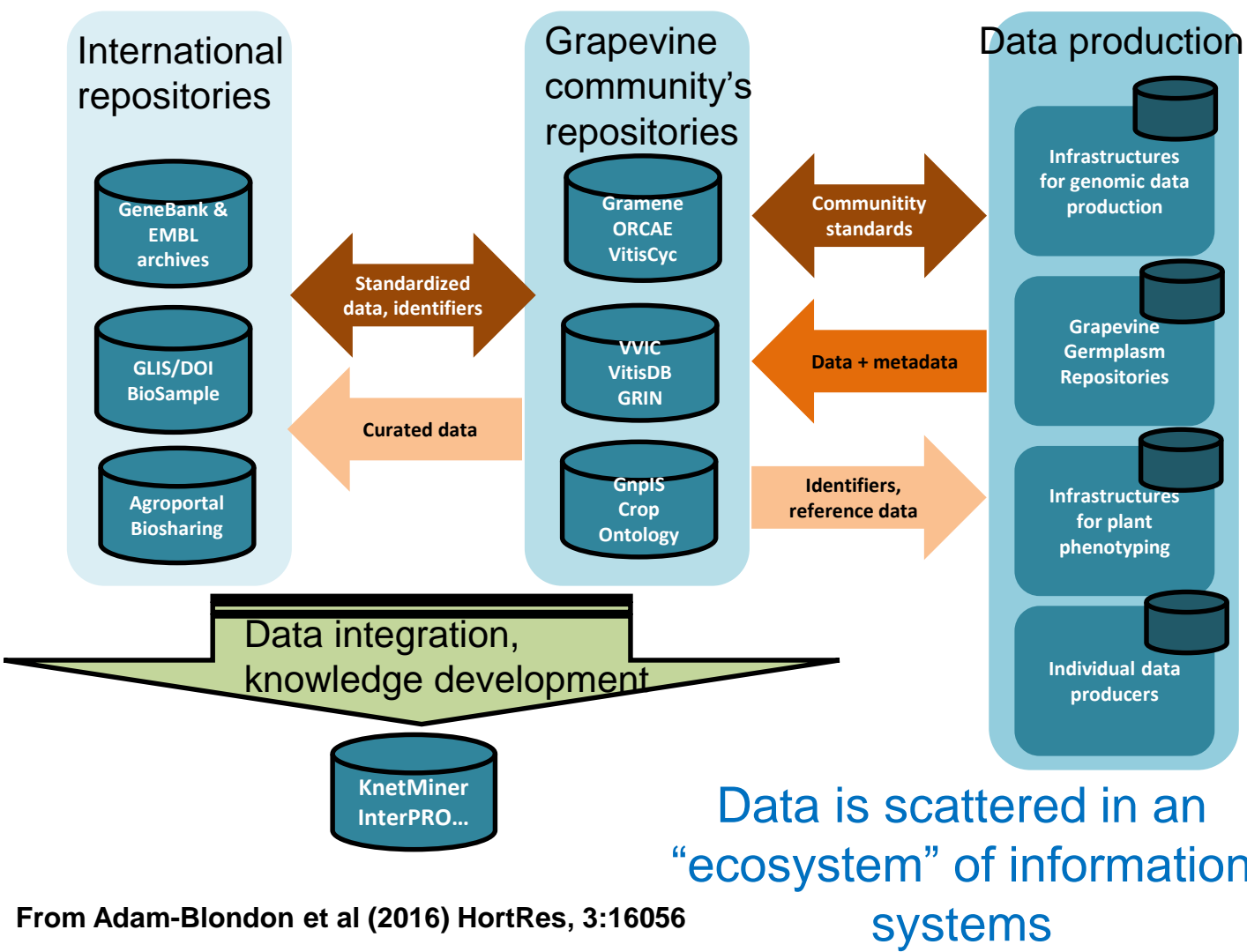
Global plant phenology data portal: www.plantphenology.org

Pan European PEP725 Plant phenology database: <http://www.pep725.eu/>

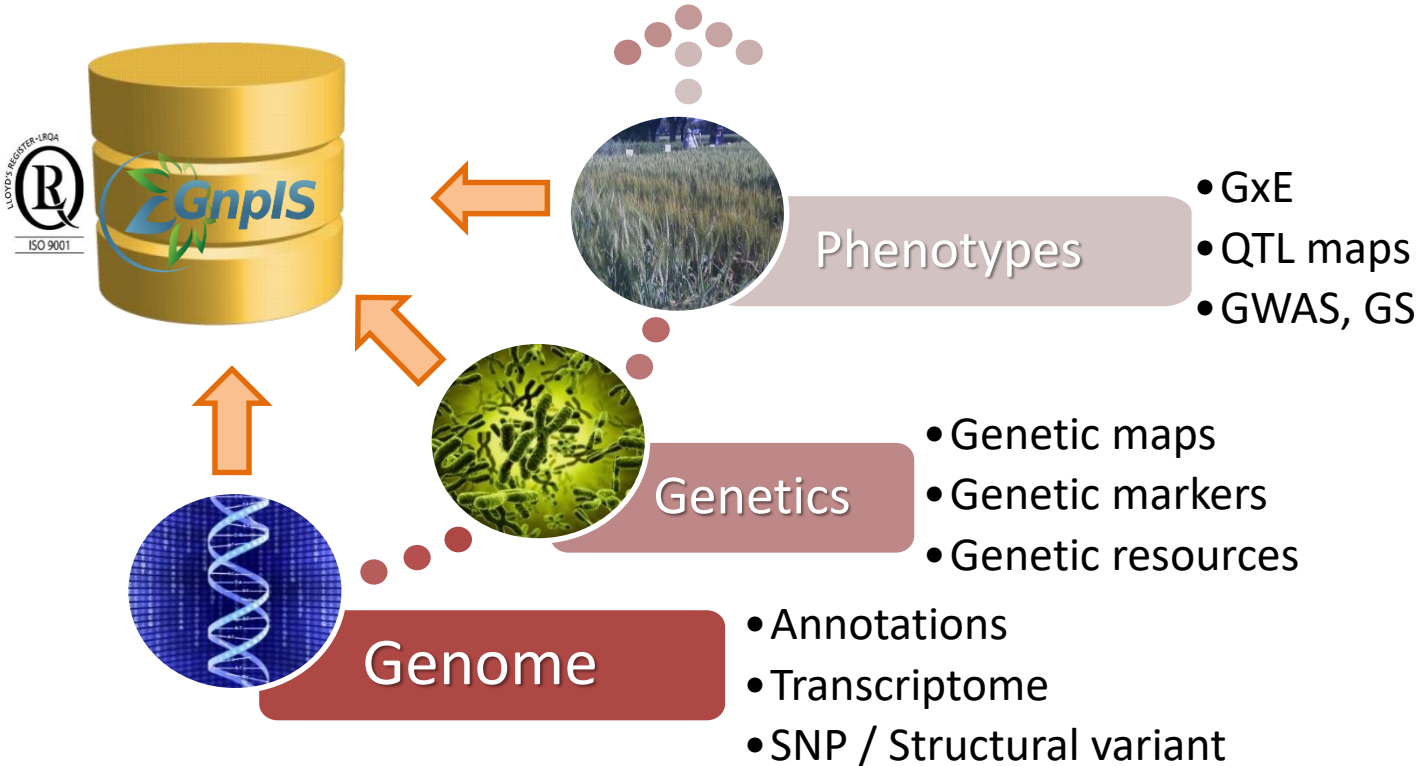


Phenology data : different sources, different accuracy in terms of identification of the species, scoring methods, record formats

- Modelers of the impact of climate change
- Geneticists, Breeders
- Genbank managers
- Experimental station managers
- Civil (economic) society: e.g. vintage dates, cherry blooming date...



Development of an INRA information system for crops, forest trees and pathogens



Insertion of GnpIS in federations of information systems

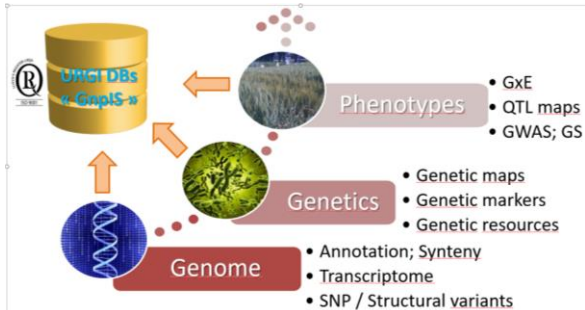


2002: Single database



2008: DB Interoperability

2010: set of interoperable databases

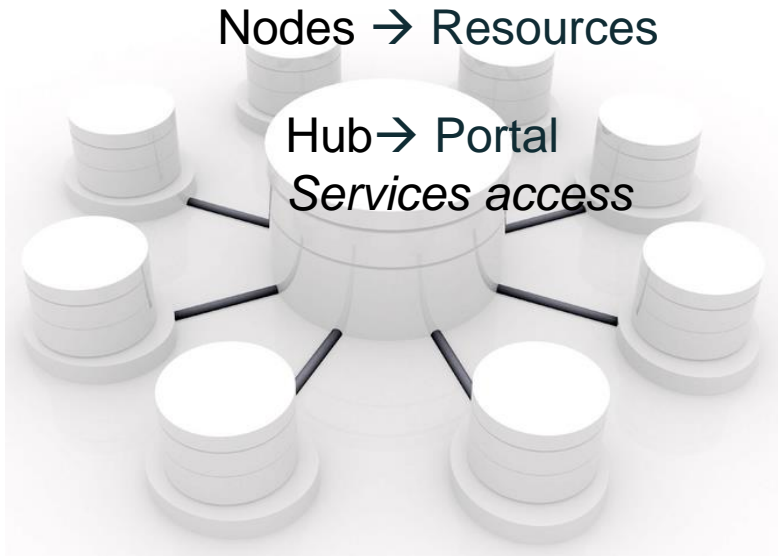


2015: Distributed information system

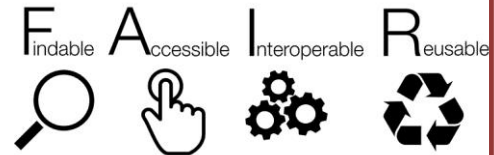


Featuring federations of information systems

- A network of (stable/sustainable) nodes
- A central portal offering services (e.g. search data)



Backbone of good practices enabling such infrastructures



Wilkinson et al (2016)
SCIENTIFIC DATA,
3:160018, DOI:
[10.1038/sdata.2016.18](https://doi.org/10.1038/sdata.2016.18)

Europe has also been continuously reinforcing its policy for facilitating open access and interoperability



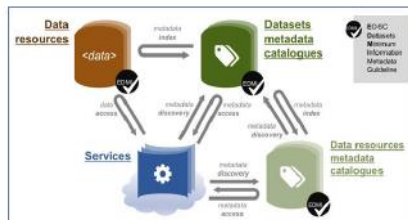
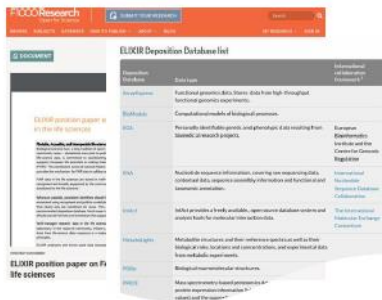
“Facilitating access to results encourages the re-use of research outputs and supports Open Science. This is essential for Europe's ability to enhance its economic performance and improve the capacity to compete through knowledge. [...] Results of publicly-funded research can therefore be disseminated more broadly and faster, to the benefit of researchers, innovative industry and citizens.



Recently funded projects were asked to add a WP supporting a FAIR compliant Data Management Plan

This policy is implemented via the European Open Science Cloud (EOSC)

- The European infrastructures in Life Science should contribute to EOSC
- E.g. European Infrastructure of Bioinformatics for Life-sciences: ELIXIR (23 countries)



FAIR data management in the life sciences

[10.7490/f1000research.11174985.1](https://doi.org/10.7490/f1000research.11174985.1)

Gateway for User access and mechanism for exposing life-science services (via *ELIXIR Registries*)

Compatible Cloud / Workflows / Reference Data Set Distribution Service



From N. Blomberg

ELIXIR's objectives

In 2023: Continent-scale, standards-based infrastructure for accessing and analysing life-science data

Marine metagenomics



Human data

Plants



Metabolomics



Galaxy Rare diseases
...delivered in partnership with research communities

Proteomics



Data



Compute



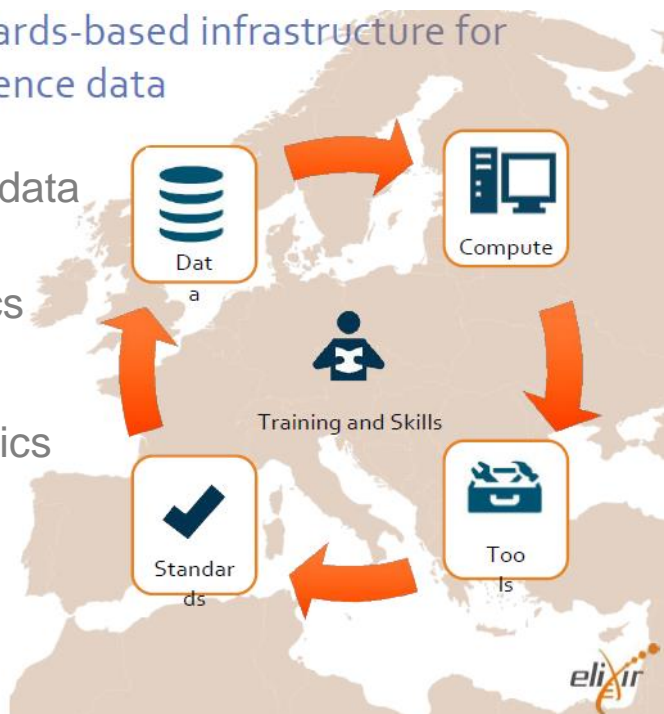
Training and Skills



Standards



Tools



Contacts Plants: Celia Miguel (IBET) & Cyril Pommier (INRA)

Examples of federations



Two main examples or “use cases”

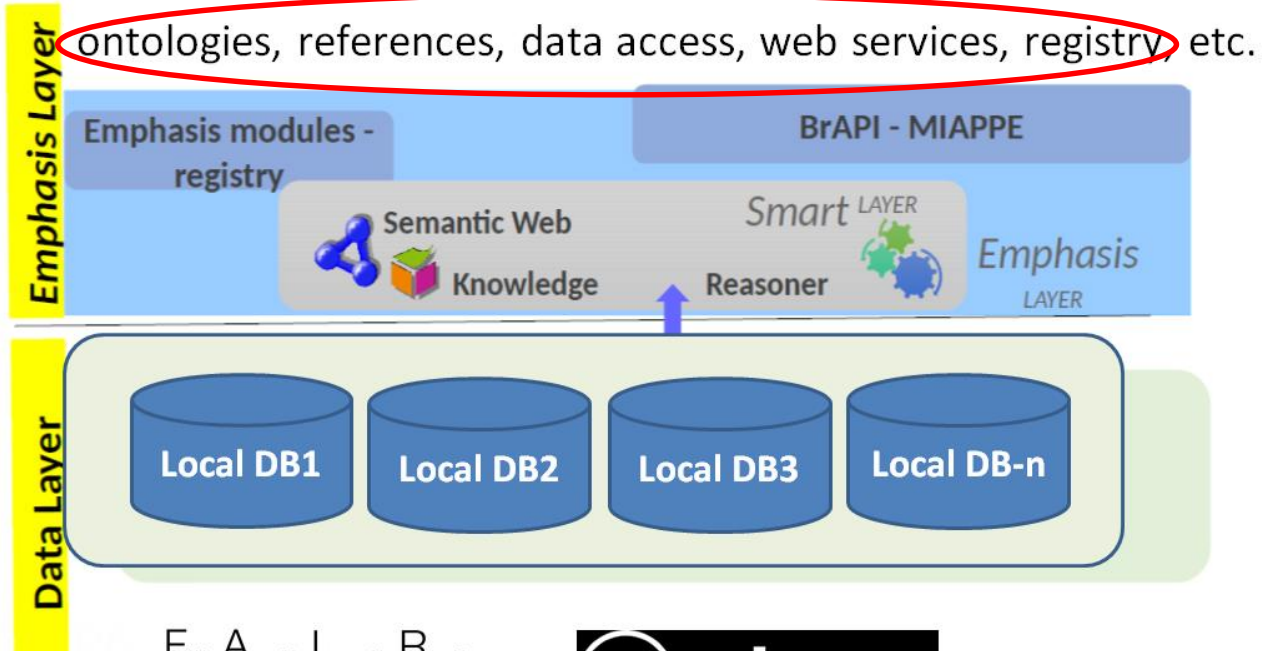
- The Wheat Initiative (G20 Initiative) and its Wheat Information System Expert Working group (www.wheatis.org). Also supported by the Research Data Alliance.



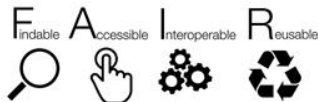
- The European Infrastructure for Multi-scale Plant Phenomics and Simulation (EMPHASIS) and its information system (<https://emphasis.plant-phenotyping.eu/e-Infrastructure>). In the frame of a strong collaboration with ELIXIR



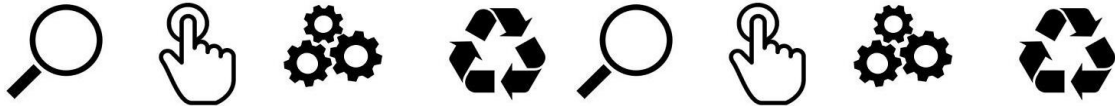
Services



ontologies, references, data access, web services, registry, etc.



Developing a federation of FAIR plant phenotyping data repositories



Development of guidelines: e.g. www.wheatis.org

About Collaborators Search **Data Standards** Submit Data Tools Links WheatIS Nodes

WheatIS

Wheat Data Interoperability Guidelines

Home Guidelines Ontologies & Vocabularies Use cases Getting involved About

Welcome

These recommendations have been prepared by members of the **Wheat Data Interoperability Working Group (WG)**, one of the WGs of the Research Data Alliance and the only WG of the **Agriculture Data Interoperability Interest Group**. The group is coordinated by members of the **Wheat Initiative**, a global initiative that aims to reinforce synergies between bread and durum wheat national and international research programmes to increase food security, nutritional value and safety while taking into account societal demands for sustainable and resilient agricultural production systems.

More specifically, the WG aims to:

- PROMOTE** the adoption of common standards, vocabularies and best practices for Wheat data management
- FACILITATE** access, discovery and reuse of wheat data
- FACILITATE** wheat data integration

GETTING INVOLVED

RDA RESEARCH DATA ALLIANCE

WheatIS

Guidelines Ontologies & Vocabularies Use Cases

Wheat Data Interoperability guidelines Copyright © 2015

WheatIS built by ThermoPhilo • Powered by WordPress

<https://ist.blogs.inra.fr/wdi/>

Dzale-Yeumo et al (2017) F1000Research, 6 : 1843



Registries of standards and guidelines



Ontology Lookup Service

- OLS Home
- Documentation
 - Project
 - Publications
- Developer Resources
 - Download
 - Implementation
 - Overview
 - Javadoc
 - WebServices documentation
- Contact Us
- Acknowledgements

Enter Ontology Term

Search Ontology:

Term Name: (Include obsolete terms) Term ID:

Additional Information:

Enter a partial search term. As you are typing, you will see suggested terms that match what are you have typed so far. If you select a term from the pull-down list, its corresponding ID will be displayed in the form. If you see "... and more" in the list of suggested values, you can select this value to be redirected to a page where all possible values are listed. As an example, enter *ribbox* in the Term Name box while the Gene Ontology is selected.

For better search results, do not type punctuation or symbols. For example, if you are looking for 4'-[L-tryptophan], try typing *4-L_ryp*.



<https://www.ebi.ac.uk/ols/ontologies>

<http://agportal.lirmm.fr/>



Development of a metadata standard for phenotyping experiments



- MIAPPE: Minimum Information About Phenotyping Experiment
- www.miappe.org
- Steering committee Emphasis, Elixir CGIARs

Last release MIAPPE v1.1 (Jan. 2019). Major improvements:

- Extension to accommodate woody plants as an additional use-case.
- Specification of a data model for easier implementation in various formats and automatic validation.
- Improved compatibility with [ISA-Tools](#) and [Breeding API \(BrAPI\)](#).
- Provision of clear definitions and examples for all fields.

Adoption of the Crop Ontology format for the description of the phenotyping variables (www.croponontology.org)

Variable = trait + method + scale

Examples

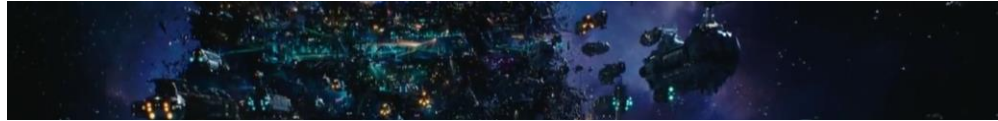
- Woody Plant Ontology
 - Wheat INRA Phenotyping Ontology v1.3 being merged with the Wheat Ontology developed by the CYMMIT
 - Grape Ontology (v2)
- Also used to describe environment variables
 - Strong curation efforts still needed: documentation of the methods, standardize the vocabulary (traits), ...
 - Environments facilitating the development and curation of ontologies are needed



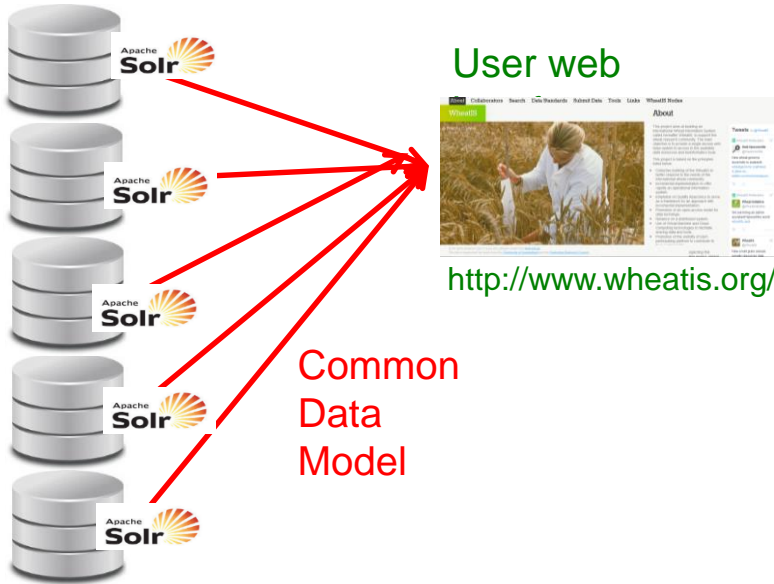
Registries of identifiers for key objects

- DOI for plant accessions (following the FAO recommendations)
- Biosample : identifiers for samples derived from accessions
- Crop Ontology : identifiers for phenotyping variables
- DOI associated to phenotyping trial sets (and data papers)

Developing search and data access across federations



Generic Data Discovery Tool



Common
Data
Model

WheatIS

Filters

Database

- TRITICEAE TOOLBOX (437)
- OPENMINTED (126)
- WHEAT GENE CATALOG AT KOMUGI (10)
- GRANGÈNES (7)
- GISIS (2)
- PLANTPHENOB (1)

Type

- ACCESSION (261)
- BIBLIOGRAPHY (126)
- EXPERIMENT (60)
- PHENOTYPE (17)
- GENE (10)
- GENETIC MAP (6)
- PHENOTYPE (1)
- PHYSICAL MAP (1)
- QTL (1)

Species

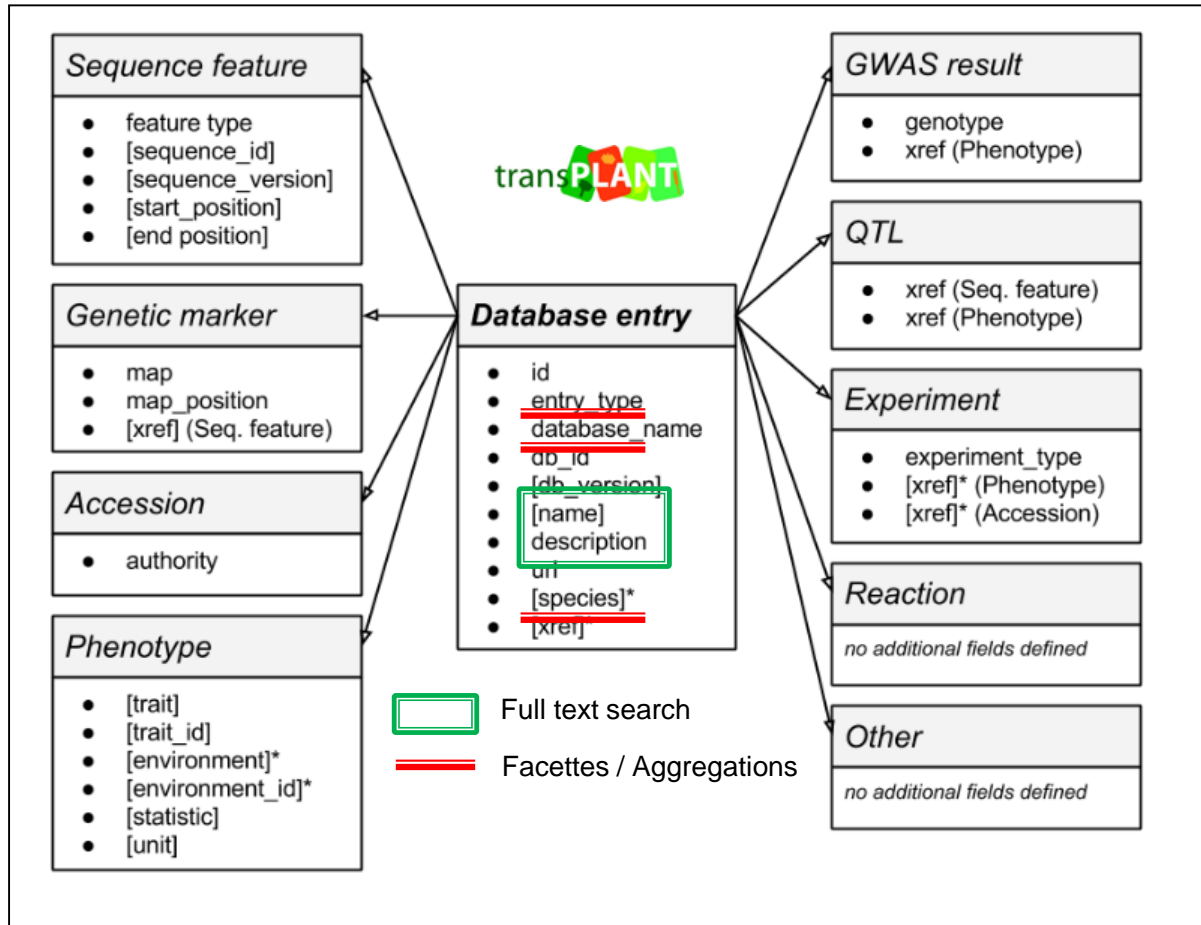
- TRITICUM AESTIVUM (454)
- TRITICUM (126)
- LEMNA PACIFICUS (1)
- TRITICUM DURUM (1)
- TRITICUM TURGIDUM SSP

Link to source	Source	Type	Taxon	Description
10.1007/s10618-006-0153-0	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10 associated with Fusarium head blight re
10.1111/j.1364-3703.2006.00349.x	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. Arabidopsis thaliana-Fusarium graminearum resistance among ecotypes Fusarium g
10.1007/s00122-006-0207-4	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. characterization of Asian head lines for
10.1139/S06-010	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. EST mapping and its association with a head
10.1007/s00122-006-0249-7	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. major gene controlling head head bl
10.1007/s00099-005-0050-4	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. transformation to improve resistance to
10.1270/biota.56.25	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. blight severity in recombinant inbred pop blight
10.1111/j.1439-0223.2006.01182.x	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. major quantitative trait loci for head head
10.1007/s00122-005-0156-3	OpenMinted	Bibliography	Triticum	Triticum. Bibliography. OpenMinted. 10. with resistance to Fusarium head blight

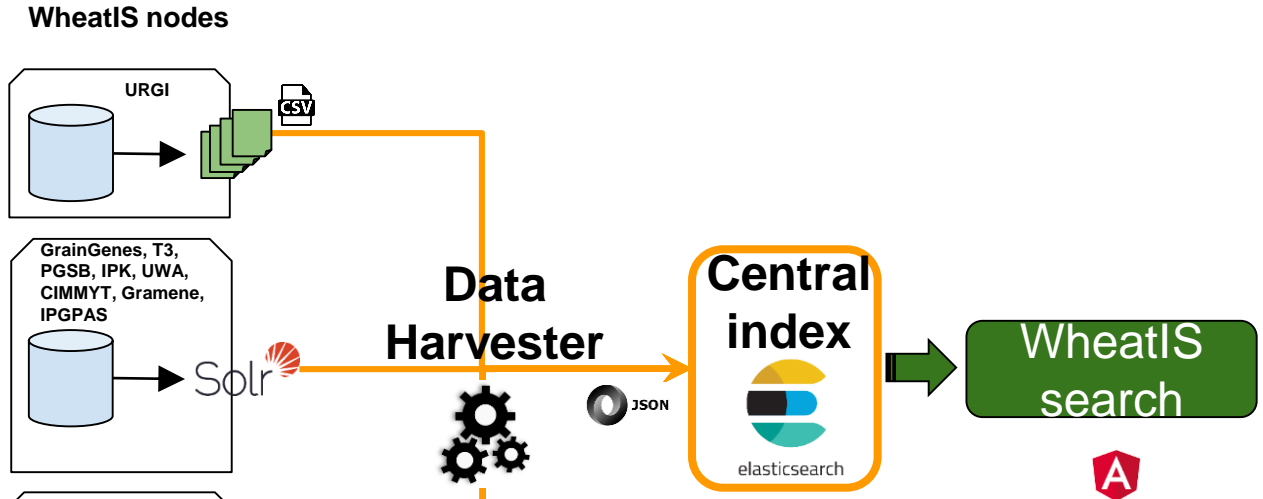
Spannagl et al. 2016, <https://doi.org/10.3835/plantgenome2015.06.0038>



transPLANT data model



WheatIS data discovery tool: evolution



- ✓ Lighter implementation for new nodes
- ✓ Nodes cannot be « down »
- ✓ Easy addition of new functionalities

WheatIS data discovery tool: evolution



Wheat@URGI WheatIS Wheat Initiative

URGI

IWGSC@GnplS [18 566 139]
GnplS [92 214]
OpenMinTeD [3 398]
WheatIS File Repository [6]

EBI

Ensembl Plants [2 122 980]

IPK

CR-EST [199 220]
GEBIS [50 875]
MetaCrop [177]

Gramene

Gramene [229 789]

UWA

Wheat Pangenome [167 167]

T3

The Triticeae Toolbox [138 441]

South Green

AgroLD [137 060]

Rothamsted Research

KNetMiner [110 775]

GrainGenes

GrainGenes [15 827]
Wheat Gene Catalog at
Komugi [3 043]

PGSB

CrowsNest [13 324]

CIMMYT

CIMMYT Dspace [981]
CIMMYT dataverse [1]

IPGPAS

PlantPhenoDB [3]

WheatIS

Wheat Information
System



Examples: yield, fhb

Search

!beta! <https://urgi.versailles.inra.fr/data-discovery-staging/>

Based on user's remarks:

- New nodes
- New data
- New filters/data types

Open software, very generic, that can (and is) adapted to any type of federation:
e.g. the federation of information systems for of the french infrastructure of genetic resources for research in agriculture, AgroBRC-RARe **(!beta!** <https://urgi.versailles.inra.fr/rare-beta/>)

Deeper interoperability in federations



The Breeding API (BrAPI) Project is an international effort to create a RESTful specification that enables interoperability among plant breeding databases.

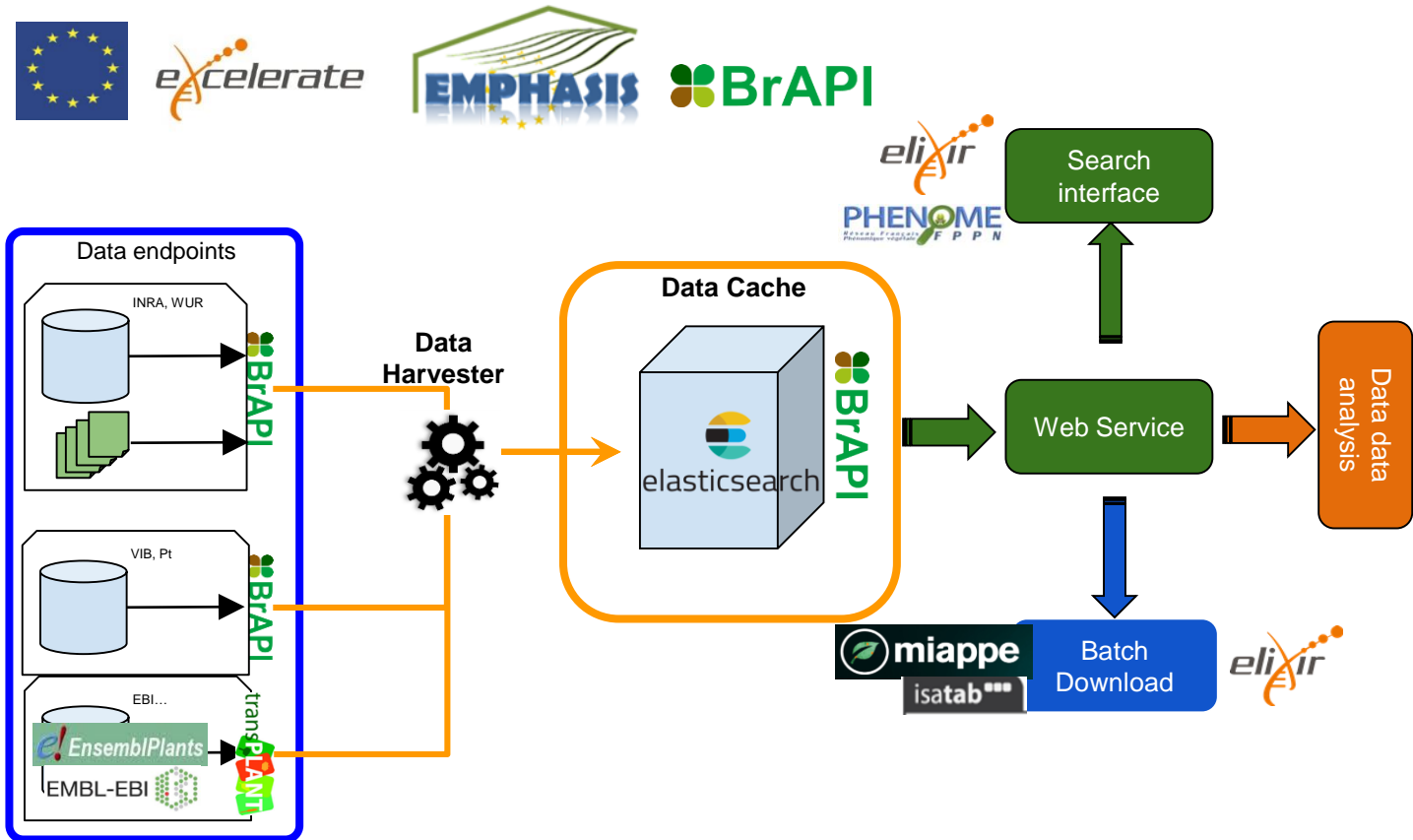


Bill & Melinda Gates Foundation



- Development of a **standard API** :
 - Calls for plant material aligned with MCPD
 - Calls for phenotyping experiments aligned with MIAPPE and of a supporting data model
- Next steps: develop the same type work on the calls for genotyping data (coordination with GA4GH)

Enabling improvements of data services



Conclusions



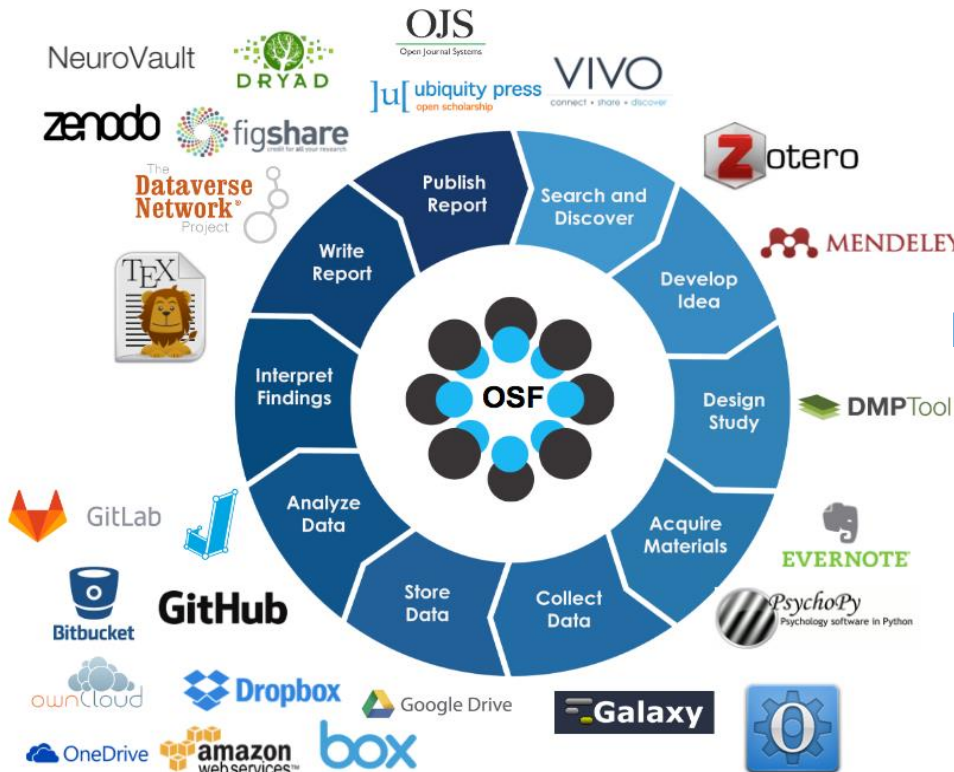
Genetic resources
Taxons
Genetic analysis
Phenotypes
Polymorphisms



Conclusions and perspectives

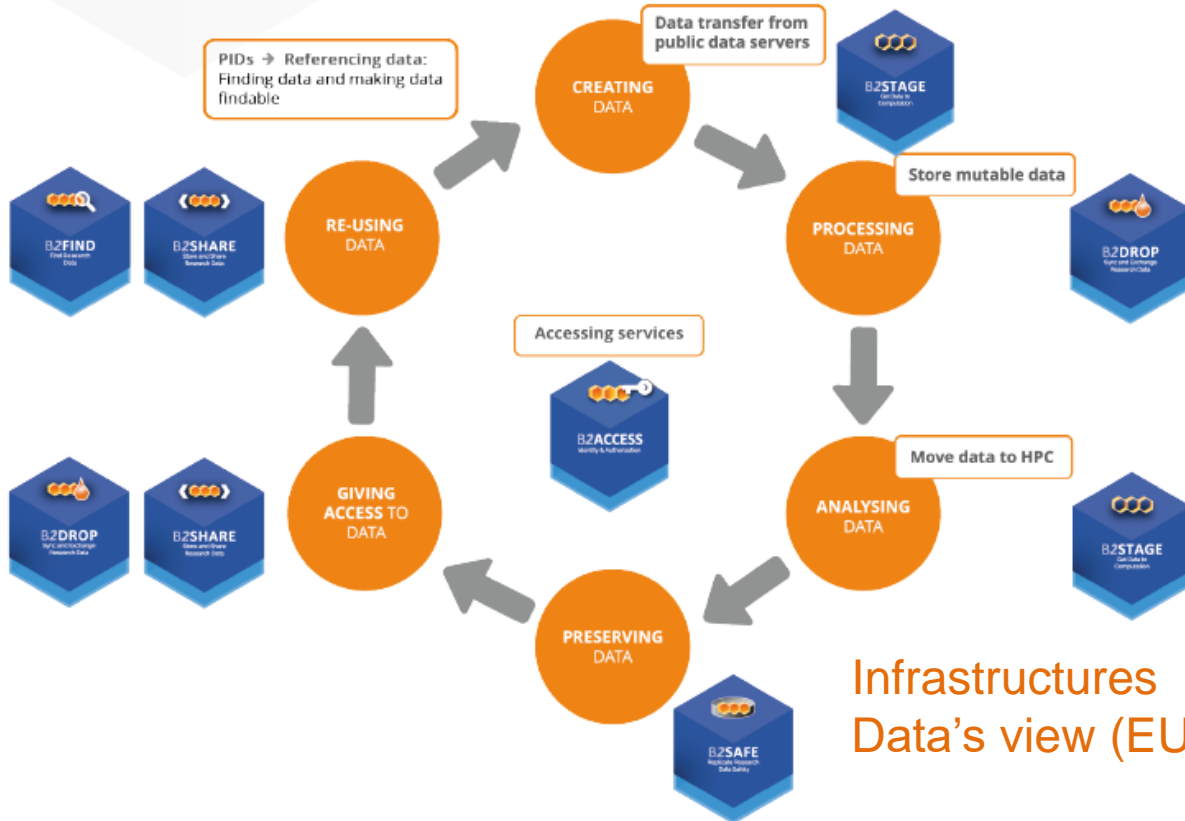
- Generic search tool used for the WheatIS: light tool that allows community building -> Monitoring of the interest of end users to be done in more detail
- BrAPI : same good properties + the possibility to diversify services
- One big challenge still ahead: get the data and get it FAIR during all its life cycle.

There is still a challenge in providing operational environments facilitating data management all along its life cycle

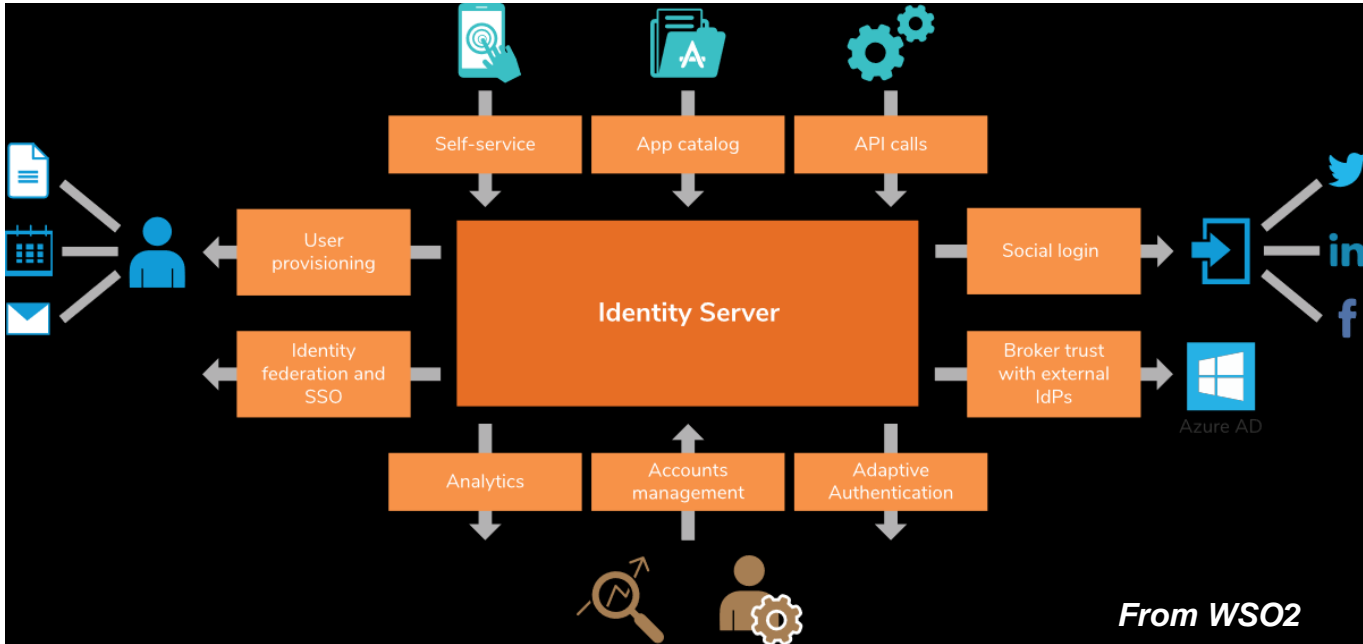


Researcher's view

There is still a challenge in providing operational environments facilitating data management all along its life cycle



There is still a challenge in providing operational environments facilitating data management all along its life cycle



Infrastructures
Identity and access view

Acknowledgements



H. Quesneville
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 R. Flores
 C. Guerche
 E. Kimmel
 T. Letellier
 C. Michotey
 N. Mohellibi

National and International infrastructures/initiatives



National and international Wheat projects



Financial supports



Thank you!

WheatIS search usage metrics

2016

Summary			
Reported period	Year 2016		
First visit	01 Jul 2016 - 03:57		
Last visit	31 Dec 2016 - 00:42		
	Unique visitors	Number of visits	Pages
Viewed traffic *	<= 460 Exact value not available in 'Year' view	689 (1.49 visits/visitor)	3,609 (5.23 Pages/Visit)
Not viewed traffic *			110

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.

2017

Summary			
Reported period	Year 2017		
First visit	01 Jan 2017 - 15:36		
Last visit	31 Dec 2017 - 08:09		
	Unique visitors	Number of visits	Pages
Viewed traffic *	<= 1,556 Exact value not available in 'Year' view	2,236 (1.43 visits/visitor)	17,568 (7.85 Pages/Visit)
Not viewed traffic *			996

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.

2018

Summary			
Reported period	Year 2018		
First visit	07 Jan 2018 - 07:20		
Last visit	27 Nov 2018 - 07:33		
	Unique visitors	Number of visits	Pages
Viewed traffic *	<= 1,931 Exact value not available in 'Year' view	3,307 (1.71 visits/visitor)	27,371 (8.27 Pages/Visit)
Not viewed traffic *			604

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.