Ontologies as Catalysts in AI-Powered Convergence of Agriculture, Health and Wealth: Reality, Possibilities and Challenges

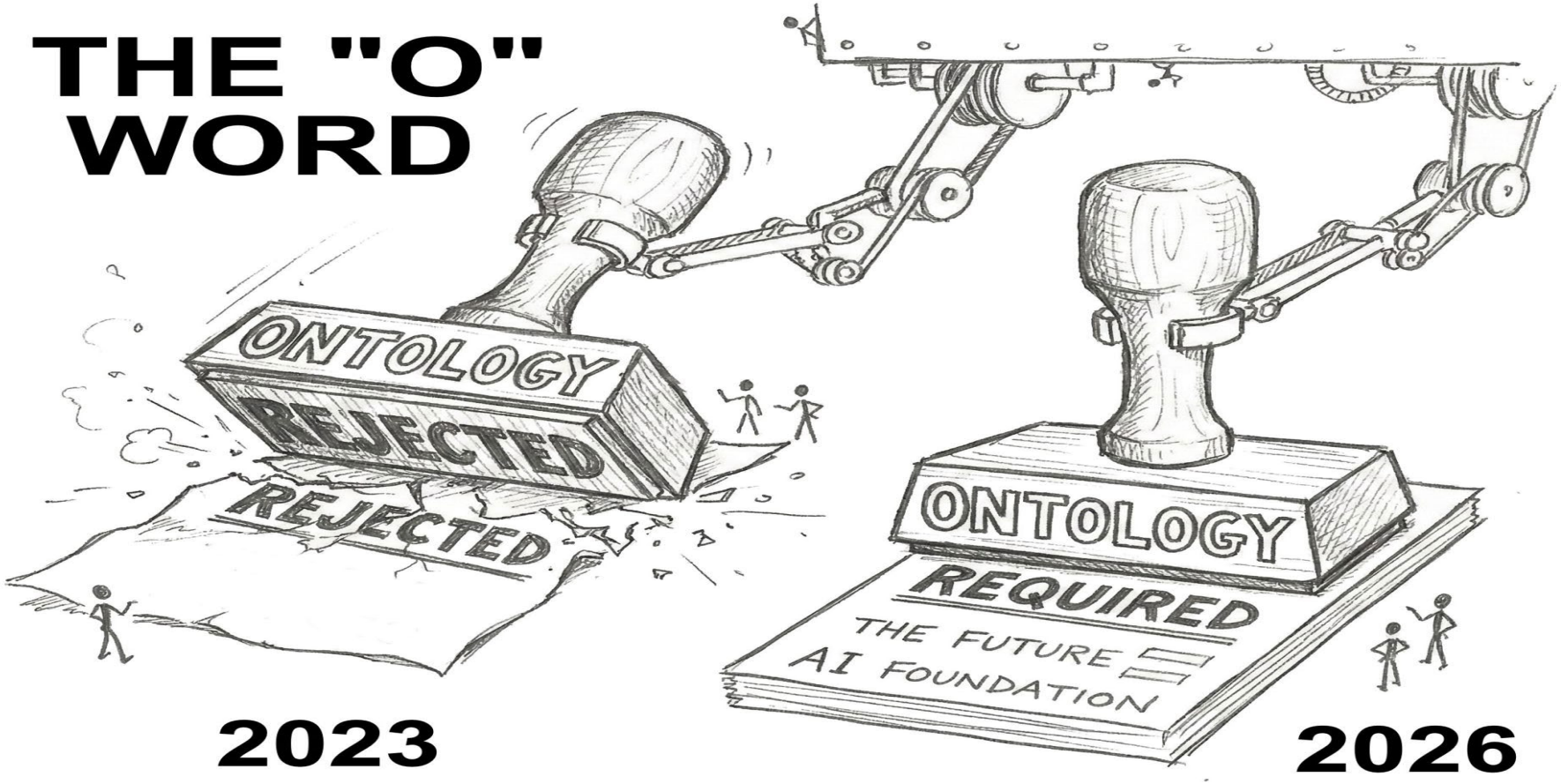
Laurette Dubé (et al)

McGill Center for the Convergence of Health and Economics

January 8th 2026

INRAE, SESAME Seminar

Ontologies as Catalysts



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Agenda

- Roadmap and principles for world reset from *economic convergence* to *convergence economy*
- Early ontology work taking health as entry point (David Buckridge as key ontologist collaborator)
- UFOOD: push the boundaries of multi-domain and top-level ontology development, alignment, adaptation and federation for real-world embedded digital backbone that can accelerate whole-society transformation at scale taking food as a key bridge domain between agriculture, health and wealth (Giancarlo Guizzardi and Damion Dooley as key ontologist collaborators)
- Possibilities and Challenges

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1. Convergence roadmap and principles

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Convergence roadmap

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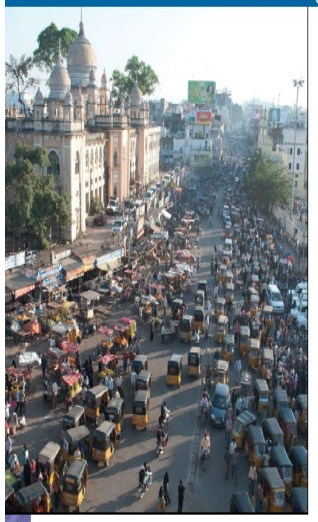
PNAS

Proceedings of the National Academy of Sciences of the United States of America www.pnas.org



Cover image: Pictured are open-air markets amidst heavy traffic in Hyderabad, India, showing the chaotic environments that populations in developing countries must contend with to obtain produce. Much of the food in these markets is transported from small farms outside the city and carried through clogged streets by a vast ad hoc network of small trucks, scooter trucks, and bicycle carts. Laurette Dubé et al. propose a roadmap for progress toward sustainable global nutrition security. Such roadmaps could help reduce hunger and poverty, and halt the spread of noncommunicable chronic diseases. See the article by Dubé et al. on pages 12294–12301, which introduces the Agriculture Development and Nutrition Security Special Feature. Image courtesy of Alex R. Freedman (Community Cooperative Farms, Sheffield, MA).

From the Cover

SPECIAL FEATURE: INTRODUC

Paths of convergence for agriculture, health, and wealth

Laurette Dubé[a,1], Prabhu Pingali[b], and Patrick Webb[c]

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This special feature calls for forward thinking around paths of convergence for agriculture, health, and wealth. Such convergence aims for a richer integration of smallholder farmers into national and global agricultural and food systems, health systems, value chains, and markets. The articles identify analytical innovation, where disciplines intersect, and cross-sectoral action where single, linear, and siloed approaches have traditionally dominated. The issues addressed are framed by three main themes: (*i*) lessons related to agricultural and food market growth since the 1960s; (*ii*) experiences related to the integration of smallholder agriculture into national and global business agendas; and (*iii*) insights into convergence-building institutional design and policy, including a review of complexity science methods that can inform such processes. In this introductory article, we first discuss the perspectives generated for more impactful policy and action when these three themes converge. We then push thematic boundaries to elaborate a roadmap for a broader, solution-oriented, and transdisciplinary approach to science, policies, and actions. As the global urban population crosses the 50% mark, both smallholder and nonsmallholder agriculture are keys in forging rural–urban links, where both farm and nonfarm activities contribute to sustainable nutrition security. The roadmaps would harness the power of business to reduce hunger and poverty for millions of families, contribute to a better alignment between human biology and modern lifestyles, and stem the spread of noncommunicable chronic diseases.

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A systems science perspective and transdisciplinary models for food and nutrition security

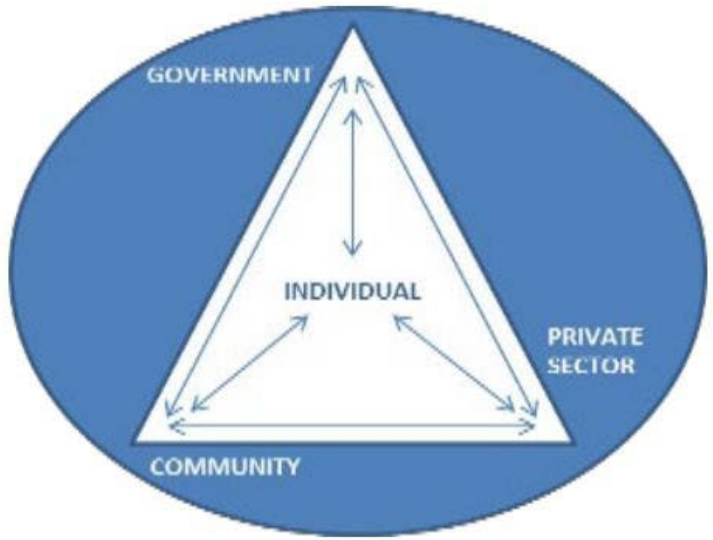
Ross A. Hammond[a,1] and Laurette Dubé[b]
[a]Center on Social Dynamics and Policy, The Brookings Institution, Washington, DC 20036; and [b]McGill World Platform for Health and Economic Convergence, McGill University, Montreal, QC, Canada H3A 1G5

Edited by Prabhu Pingali, Bill and Melinda Gates Foundation, Seattle, WA, and approved March 30, 2012 (received for review June 10, 2011)

We argue that food and nutrition security is driven by complex underlying systems and that both research and policy in this area would benefit from a systems approach. We present a framework for such an approach, examine key underlying systems, and identify transdisciplinary modeling tools that may prove especially useful.

Convergence-by-Design

A Person-in-Systems Approach to Adaptive Real World Behavior and Context.
The approach is person-centric and digital-powered to position the whole person at the core of the systems of systems that create contexts, and by doing so, to accelerate societal scale transformation, accounting for path dependency, and targeting adaptive real-world behavior and adaptive real world contexts, at the same time as it advances next-generation research for real-time, robust, and agile evidence to support action.



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Convergent Innovation: Changing the Way We Innovate

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES
Issue: *Paths of Convergence for Agriculture, Health, and Wealth*

Convergent innovation for sustainable economic growth and affordable universal health care: innovating the way we innovate

Laurette Dubé,[1,2] Srivardhini Jha,[2,3] Aida Faber,[1,2] Jeroen Struben,[1] Ted London,[4] Archisman Mohapatra,[5] Nick Drager,[2,6,7] Chris Lannon,[2] P. K. Joshi,[8] and John McDermott[8,9]

This paper introduces convergent innovation (CI) as a form of *meta-innovation*—an innovation in the way we innovate. CI integrates human and economic development outcomes, through behavioral and ecosystem transformation at scale, for sustainable prosperity and affordable universal health care within a whole-of-society paradigm. To this end, CI combines technological and social innovation (including organizational, social process, financial, and institutional), with a special focus on the most underserved populations. CI takes a modular approach that convenes around roadmaps for real world change—a portfolio of loosely coupled complementary partners from the business community, civil society, and the public sector. Roadmaps serve as collaborative platforms for focused, achievable, and time-bound projects to provide scalable, sustainable, and resilient solutions to complex challenges, with benefits both to participating partners and to society. In this paper, we first briefly review the literature on technological innovation that sets the foundations of CI and motivates its feasibility. We then describe CI, its building blocks, and enabling conditions for deployment and scaling up, illustrating its operational forms through examples of existing CI-sensitive innovation.

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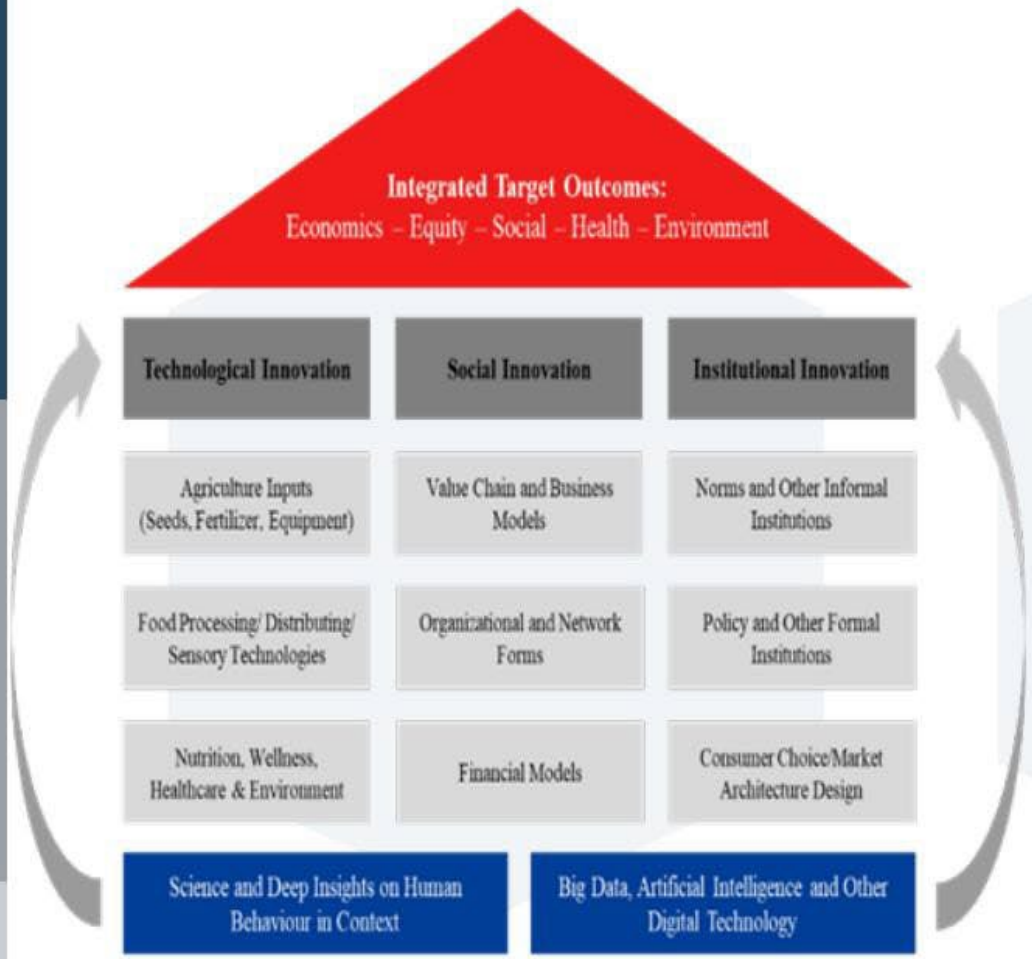


Data

Big Data , Omics with other data sources and methods including artificial intelligence and machine learning now can be embedded in real-world transformation

Complexity

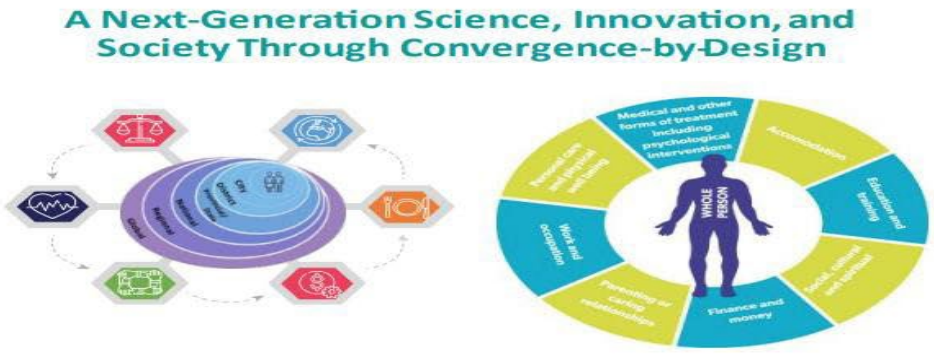
Advances in complexity science and other multi-level and dynamic modeling in description, predictive and prescriptive analytics

Building Blocks

Omics and diseases are not everything for a patient who is a whole person in a whole society....

Convergence of Health, Economic, Social and Environmental Outcome for Individual, Profession, Organization and System

SDoH from Health Implementation Science Vs Convergence-by-Design



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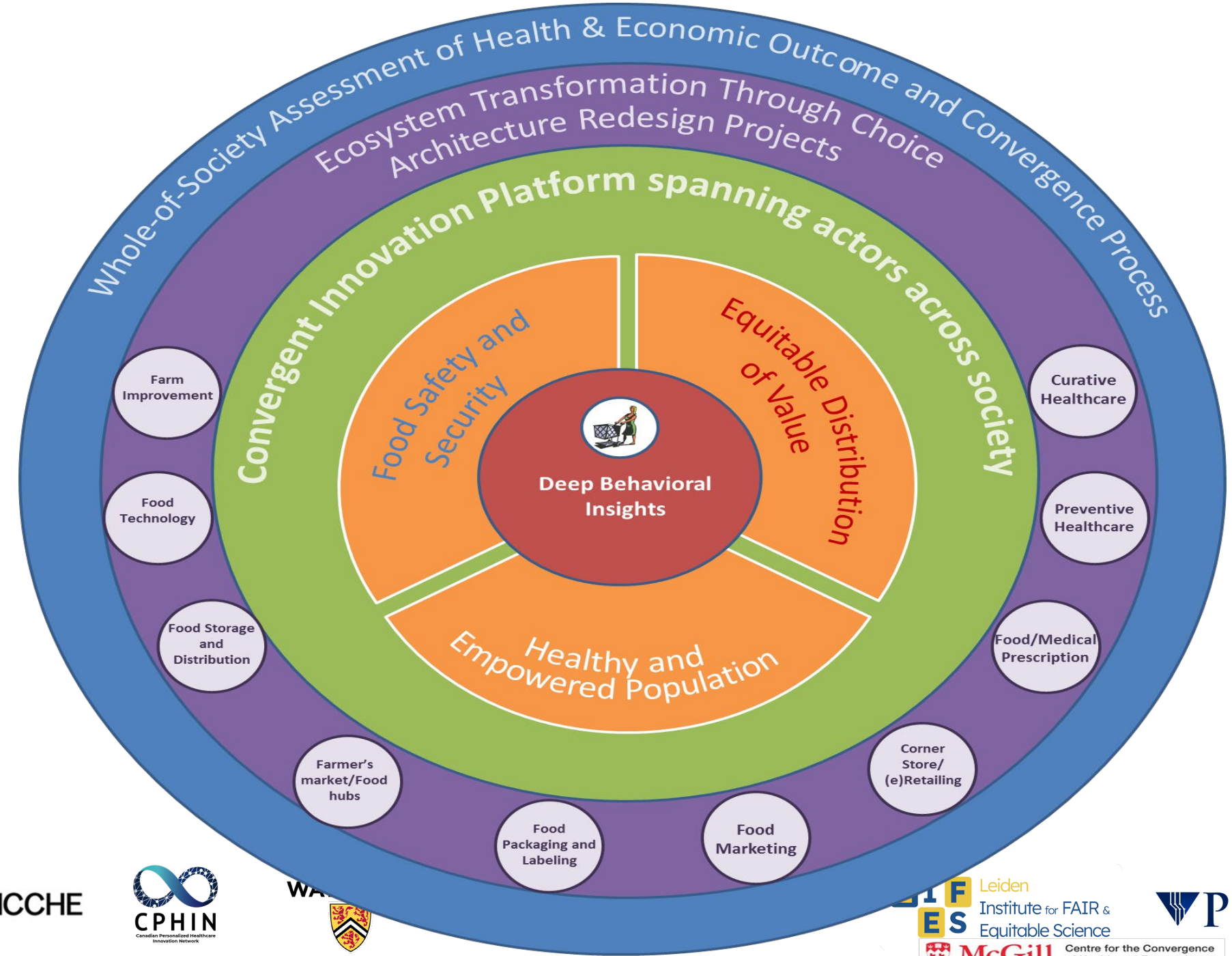
Whole-of-Society Assessment of Health & Economic Outcome and Convergence Process
Ecosystem Transformation Through Choice Architecture Redesign Projects
Convergent Innovation Platform spanning actors across society
Food Safety and Security
Equitable Distribution of Value
Deep Behavioral Insights
Healthy and Empowered Population
Farm Improvement
Food Technology
Food Storage and Distribution
Farmer's market/Food hubs
Food Packaging and Labeling
Food Marketing
Corner Store/ (e)Retailing
Food/Medical Prescription
Preventive Healthcare
Curative Healthcare

Precision convergence *(WoP in WoS):* Inventing a Science of the Real World

A precision convergence science and innovation lens (PC) relies on building organic coalitions that bridge on-the-ground, digitally-powered health system initiatives, turning them into magnets for AI companies, healthcare enterprises, and investors to individually and collectively improve scientific and societal investments and impact.

It is at once a concept, a way of doing things, and a way of measuring, all three facets deployed at the same time while continuously learning and evolving toward meaningful transformation at scale. It applies to individuals, communities, enterprises, governments, and investors, in short, to the whole society.

The ambition is to sustain a growing network of real-world projects and on-going use cases that target health system transformations at multiple scales. Each initiative takes a distinct entry point along the health and disease system continuum, under varied geopolitical, cultural, and functional conditions, covering the full spectrum of technological readiness and change processes.

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The Ten Principles of Precision Convergence

1) placing humans in all their roles, contexts and lifecourse positions at the center, including roles as care givers, workers, patients, investors, citizens and others, accommodating contexts heterogeneity tied to geo-spatial and geo-political conditions and dynamics and facilitating individual and collective well-being in all its dimension and over development lifecourse,

2) building 2-way linkages between system change and real-time individual and collective behavior change,

3) maintaining productive tension between aspiration and pragmatism,

4) balancing evolution (to account for initial conditions) with revolution (to prevent AI from simply automatizing non-adaptive process and system components),

5) embracing methodological pluralism in science, design, action, and policy,

6) moving from binary views of the world to views based on continua and diversity of causes and solutions, accounting for a modern world where everyone has a manner to impact one another at unprecedented speed and scale."

7) treating individual and collective agency and trust as essential currencies, not only money and power,

8) achieving whole-society scale through distributed leadership and distributed innovation, transitioning from multiple niches to systems changes,

9) respecting data sovereignty through federated architecture networks embedded into and evolving with real-world initiatives, and

10) enabling convergence through co-creation and reciprocity, engaging in dynamic "coalitions of the willing" built upon shared goals, interests, values, or resources, not only on shared institutions..

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2. Early ontology development-Health as entry points

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An infrastructure for real-time population health assessment and monitoring

The fragmented nature of population health information is a barrier to public health practice. Despite repeated demands by policymakers, administrators, and practitioners to develop information systems that provide a coherent view of population health status, there has been limited progress toward developing such an infrastructure. We are creating an informatics platform for describing and monitoring the health status of a defined population by integrating multiple clinical and administrative data sources. This infrastructure, which involves a population health record, is designed to enable development of detailed portraits of population health, facilitate monitoring of population health indicators, enable evaluation of interventions, and provide clinicians and patients with population context to assist diagnostic and therapeutic decision-making. In addition to supporting public health professionals, clinicians, and the public, we are designing the infrastructure to provide a platform for public health informatics research. This early report presents the requirements and architecture for the infrastructure and describes the initial implementation of the population health record, focusing on indicators of chronic diseases related to obesity.

D. L. Buckeridge *et al.*, "An infrastructure for real-time population health assessment and monitoring," in *IBM Journal of Research and Development*, vol. 56, no. 5, pp. 2:1-2:11, Sept.-Oct. 2012

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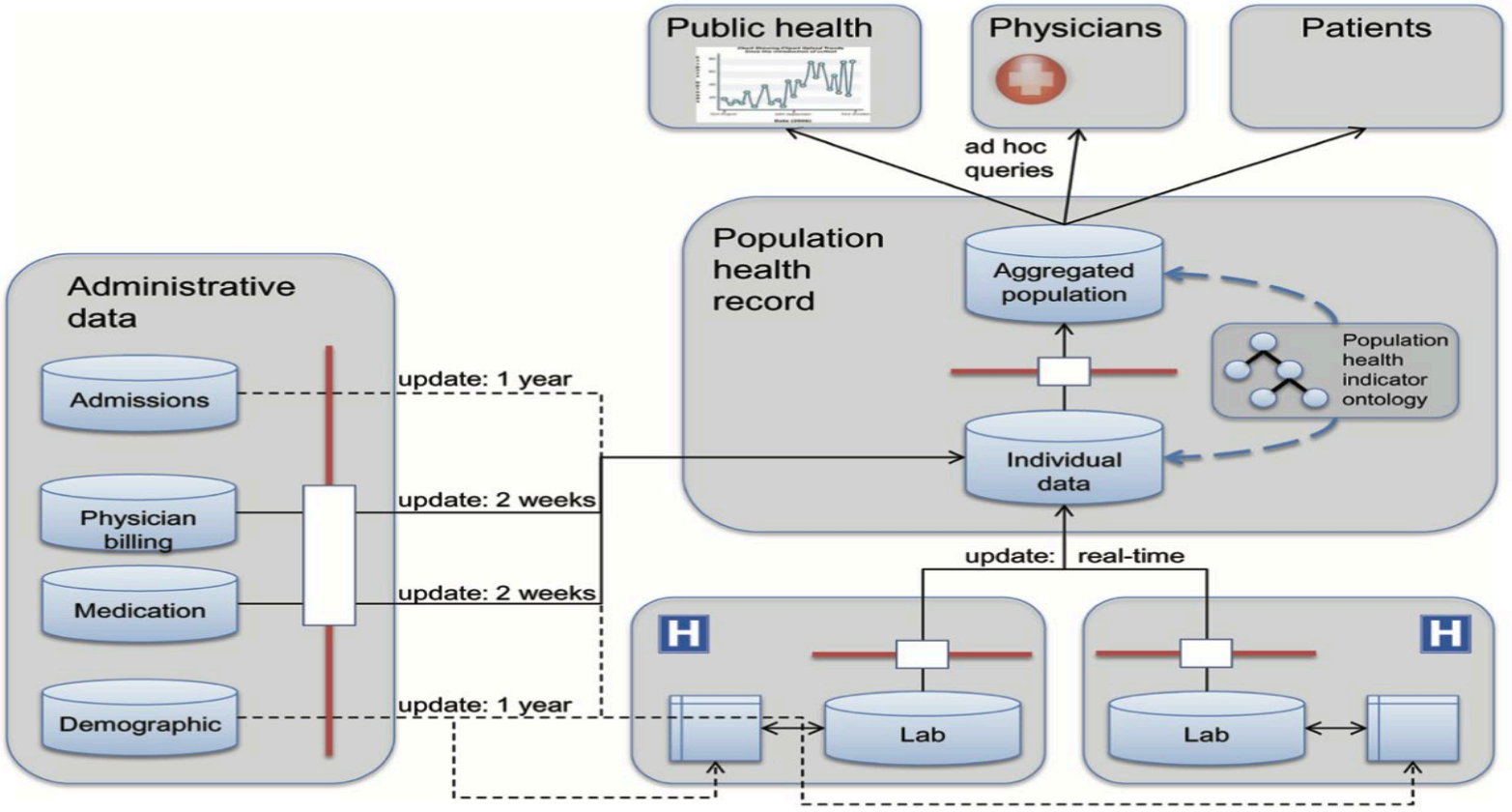
PoP-HR: An infrastructure for real-time population health assessment and monitoring



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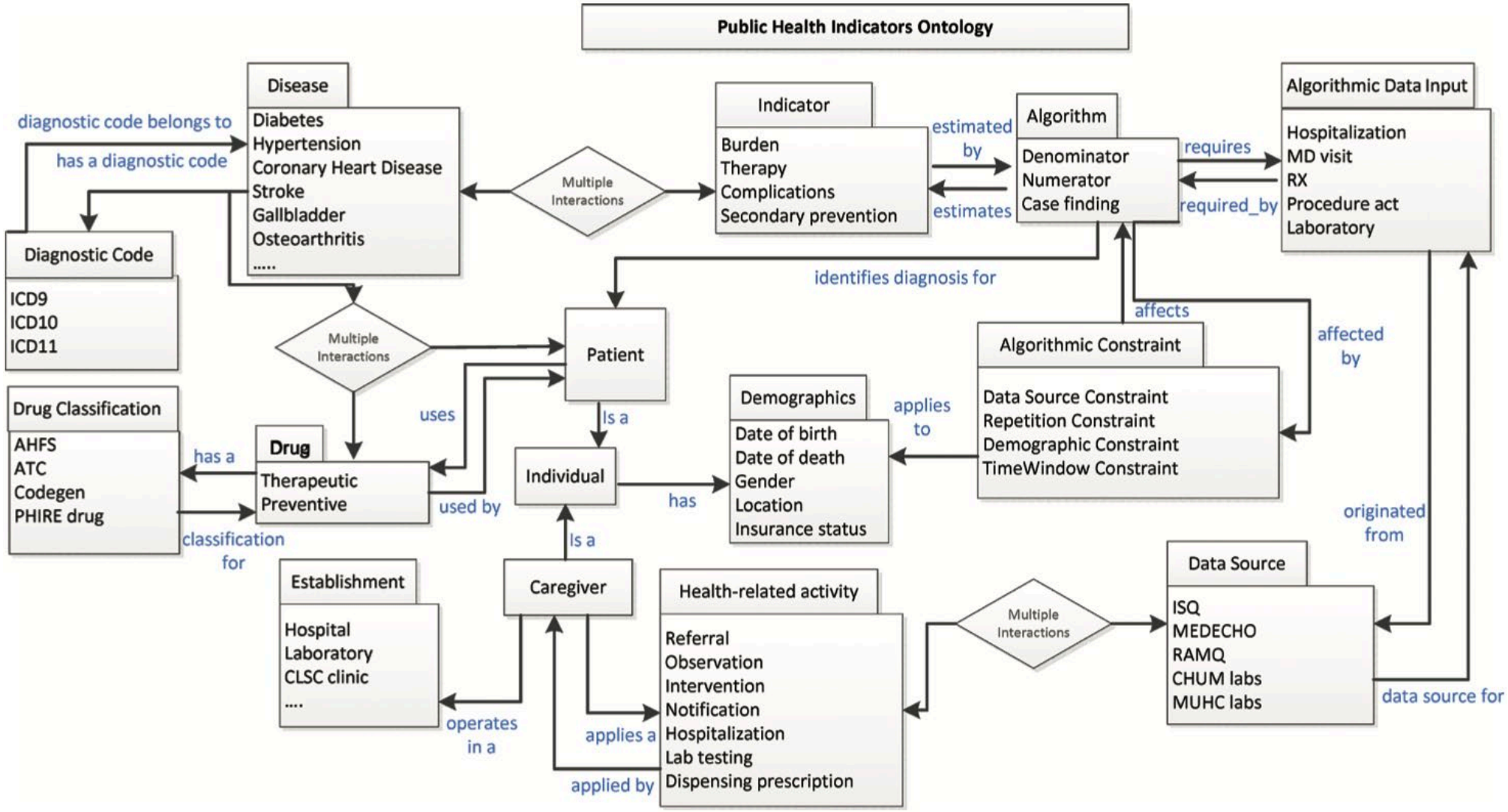
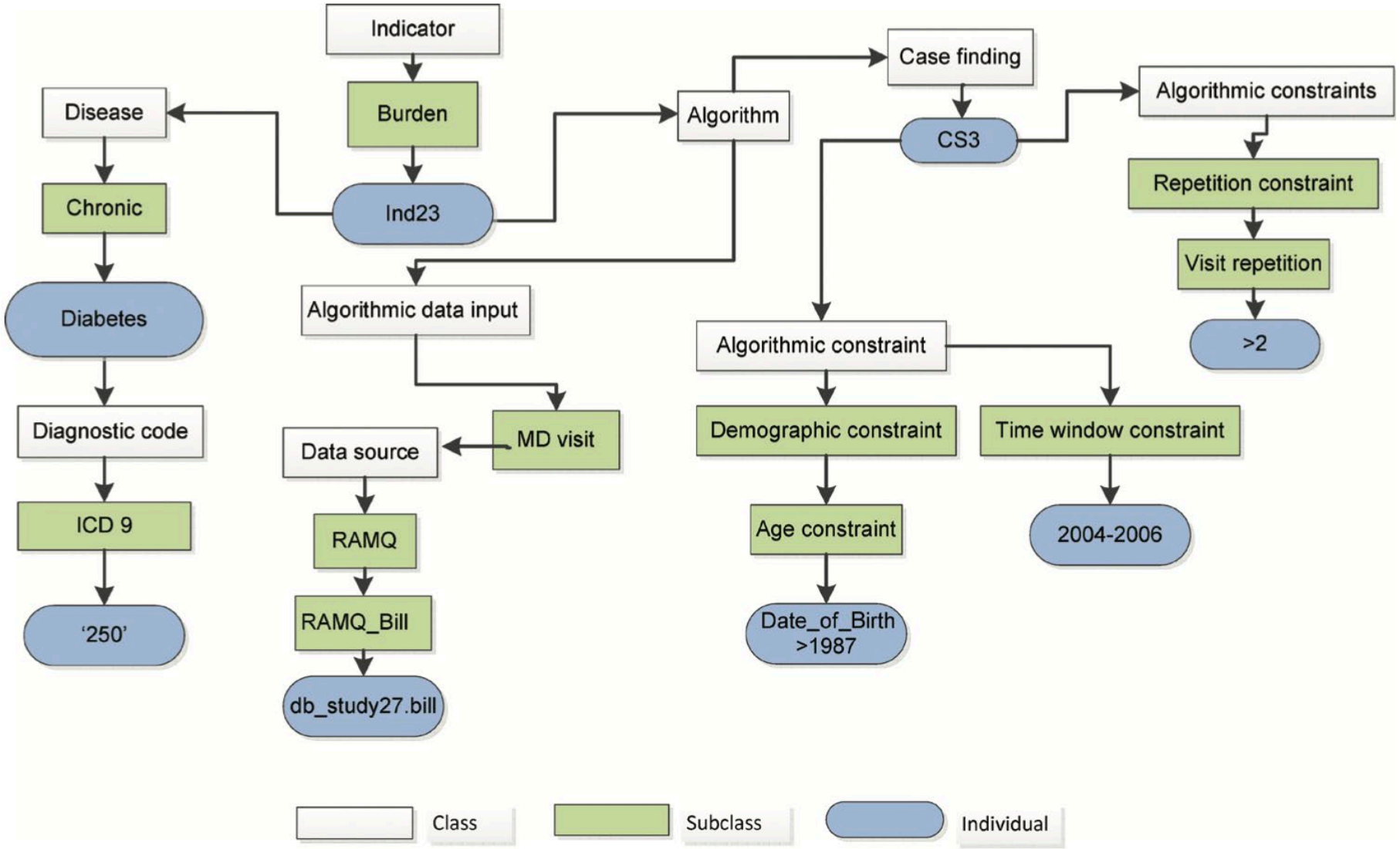

Public Health Indicators Ontology
Disease
Diabetes
Hypertension
Coronary Heart Disease
Stroke
Gallbladder
Osteoarthritis
.....
diagnostic code belongs to
has a diagnostic code
Diagnostic Code
ICD9
ICD10
ICD11
Multiple Interactions
Indicator
Burden
Therapy
Complications
Secondary prevention
estimated by
estimates
Algorithm
Denominator
Numerator
Case finding
requires
required_by
Algorithmic Data Input
Hospitalization
MD visit
RX
Procedure act
Laboratory
identifies diagnosis for
Patient
Multiple Interactions
affects
affected by
Algorithmic Constraint
Data Source Constraint
Repetition Constraint
Demographic Constraint
TimeWindow Constraint
Drug Classification
AHFS
ATC
Codegen
PHIRE drug
has a
classification for
Drug
Therapeutic
Preventive
uses
used by
Is a
Individual
has
Demographics
Date of birth
Date of death
Gender
Location
Insurance status
applies to
originated from
Establishment
Hospital
Laboratory
CLSC clinic
....
operates in a
Caregiver
Is a
Health-related activity
Referral
Observation
Intervention
Notification
Hospitalization
Lab testing
Dispensing prescription
applies a
applied by
Multiple Interactions
Data Source
ISQ
MEDECHO
RAMQ
CHUM labs
MUHC labs
data source for



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Ultra-processed Foods and Cardiovascular Diseases: In need of ontologies different from Agriculture and Health Ontologies

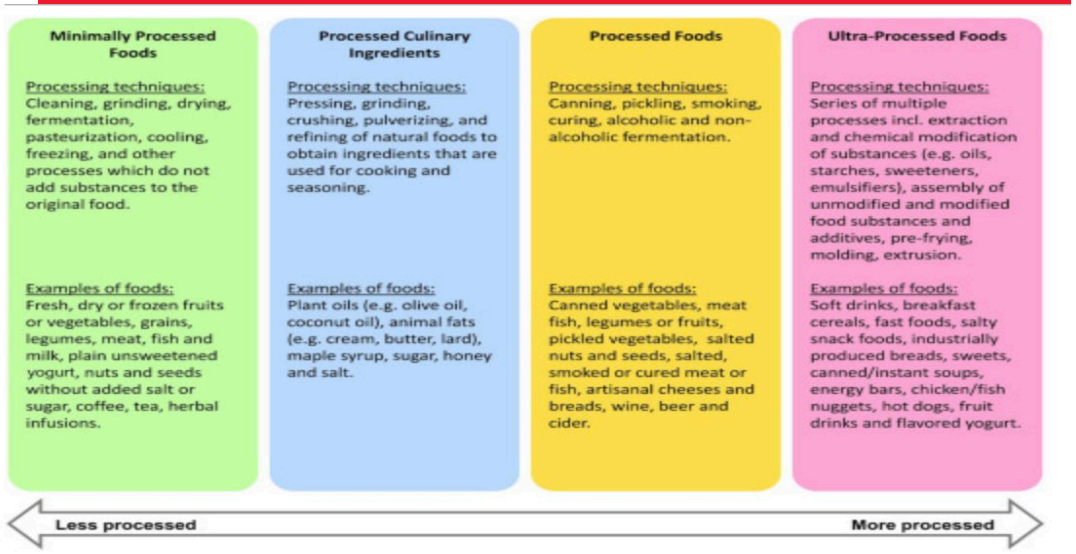

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FIGURE 1. Food-processing spectrum as defined by the NOVA framework. NOVA (a name, not an acronym) classifies foods as minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods based on the extent and purpose of industrial processing they have been submitted to (5). The figure provides examples of foods and the types of processing techniques used within each level.

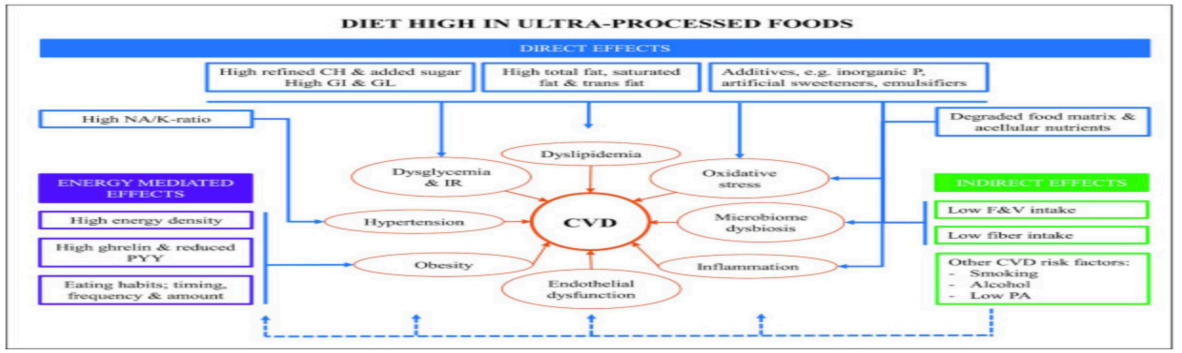

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FIGURE 2. Potential biological mechanisms underlying the association between ultra-processed foods and CVD. The diagram describes plausible biological pathways through which a diet high in ultra-processed foods may contribute to CVD. Key mechanisms include altered serum lipid concentrations, modified gut microbiota and host–microbiota interactions, obesity, inflammation, oxidative stress, dysglycemia, insulin resistance, and hypertension and hormonal imbalances. Arrows indicate stimulation of a pathway. CH, carbohydrates; CVD, cardiovascular disease; F&V, fruit and vegetables; GI, glycemic index; GL, glycemic load; IR, insulin resistance; NA/K-ratio, sodium-to-potassium ratio; P, phosphorus; PA, physical activity; PYY; peptide YY.

Juul, F., Vaidean, G., & Parekh, N. (2021). Ultra-processed foods and cardiovascular diseases: Potential mechanisms of action. *Advances in Nutrition*, *12*(5), 1673–1680. https://doi.org/10.1093/advances/nmab049

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Multi-dimensional Temporality of Food, Eating and Health/Disease Need to be More fully considered

This literature review uses four dimensions to classify and compare how food-related decision-making is conceptualized and experimentally assessed in neuroscience and other disciplines: (1) food-related decision-making other than the decision of *what* to eat that is part of each eating episode, (2) decision complexes other than the eating episode itself, (3) the evolution of food-related decision-making over time, and (4) the nature of food related decisions. In neuroscience in particular, food-related decision-making research has been dominated by studies exploring the influence of a wide range of factors on the final outcome, the type and amount of foods eaten. In comparison, the steps that are leading up to this outcome have only rarely been discussed. Neuroscientists should broaden their historically narrow conceptualization of food-related decision-making. Then neuroscience research could help group the numerous hypothesized influences for each of the decision complexes into meaningful clusters that rely on the same or similar brain mechanisms and that thus function in similar ways. This strategy could help researchers improve existing broad models of human food-related decision-making from other disciplines. The integration of neuroscientific and behavioral science approaches can lead to a better model of food-related decision-making grounded in the brain and relevant to the design of more effective school and nonschool lifestyle interventions to prevent and treat obesity in children, adolescents, and adults.

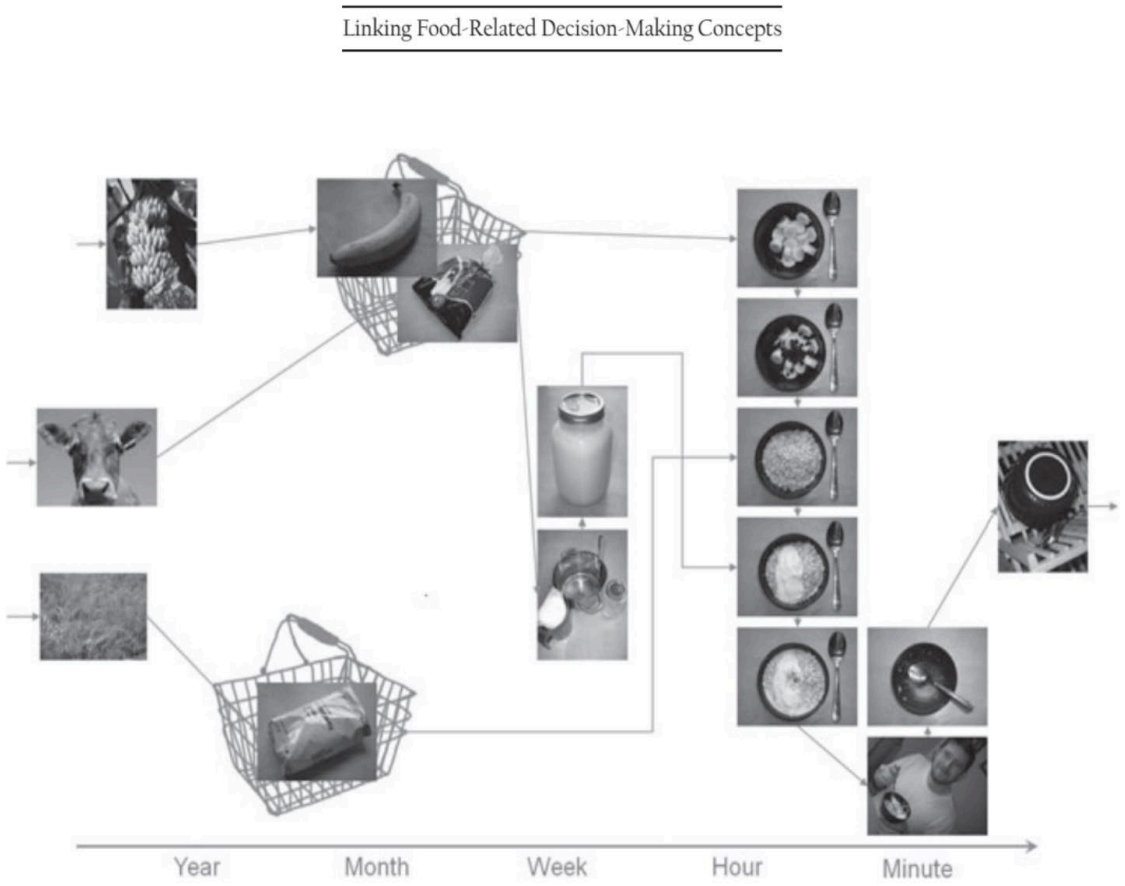

Fig. 1. Food-related decision-making example. The figure shows the evolution over time of the decision to consume a bowl of cereal for breakfast on a given morning (specific eating episode), including the various production, acquisition, preparation, and clean-up decision complexes along with their interdependencies.

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An OWL 2-Based Knowledge Platform Combining the Social and Semantic Webs for an Ambient Childhood Obesity Prevention System

Amid the extremely active Semantic Web community and the Social Web's exceptionally rising popularity, experts believe that an amplified fusion between the two webs will give rise to the next huge advancement in Web intelligence. Such advances can particularly be translated into ambient and ubiquitous systems and applications. In this paper, we delve into the recent advances in knowledge representation, semantic web, natural language processing and online social networking data and concepts, to propose an inclusive platform and framework defining ambient recommender and decision support systems that aim at facilitating cross-sectional analysis of the domain of childhood obesity and generating both generic and customized preventive recommendations.

Jinan El-Hachem, Arash Shaban-Nejad, Volker Haarslev, Laurette Dubé, David L. Buckeridge, An OWL 2-Based Knowledge Platform Combining the Social and Semantic Webs for an Ambient Childhood Obesity Prevention System, Procedia Computer Science, Volume 10, 2012, Pages 110-119, ISSN 1877-0509,

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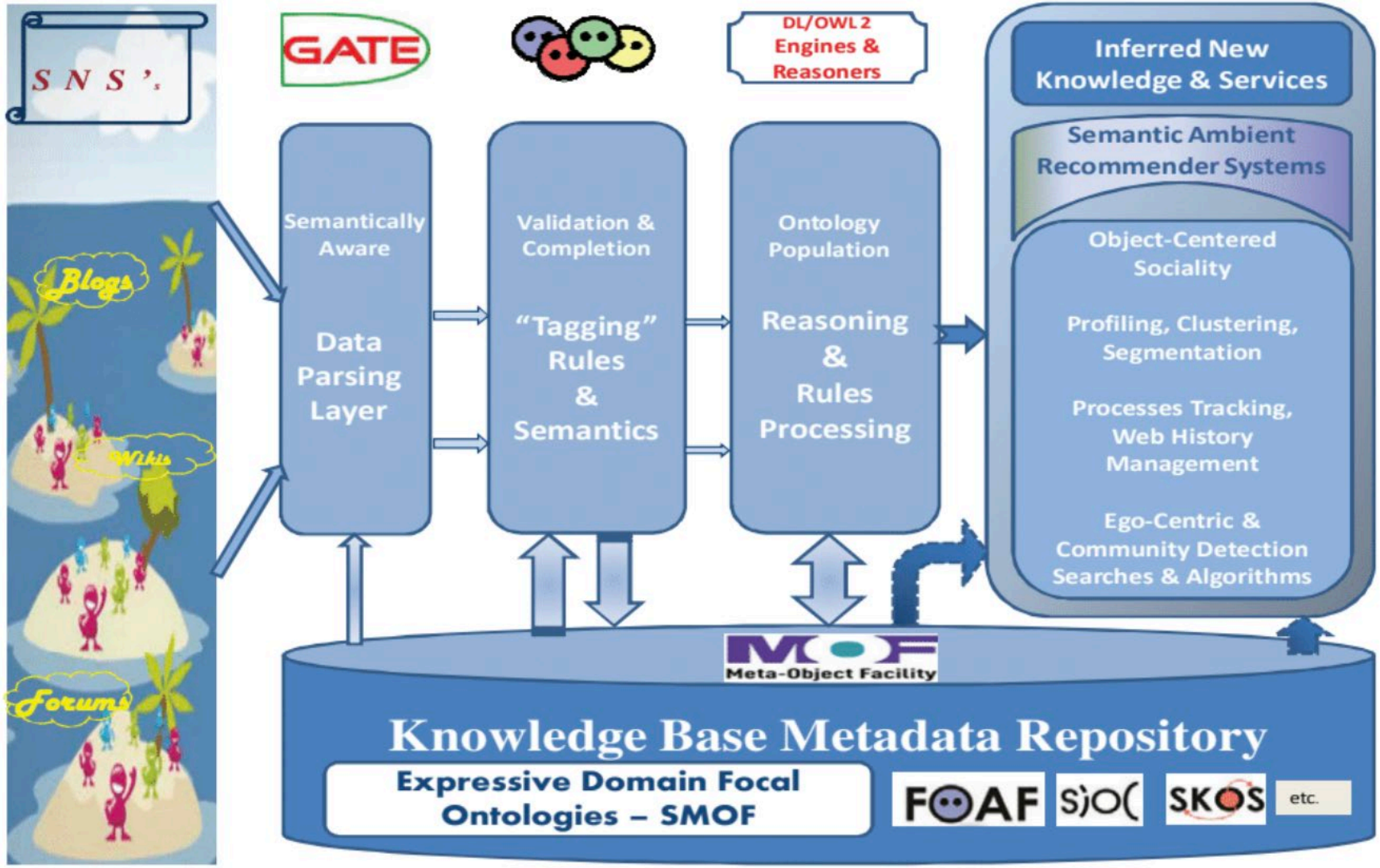


Fig 1. General overview of the proposed real-time knowledge-based architecture and modeling platform.

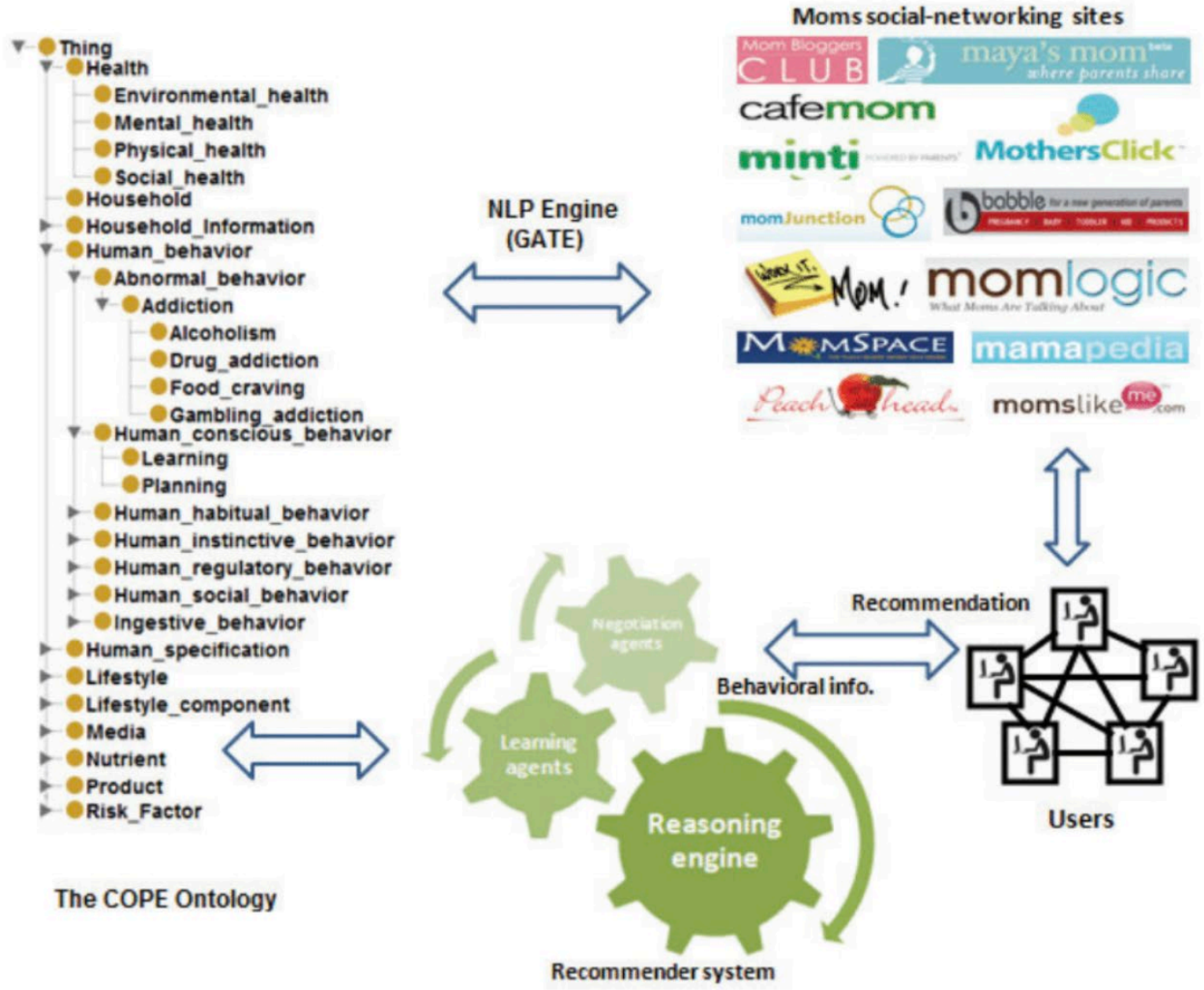


Fig. 2. COPE ontology as basis for appropriate recommendations based on inferred knowledge from users' behaviors and activities.

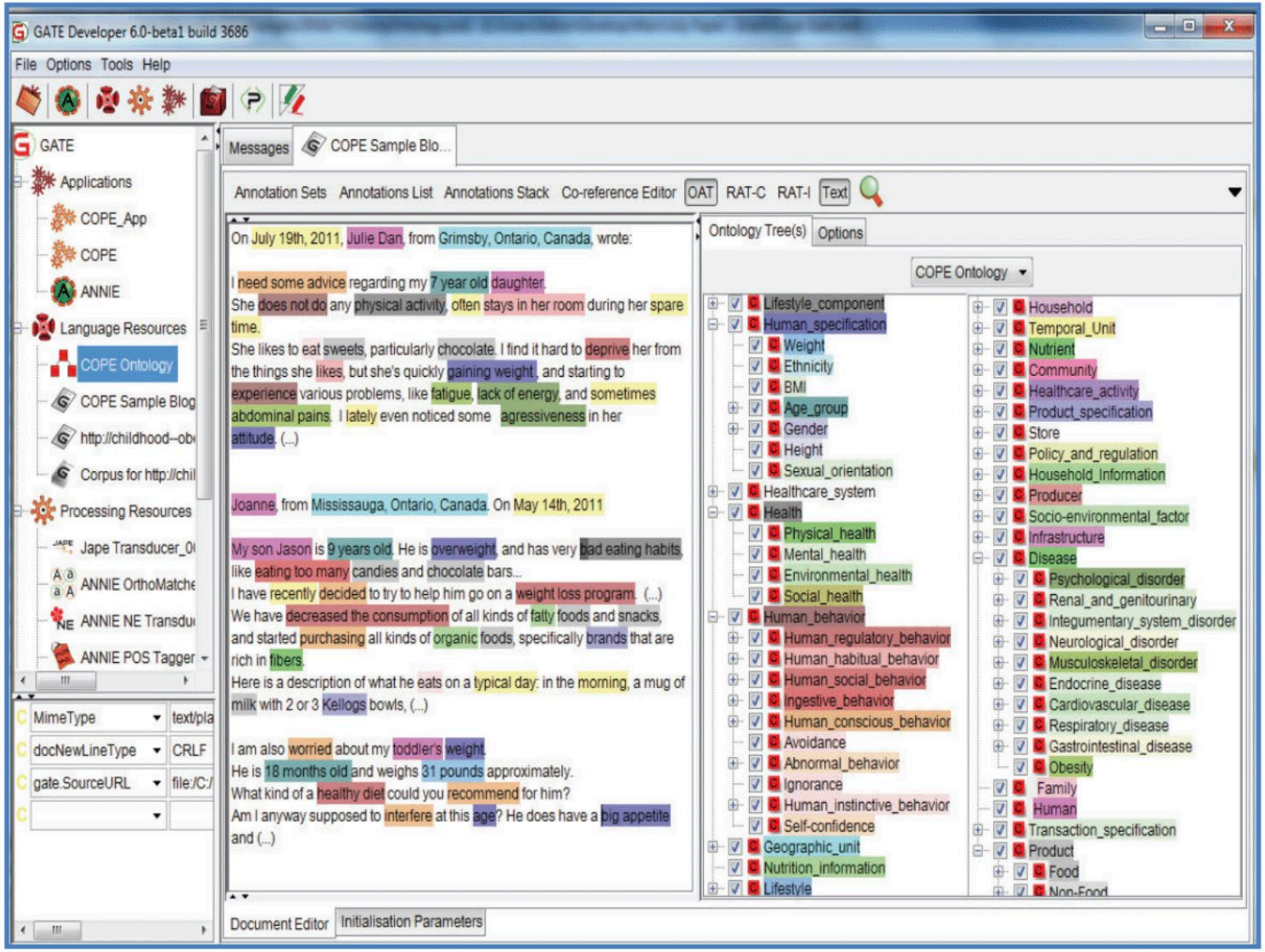


Fig. 3. Sample processed annotations using GATE. (Note that the results have been shown in different color codes)

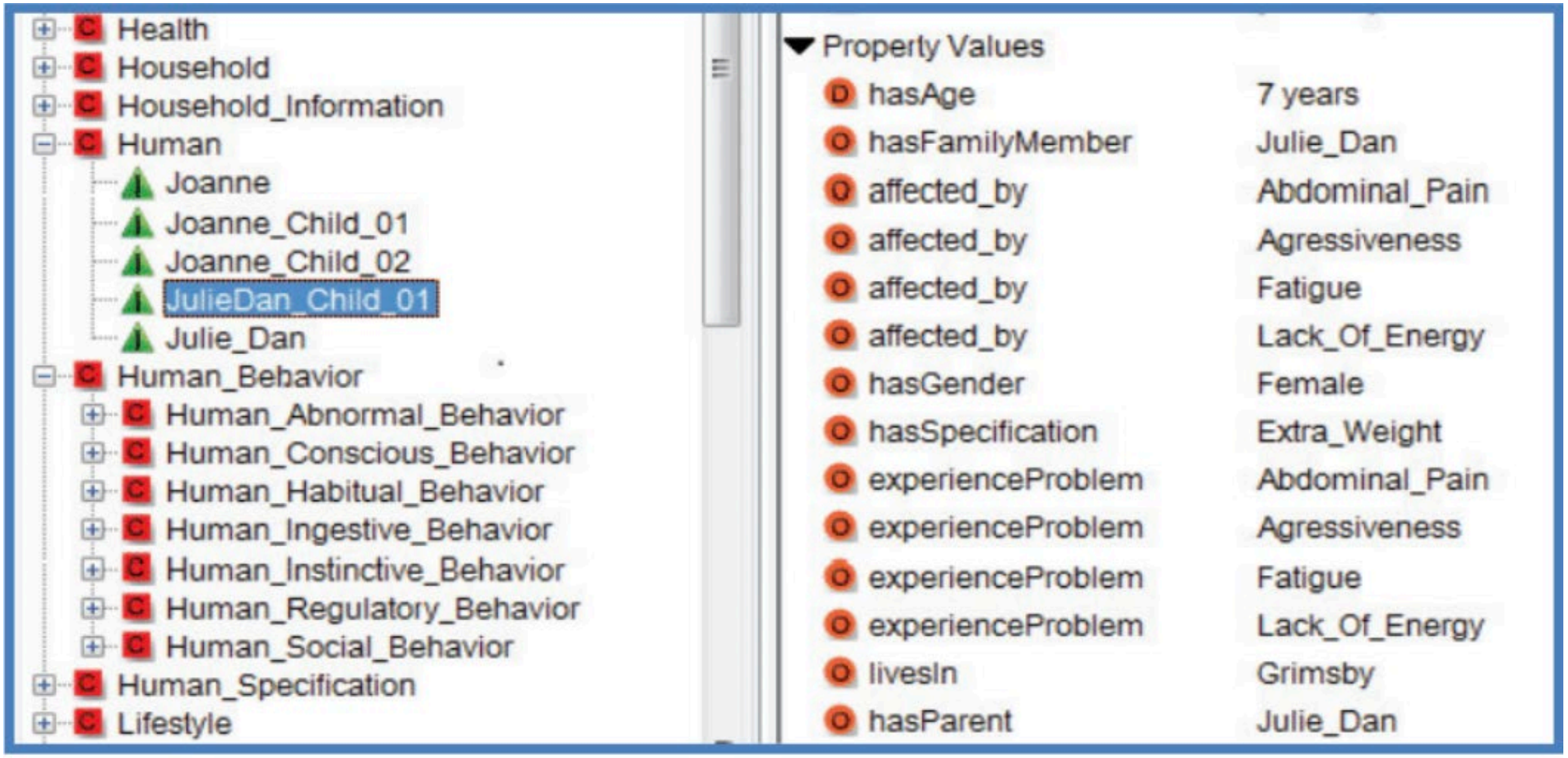
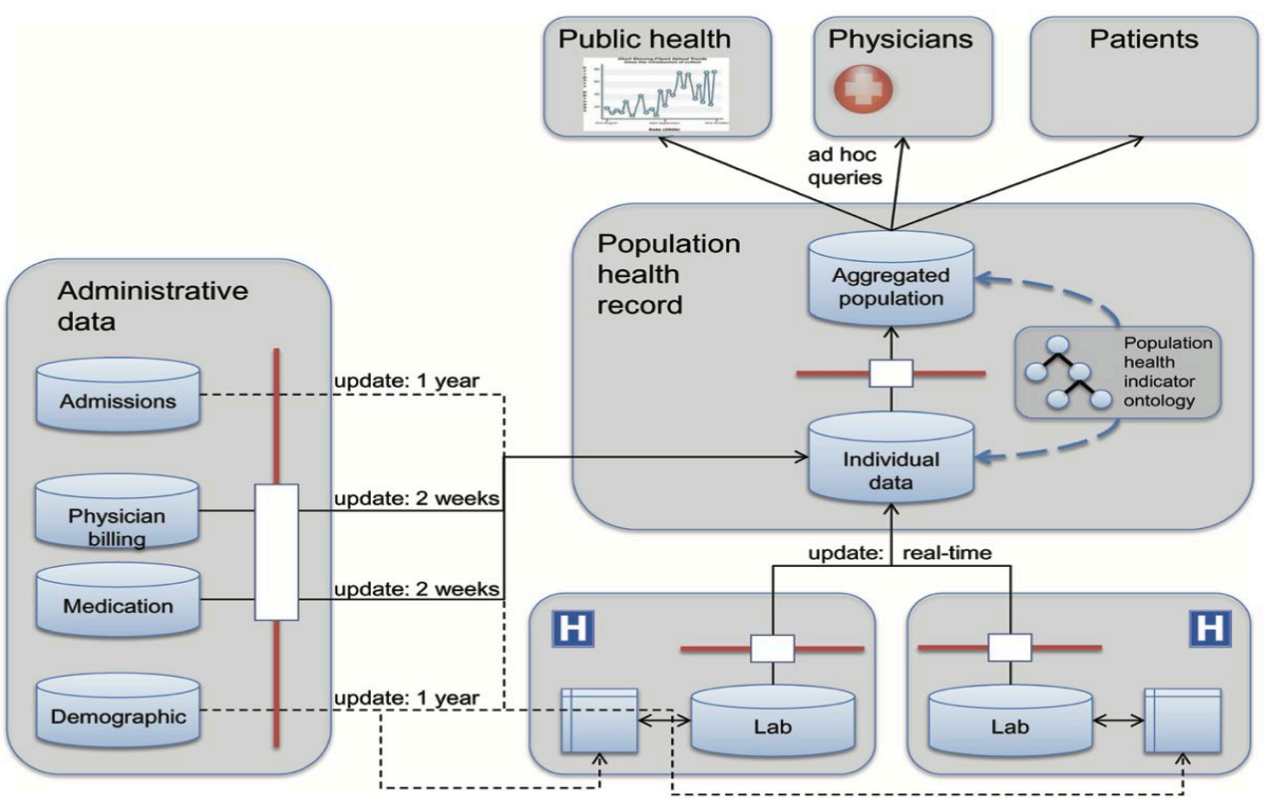
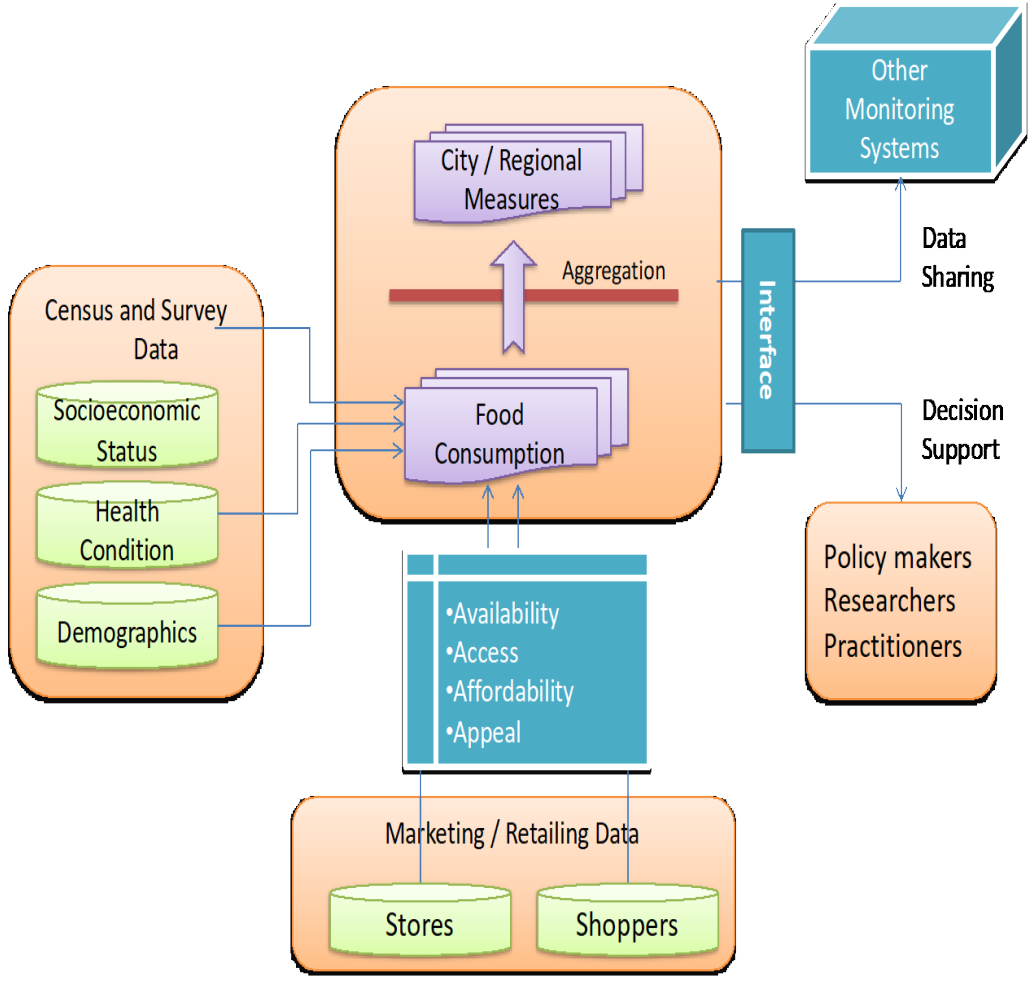


Fig. 4. Sample individual properties and values.

PoP-HR and its Food Extensions





D. L. Buckeridge *et al.*, "An infrastructure for real-time population health assessment and monitoring," in *IBM Journal of Research and Development*, vol. 56, no. 5, pp. 2:1-2:11, Sept.-Oct. 2012

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Estimating neighborhood spatial patterning of dietary behaviors using grocery transaction data

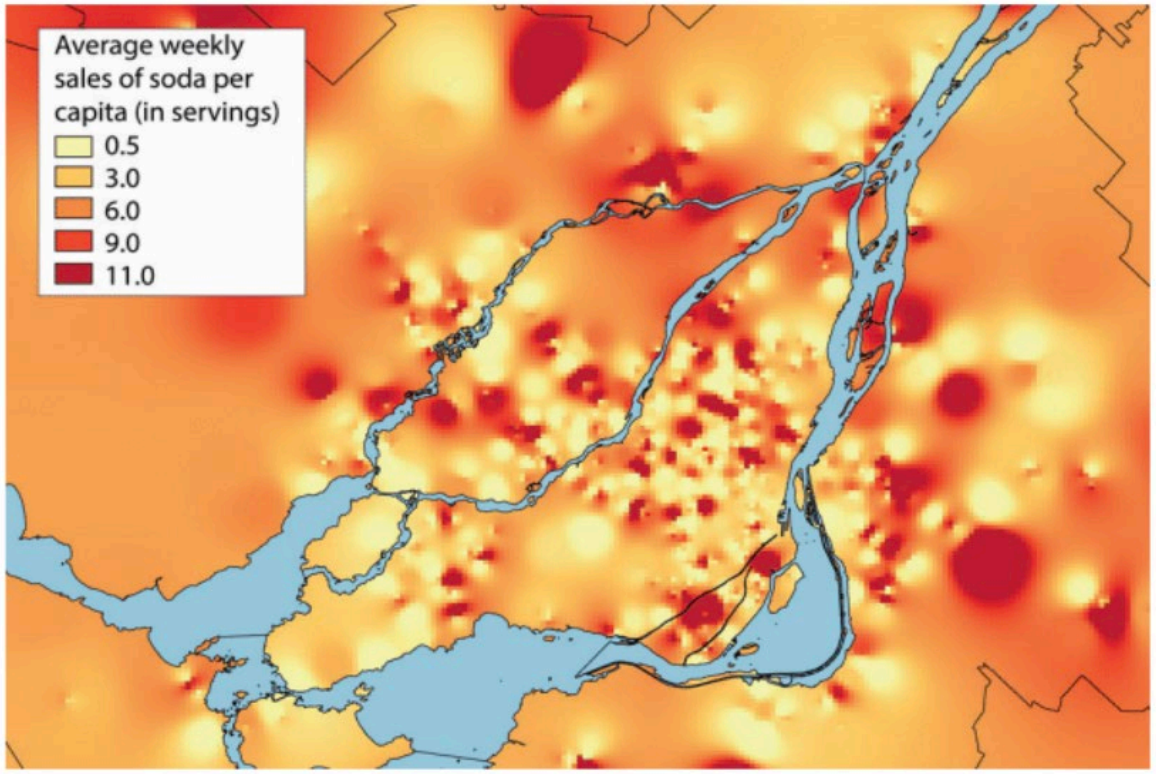

Figure2: Predicted weekly sales of soda in the Montreal CMA in 2012. Spatial interpolation was performed on the point quantities of predicted sales at each store.

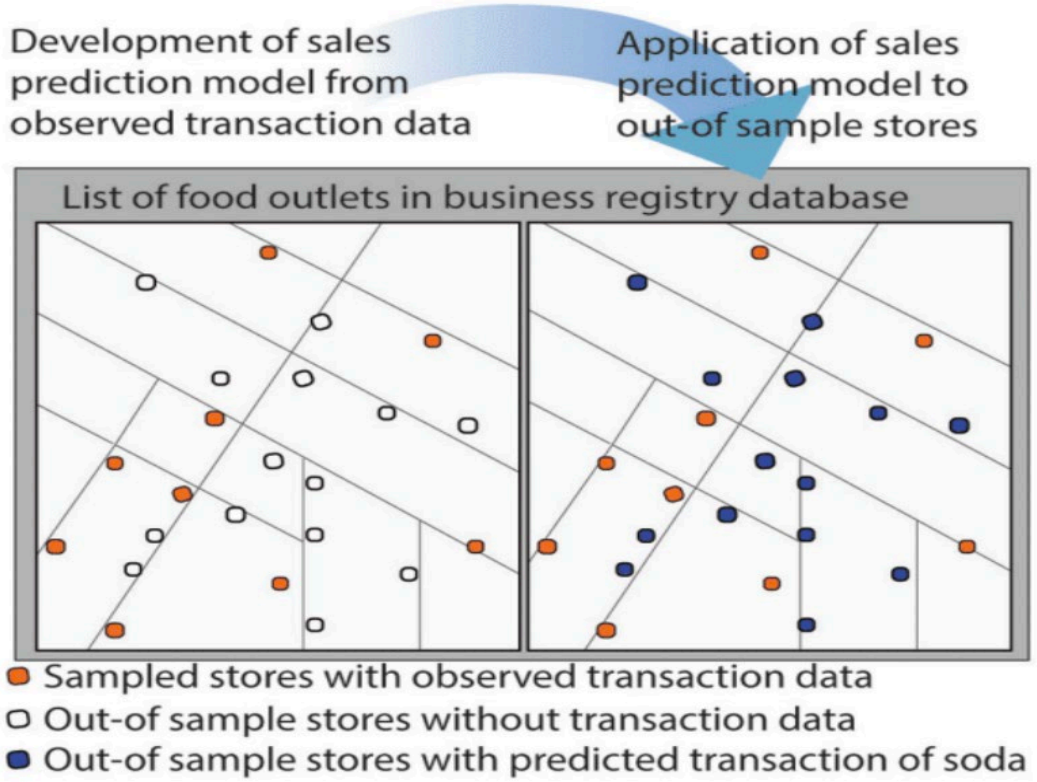

Figure 1: Schematic representation of the process generating spatial food selection measure using grocery transaction data and business establishment database

Mamiya, H., Moodie, E., & Buckeridge, D. (2017). Estimating spatial patterning of dietary behaviors using grocery transaction data. *Online Journal of Public Health Informatics*, *9*(1), e62050.

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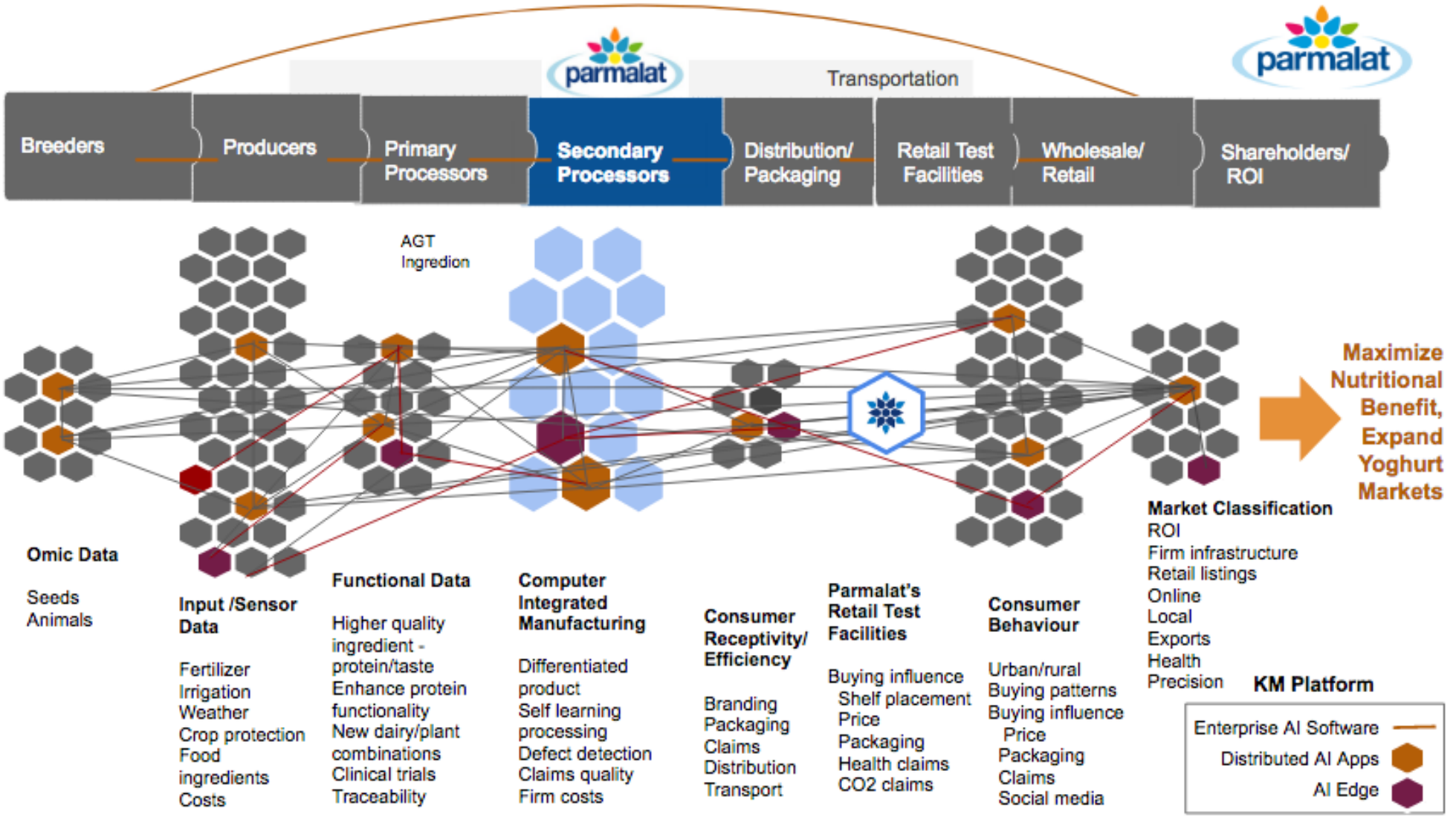
End-to-End Agri-Food Analytics



What about need of social ontologies?

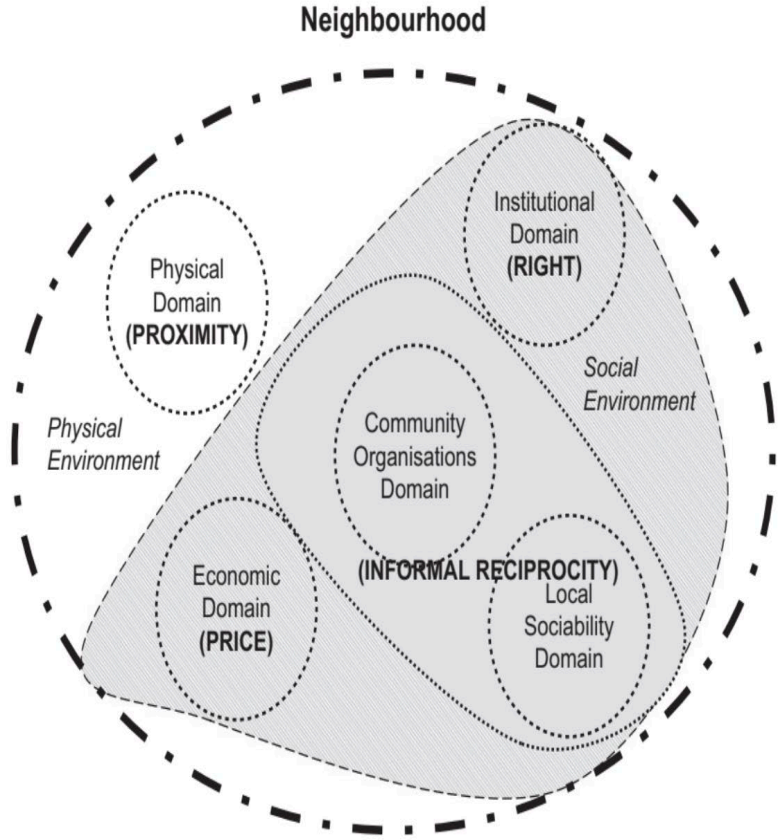


Fig. 1. Neighbourhood environments and rules of access. *Note*: Four sets of rules (indicated in bold capital letters) determine access to neighbourhood resources coming from the physical environment as well as from the social environment. The neighbourhood social environment (indicated by the light shade of grey) comprises four domains. Two of these domains (indicated by the darker shade of grey) both obey the rule of informal reciprocity. All these environments and domains are in mutual interaction.

Health Informatics, 9(1), e62050.

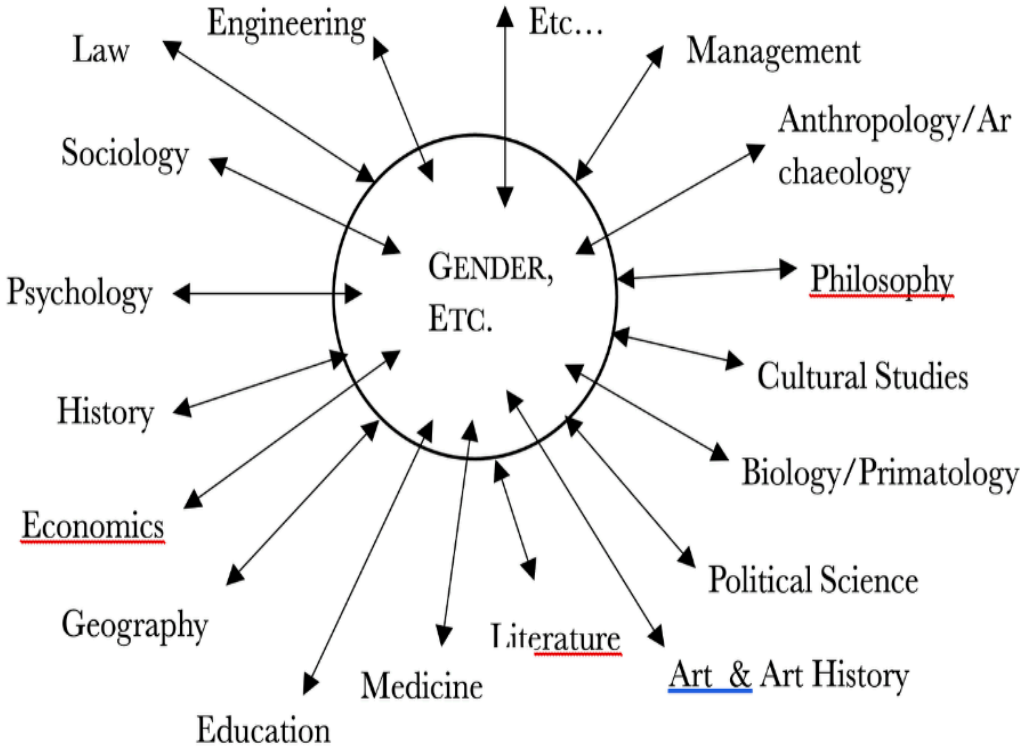


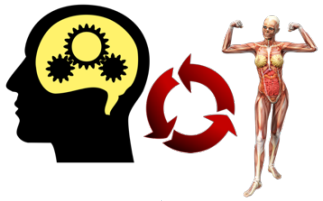
Figure 1.

SYNTHECO. Multi-Scale Data and Platforms for Convergent Innovation and Societal-Scale Personalization and Transformation

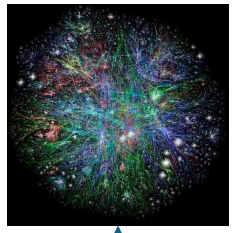
Census Data

Manufacturer Data

Food Retail Data

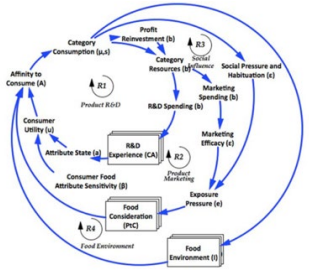


Behavioural Composition & Behavioural Model Repo

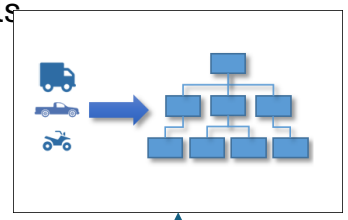


Synthetic Ecosystems

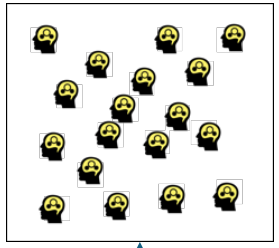
Agriculture Forecasting



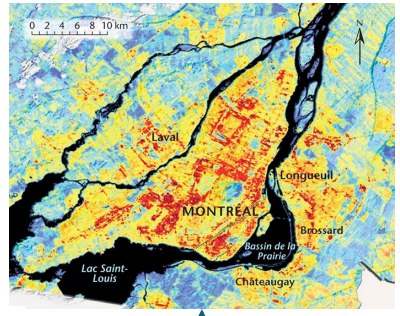
FCI System Dynamics Models



Supply Chain Modeling



Fine-Grained Agent-Based Model



Population-Level Agent-Based Model

CI Digital Backbone (Provides Standard Interface)

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3. UFOOD-Multi-domain and multi-level ontologies for real-world embedded architecture

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The Ten Principles of Precision Convergence

1) placing humans in all their roles, contexts and lifecourse positions at the center, including roles as care givers, workers, patients, investors, citizens and others, accommodating contexts heterogeneity tied to geo-spatial and geo-political conditions and dynamics and facilitating individual and collective well-being in all its dimension and over development lifecourse,

2) building 2-way linkages between system change and real-time individual and collective behavior change,

3) maintaining productive tension between aspiration and pragmatism,

4) balancing evolution (to account for initial conditions) with revolution (to prevent AI from simply automatizing non-adaptive process and system components),

5) embracing methodological pluralism in science, design, action, and policy,

6) moving from binary views of the world to views based on continua and diversity of causes and solutions, accounting for a modern world where everyone has a manner to impact one another at unprecedented speed and scale."

7) treating individual and collective agency and trust as essential currencies, not only money and power,

8) achieving whole-society scale through distributed leadership and distributed innovation, transitioning from multiple niches to systems changes,

9) respecting data sovereignty through federated architecture networks embedded into and evolving with real-world initiatives, and

10) enabling convergence through co-creation and reciprocity, engaging in dynamic "coalitions of the willing" built upon shared goals, interests, values, or resources, not only on shared institutions..

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Engineering requirements for precision convergence digital backbone

1)An ontology federation with: an alignment between DOLCE, BFO and UFO

2) An ontology network with mid-level (about value, trust, risk and risk propagation, resilience and contractual relations), ontologies and domain-ontologies of relevance for food and food systems

3)A novel approach for flexible alignments considering a value-based criteria for alignment precision but also allowing for the dynamics of change and evolution of the aligned models

4)An approach for dynamic construction of ontologies in unstable and fast changing domains and for which knowledge consensus is yet to be formed.

5)An infrastructure for secure, private, scalable and trustworthy FAIR data sharing with ontology-based data access but with dynamically aligned ontologies.

6)A neurosymbolic prediction and recommendation system capable of: 1)reasoning about goal satisfaction, risk and risk propagation, trust and legal relations, event and causality, food and food component, etc; 2) anticipate disruptive events; 3) recommend action and behavioural change in a way that is explainable and personalized to the values, goals, norms and background of each stakeholder

7) A common ethical and trust framework whose operationalization could translate into a set of enforceable ethical guardrails embedded into every A.I.-enabled device employed by humans or machines that could ensure that A.I. is used only for the benefit of humanity.

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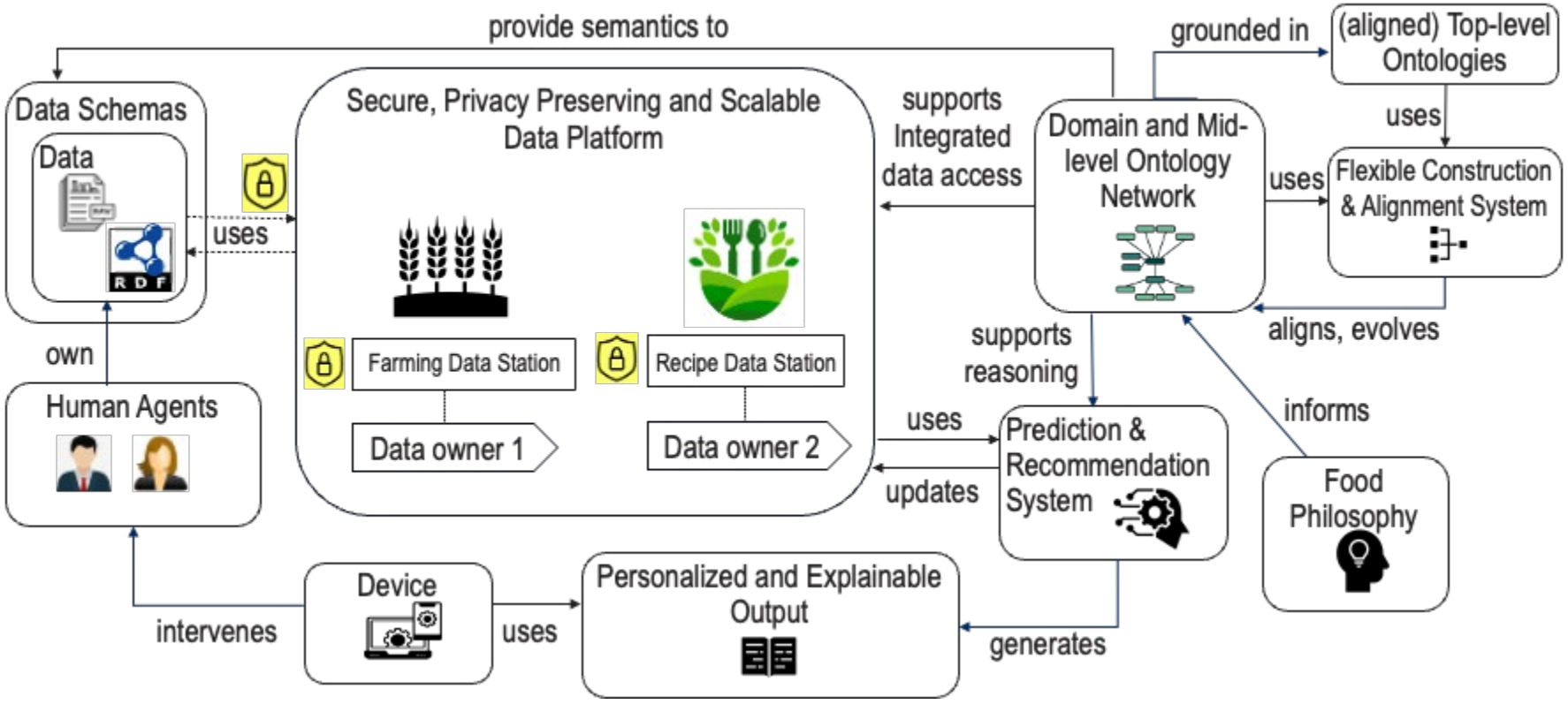
High-level schematic model of UFOOD's computing architecture (Guizzardi et al)



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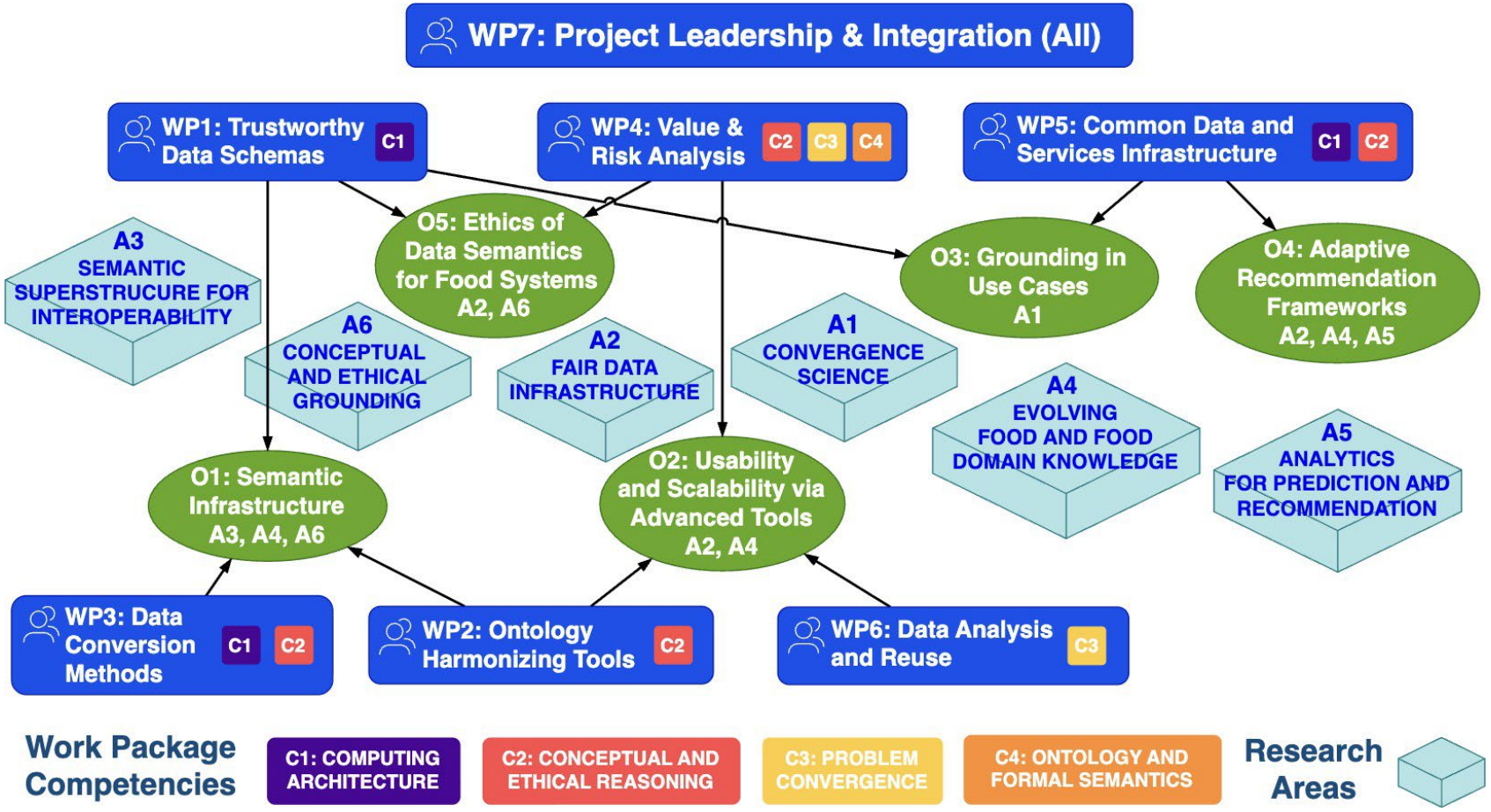
UFOOD's convergent research approach *(Guizzardi et al)*



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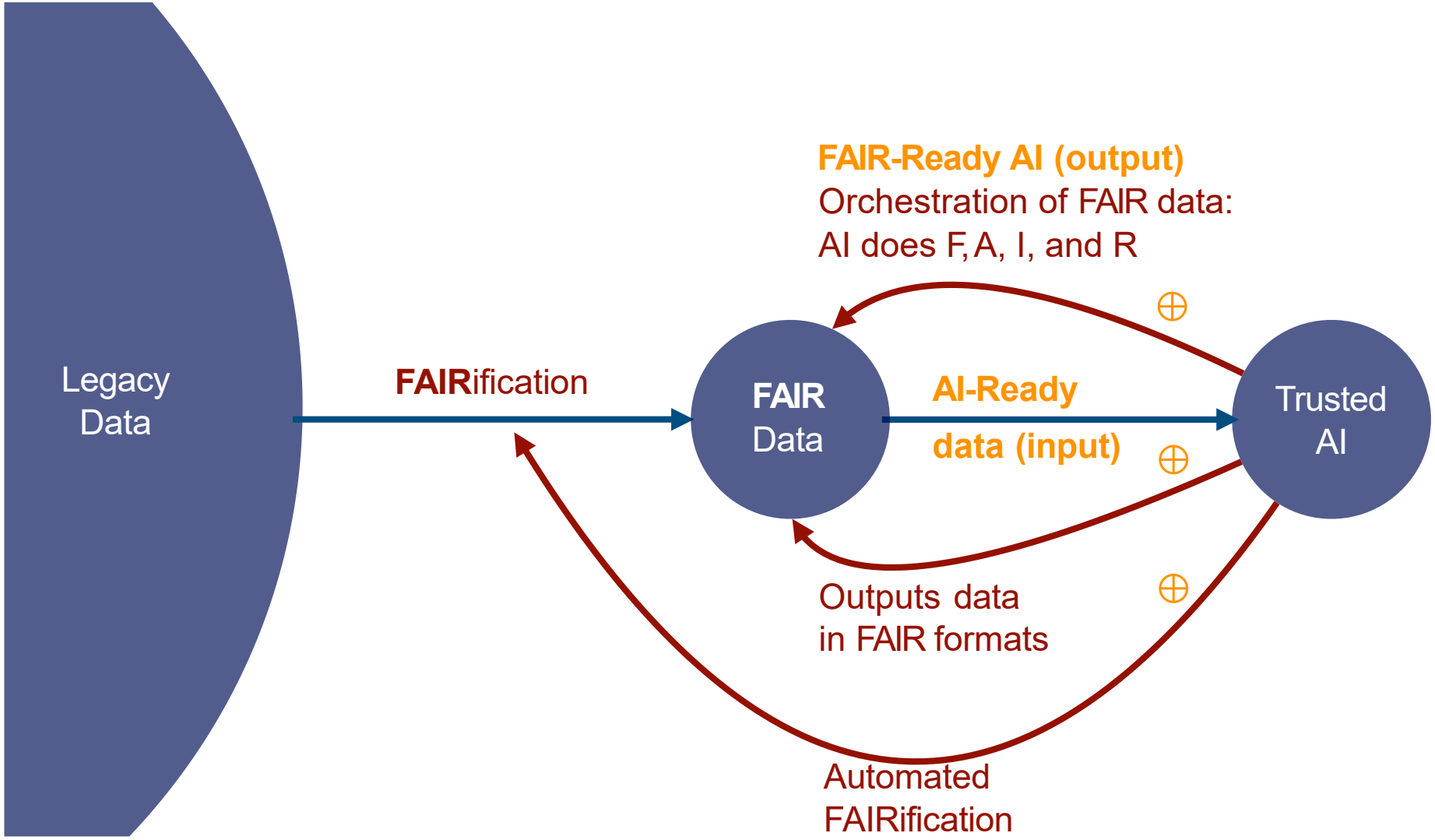
FAIR Data for Trusted AI in Real World Contexts



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Explanation, semantics, and ontology

The terms ‘semantics’ and ‘ontology’ are increasingly appearing together with ‘explanation’, not only in the scientific literature, but also in everyday social interactions, in particular, within organizations. Ontologies have been shown to play a key role in supporting the semantic interoperability of data and knowledge representation structures used by information systems. With the proliferation of applications of Artificial Intelligence (AI) in different settings and the increasing need to guarantee their explainability (but also their interoperability) in critical contexts, the term ‘explanation’ has also become part of the scientific and technical jargon of modern information systems engineering. However, all of these terms are also significantly overloaded. In this paper, we address several interpretations of these notions, with an emphasis on their strong connection. Specifically, we discuss a notion of explanation termed ontological unpacking, which aims at explaining symbolic domain descriptions (e.g., conceptual models, knowledge graphs, logical specifications) by revealing their ontological commitment in terms of their so-called truthmakers, i.e., the entities in one’s ontology that are responsible for the truth of a description. To illustrate this methodology, we employ an ontological theory of relations to explain a symbolic model encoded in the de facto standard modeling language UML. We also discuss the essential role played by ontology-driven conceptual models (resulting from this form of explanation processes) in supporting semantic interoperability tasks. Furthermore, we revisit a proposal for quality criteria for explanations from philosophy of science to assess our approach. Finally, we discuss the relation between ontological unpacking and other forms of explanation in philosophy and science, as well as in the subarea of Artificial Intelligence known as Explainable AI (XAI).

Guizzardi, G., & Guarino, N. (2024). Explanation, semantics, and ontology. *Data & Knowledge Engineering*, *153*, 102325.

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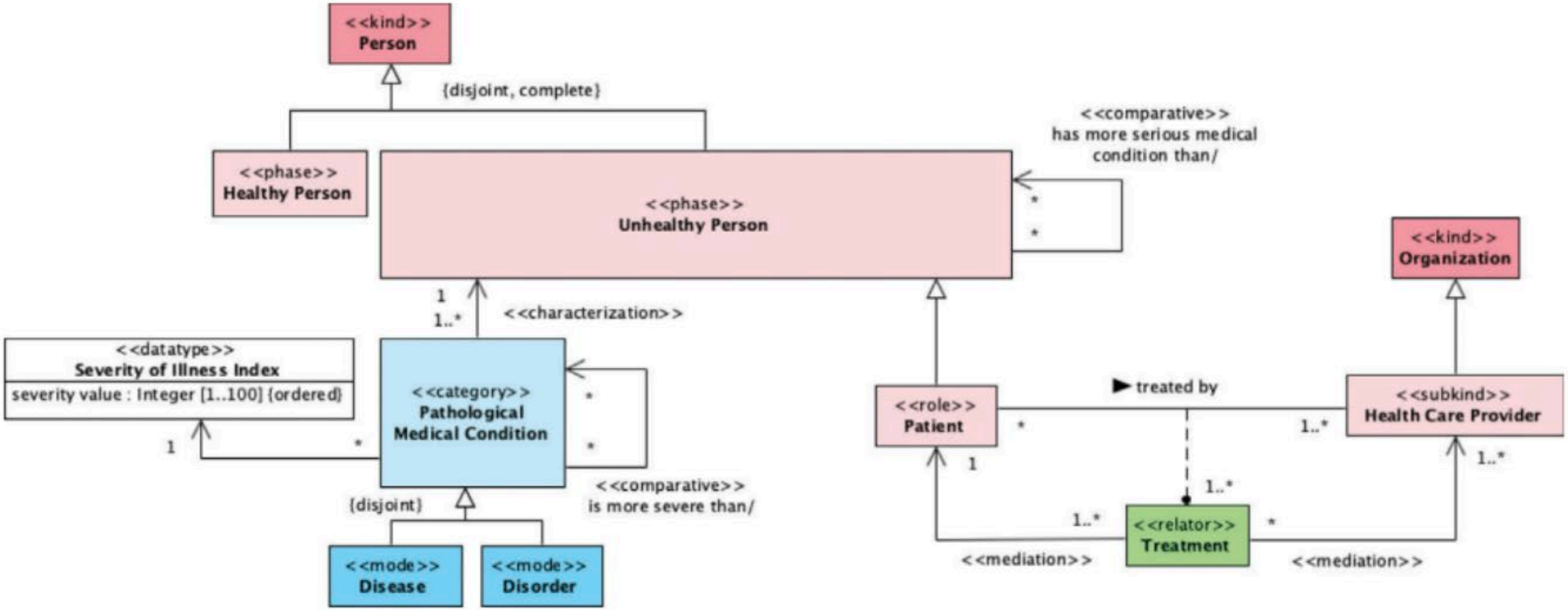

Fig. 4. The result of an ontological unpacking of the model of Fig. 3.

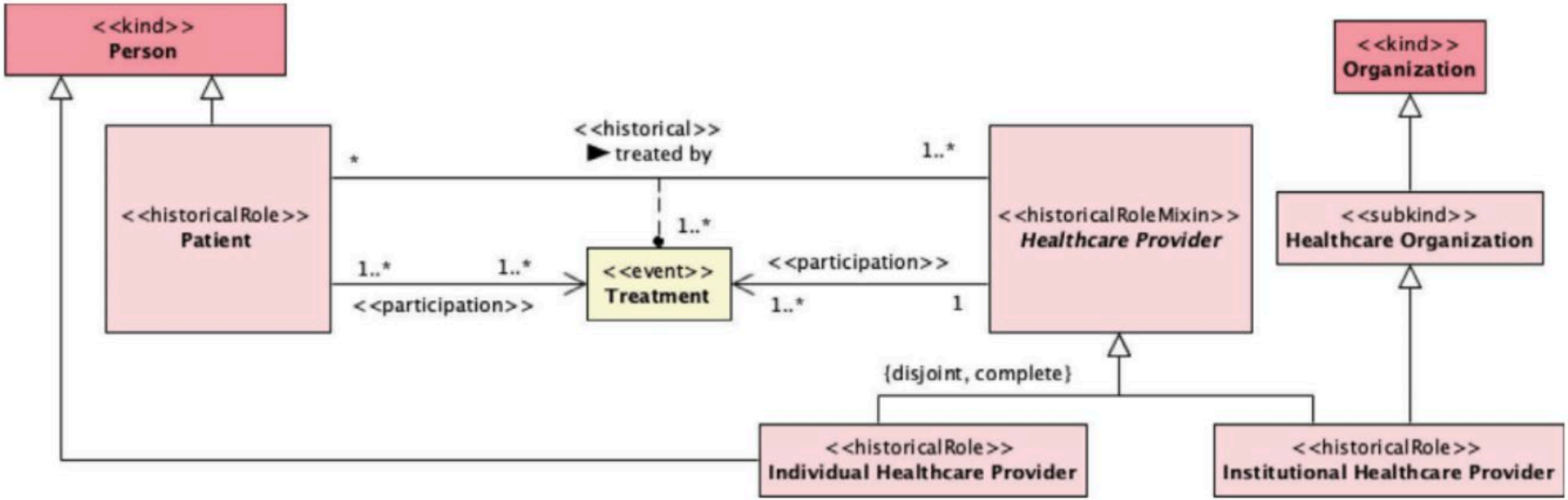

Fig. 5. An alternative unpacking for the model of Fig. 3.

On the multiple roles of ontologies in explanations for neuro-symbolic AI

There has been a renewed interest in symbolic AI in recent years. Symbolic AI is indeed one of the key enabling technologies for the development of neuro-symbolic AI systems, as it can mitigate the limited capabilities of black box deep learning models to perform reasoning and provide support for explanations. This paper discusses the different roles that explicit knowledge, in particular ontologies, can play in drawing intelligible explanations in neuro-symbolic AI. We consider three main perspectives in which ontologies can contribute significantly, namely reference modelling, common-sense reasoning, and knowledge refinement and complexity management. We overview some of the existing approaches in the literature, and we position them according to these three proposed perspectives. The paper concludes by discussing some open challenges related to the adoption of ontologies in explanations.

Confalonieri, R., & Guizzardi, G. (2025). On the multiple roles of ontologies in explanations for neuro-symbolic AI. Neurosymbolic Artificial Intelligence, 1, NAI-240754.

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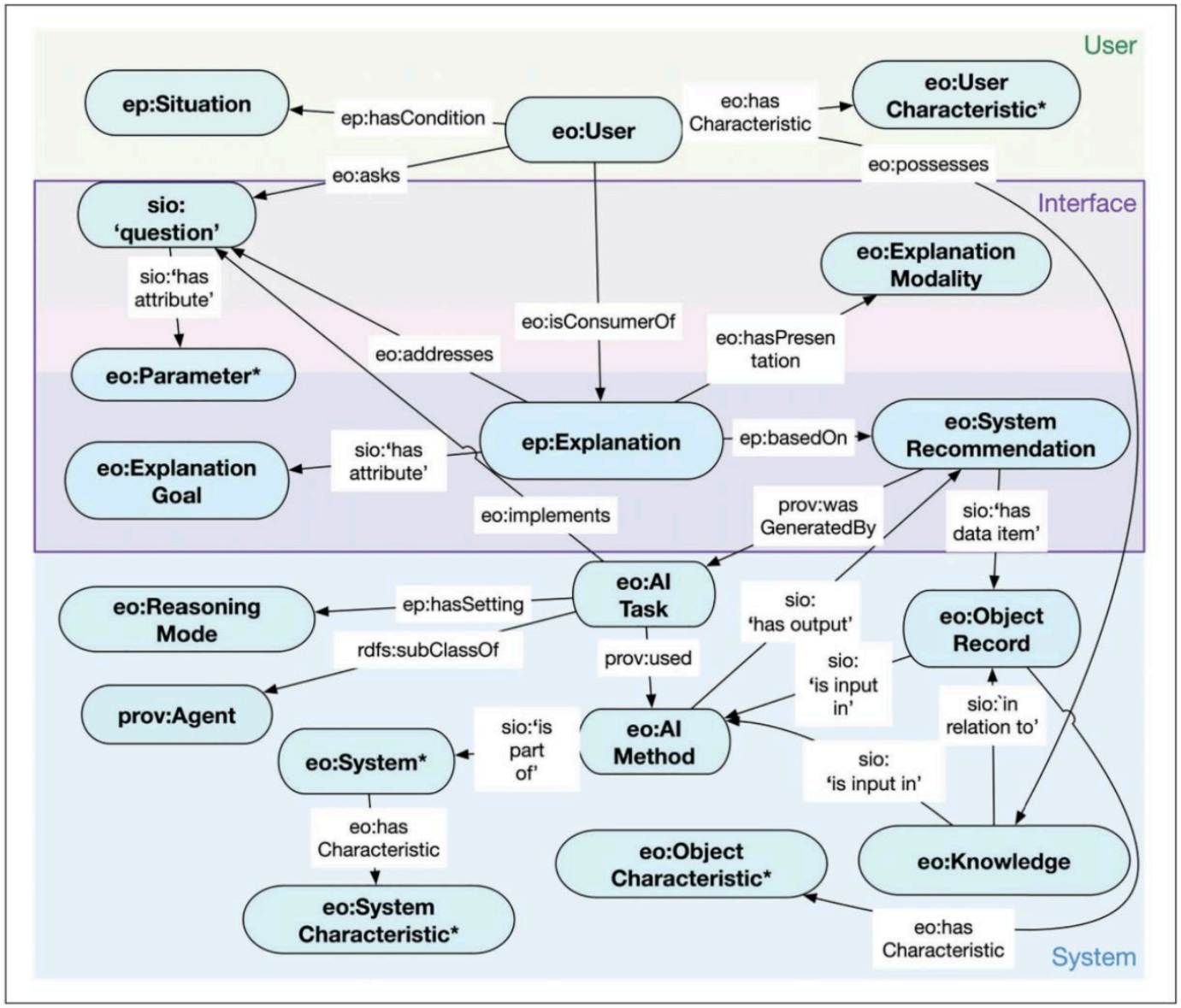

Figure 2. Explanation ontology overview with key classes separated into three overlapping attribute categories: user, interface, and system [11].

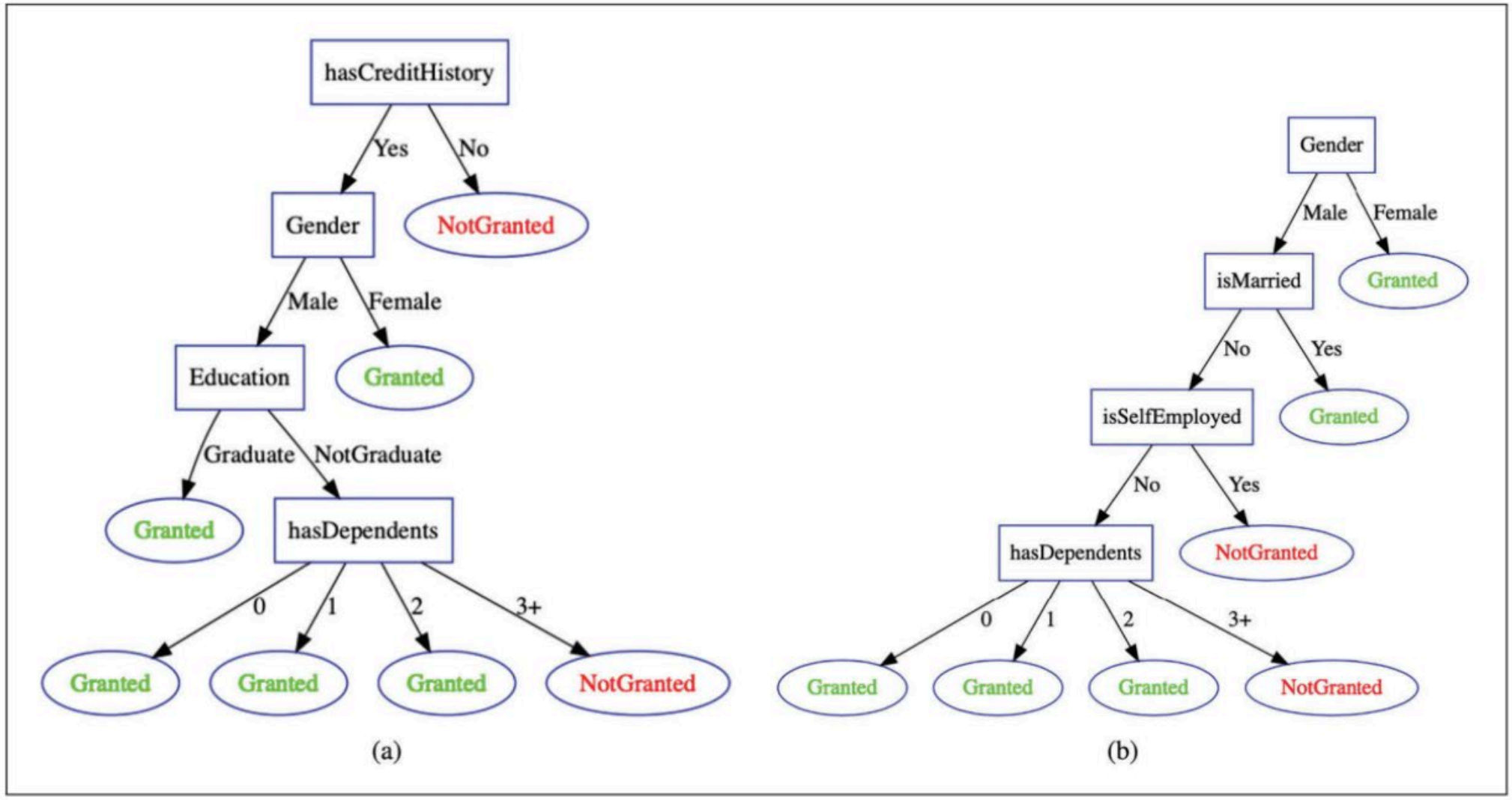

Figure 3. Decision tree extracted without (a) and with (b) a domain ontology to explain the conditions to grant or refuse a loan [16]. It can be seen that the use of an ontology leads to different features appearing in the decision nodes.

Food process ontology requirements

People often value the sensual, celebratory, and health aspects of food, but behind this experience exists many other value-laden agricultural production, distribution, manufacturing, and physiological processes that support or undermine a healthy population and a sustainable future. The complexity of such processes is evident in both every-day food preparation of recipes and in industrial food manufacturing, packaging and storage, each of which depends critically on human or machine agents, chemical or organismal ingredient references, and the explicit instructions and implicit procedures held in formulations or recipes. An integrated ontology landscape does not yet exist to cover all the entities at work in this farm to fork journey. It seems necessary to construct such a vision by reusing expert-curated fit-to-purpose ontology subdomains and their relationship, material, and more abstract organization and role entities. The challenge is to make this merger be, by analogy, one language, rather than nouns and verbs from a dozen or more dialects which cannot be used directly in statements about some aspect of the farm to fork journey without expensive translation or substantial dialect education in order to understand a particular text or domain of knowledge. This work focuses on the ontology components - object and data properties and annotations - needed to model food processes or more general process modelling within the context of the Open Biological and Biomedical Ontology Foundry and congruent ontologies. Ideally these components can be brought together in a general process ontology that can be specialized not only for the food domain but for carrying out other protocols as well. Many operations involved in food identification, preparation, transportation and storage - shaking, boiling, mixing, freezing, labeling, shipping - are actually common to activities from manufacturing and laboratory work to local or home food preparation.

Dooley, D., Weber, M., Ibanescu, L., Lange, M., Chan, L., Soldatova, L., Yang, C., Warren, R., Shimizu, C., McGinty, H. K., & Hsiao, W. (2022). Food process ontology requirements. *Semantic Web*, *15*(4), 1133–1164. https://doi.org/10.3233/sw-223096

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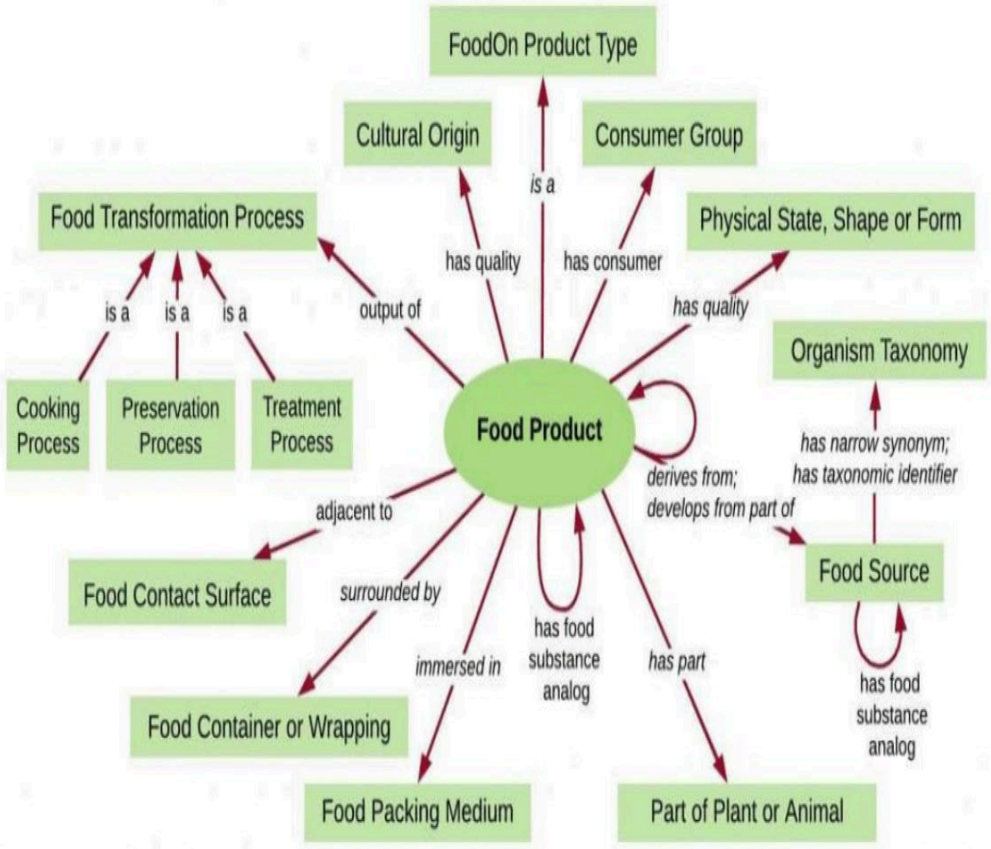
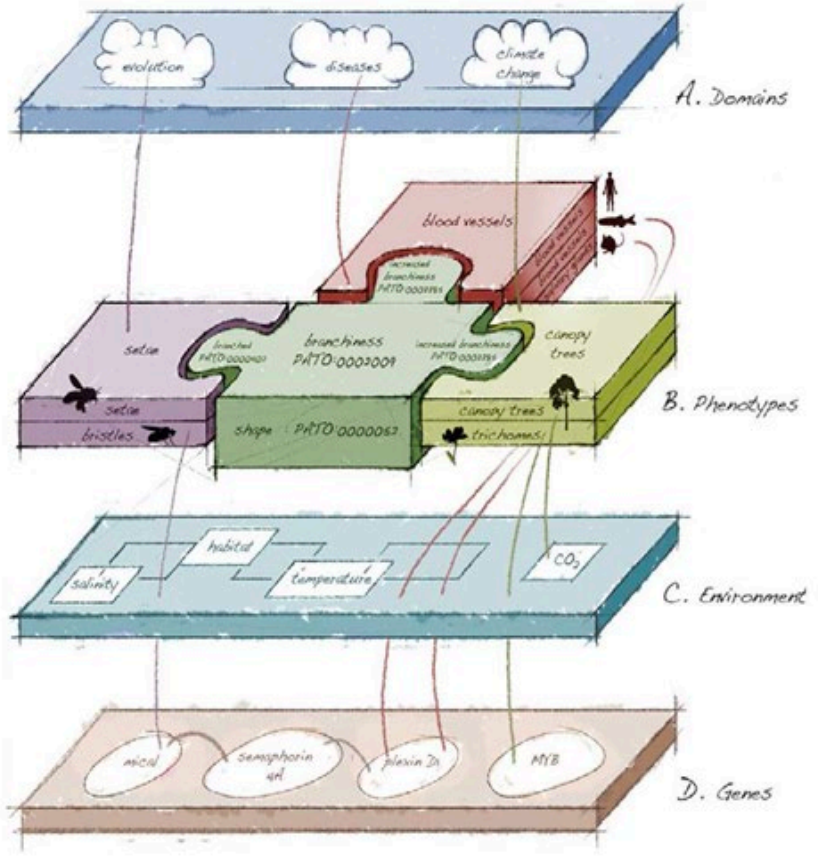
Food process ontology requirements





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mantic

Fig. 1. Micromodel linkage. Used with permission from: "Finding our way through phenotypes" [12].

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Food process ontology requirements

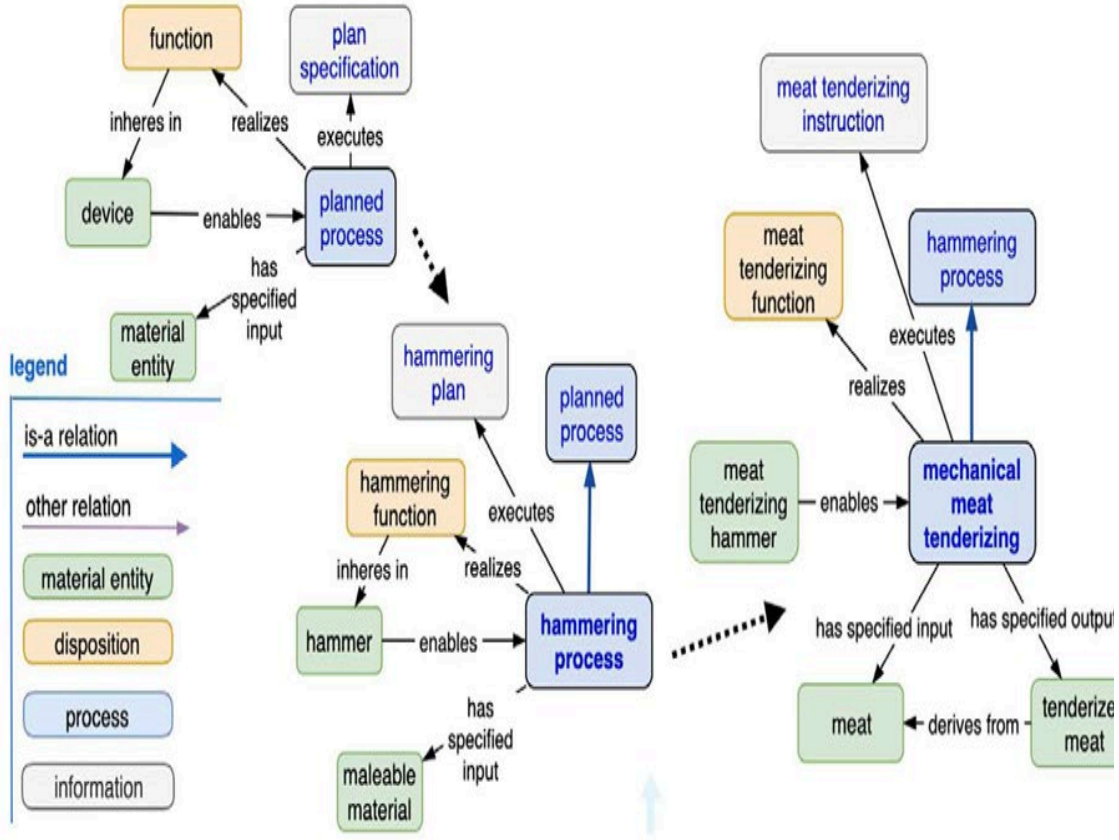

Fig. 2. Specialization of planned process and plan specification.

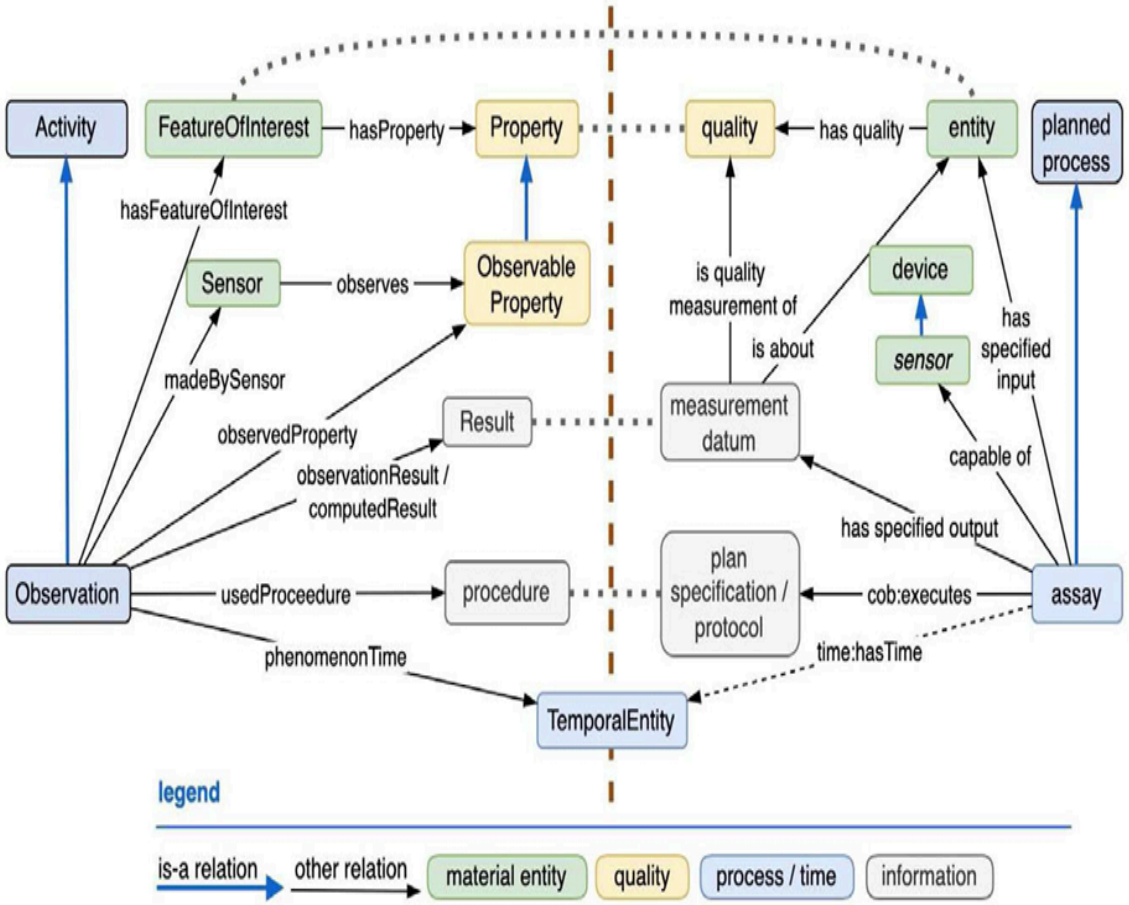

Fig. 18. Comparison of SOSA observation and OBO time-enhanced process.

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Food process ontology requirements

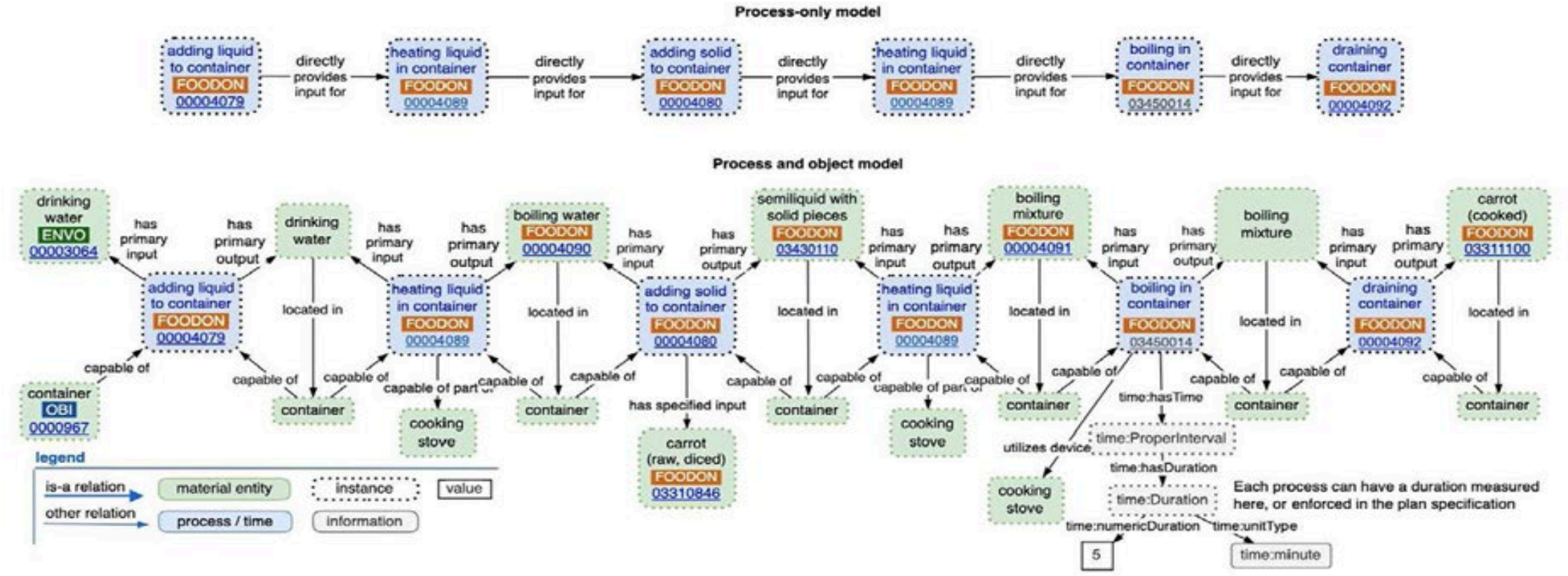

Fig. 26. Boiled carrots recipe process-oriented view, and the more detailed input / output view.

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Crossing the streams: improving data quality and integration across the One Health genomics continuum with data standards and implementation strategies

The Canadian Genomics Research and Development Initiative for Antimicrobial Resistance (GRDI-AMR) uses a genomics-based approach to understand how health care, food production and the environment contribute to the development of antimicrobial resistance. Integrating genomics contextual data streams across the One Health continuum is challenging because of the diversity in data scope, content and structure. To better enable data harmonization for analyses, a contextual data standard was developed. However, development of standards does not guarantee their use. Implementation strategies are critical for putting standards into practice. This work focuses on the development of implementation strategies to better operational-ize data standards across the Canadian federal genomics ecosystem. Results include improved understanding of complex data models that can create challenges for existing systems. Technical implementation strategies included spreadsheet-based solu-tions, new exchange formats, and direct standards integration into new databases. Data curation exercises highlighted common data collection and sharing issues, which informed improved practices and evaluation procedures. These new practices are contributing to improved data quality and sharing within the GRDI-AMR consortium as evidenced by publicly available datasets. The implementation strategies and lessons learned described in this work are generalizable for other standards and can be applied more broadly within other initiatives.

Griffiths, E., Jurga, E., Wajnberg, G., Shay, J. A., Cameron, R., Barclay, C., Sehar, A., Dooley, D., John, N. S., Scott, A., Johnson, L. A., Robertson, J., Schonfeld, J., Bastedo, D. P., Tang, J., Yin, X., Rehman, A., Wallace, R. L., Thomas, K., . . . Hsiao, W. (2025). Crossing the streams: improving data quality and integration across the One Health genomics continuum with data standards and implementation strategies. *Canadian Journal of Microbiology*, *71*, 1–14. https://doi.org/10.1139/cjm-2024-0203

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Crossing the streams: improving data quality and integration across the One Health genomics continuum with data standards and implementation strategies

Fig. 5. Simplified schema of the Virtual Microbial Resource, a database implementation of the GRDI-AMR One Health data standard. Major categories of data have been compartmentalized into their own tables linked by foreign-key relationships to maintain referential integrity. Fields constrained by ontology terms are linked to an Ontology table that contains information relating to the term—Not shown here are intermediate "lookup" tables that ensure ontology terms from unrelated fields are not input where they should not be. The full schema consists of 560 rows across 155 tables.

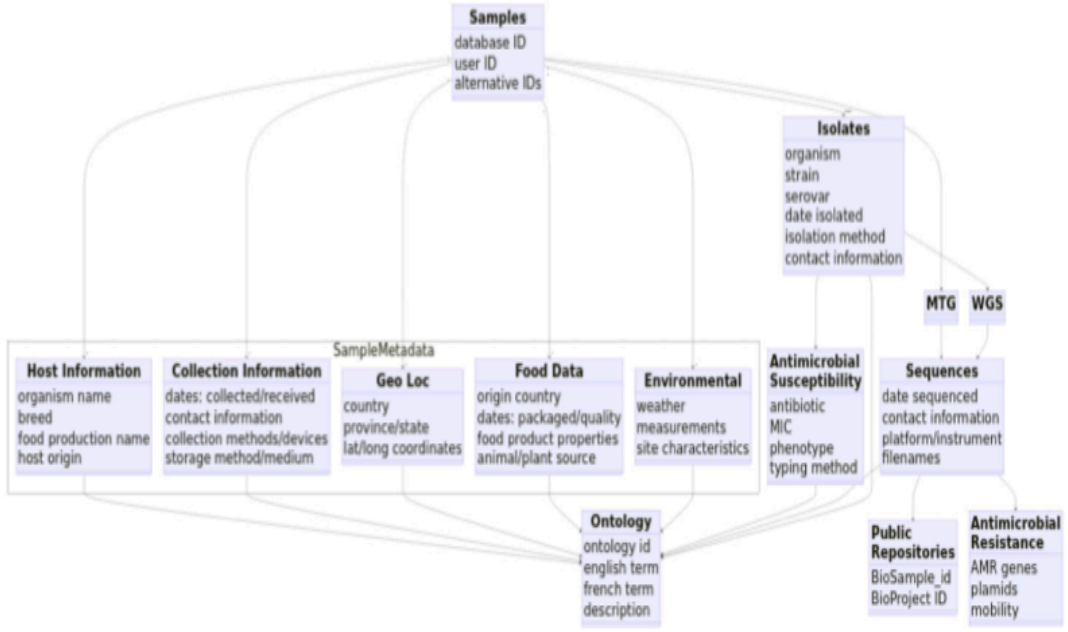
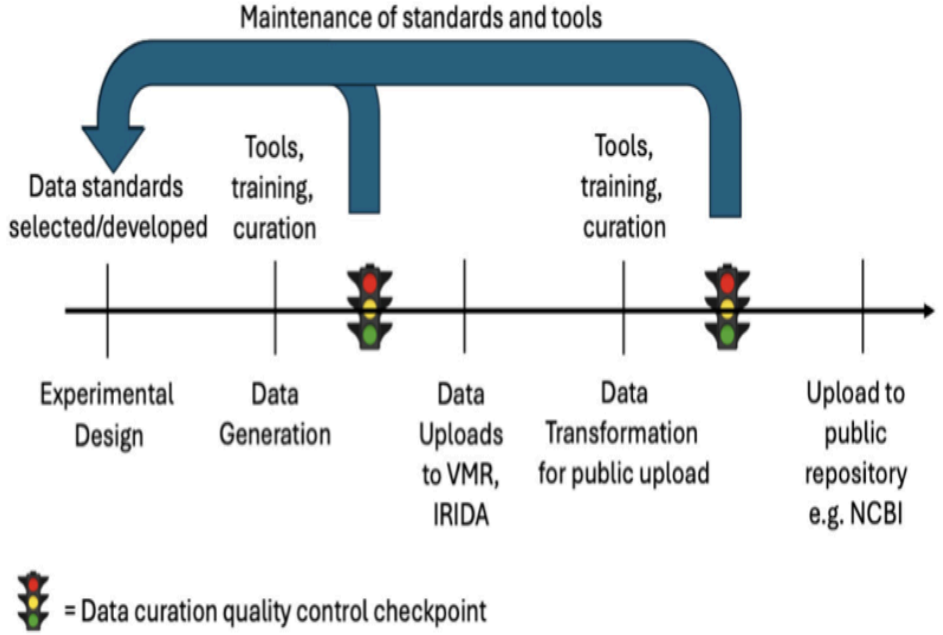


Fig. 6. Curation checkpoints along the data generation and sharing continuum. Curation oversight to ensure correct implementation and adherence to data standards is in place after data are first generated and initially curated in laboratories prior to IRIDA upload. A second curation checkpoint to ensure that data are properly formatted for NCBI upload is in place to ensure quality control and consistency prior to public sharing. These checkpoints and the implementation of the GRDI-AMR specification are parts of the GRDI quality control framework.



Future-proofing and maximizing the utility of metadata: The PHA4GE SARS-CoV-2 contextual data specification package

Background

The Public Health Alliance for Genomic Epidemiology (PHA4GE) (https://pha4ge.org) is a global coalition that is actively working to establish consensus standards, document and share best practices, improve the availability of critical bioinformatics tools and resources, and advocate for greater openness, interoperability, accessibility, and reproducibility in public health microbial bioinformatics. In the face of the current pandemic, PHA4GE has identified a need for a fit-for-purpose, open-source SARS-CoV-2 contextual data standard.

Results

As such, we have developed a SARS-CoV-2 contextual data specification package based on harmonizable, publicly available community standards. The specification can be implemented via a collection template, as well as an array of protocols and tools to support both the harmonization and submission of sequence data and contextual information to public biorepositories.

Conclusions

Well-structured, rich contextual data add value, promote reuse, and enable aggregation and integration of disparate datasets. Adoption of the proposed standard and practices will better enable interoperability between datasets and systems, improve the consistency and utility of generated data, and ultimately facilitate novel insights and discoveries in SARS-CoV-2 and COVID-19. The package is now supported by the NCBI's BioSample database.

Griffiths, E. J., Timme, R. E., Mendes, C. I., Page, A. J., Alikhan, N. F., Fornika, D., ... & MacCannell, D. R. (2022). Future-proofing and maximizing the utility of metadata: The PHA4GE SARS-CoV-2 contextual data specification package. GigaScience, 11, giac003.

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Future-proofing and maximizing the utility of metadata: The PHA4GE SARS-CoV-2 contextual data specification package

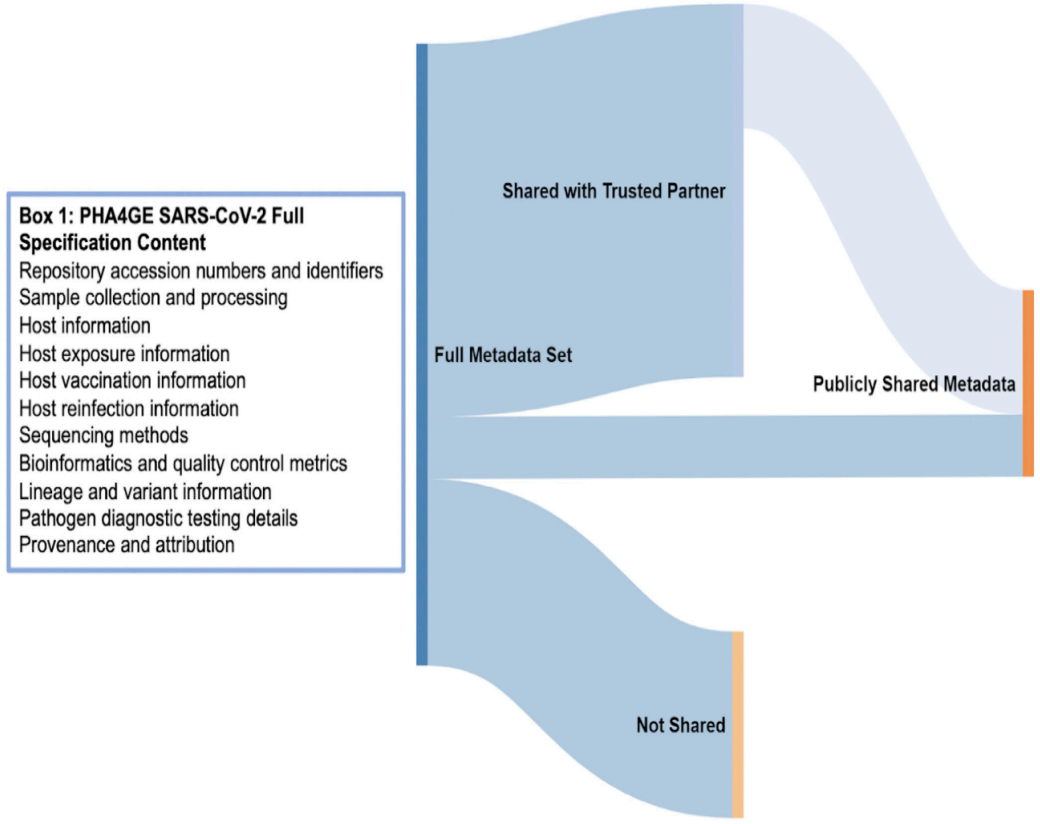

Figure 1: Contextual data flow. Contextual data can be captured and structured using the PHA4GE specification so that they can be more easily harmonized across different data sources and providers. Different subsets of the harmonized data can be (i) shared with public repositories, e.g., GISAID and INSDC; (ii) shared with trusted partners, e.g., national sequencing consortia, public health partners; and (iii) kept private and retained locally with the potential for sharing in the future for particular surveillance or research activities. While fields have been colour-coded in the template to indicate whether they are considered "required," "strongly recommended," or "optional," how the specification is implemented and whether any of the data are shared is ultimately at the discretion of the user. Box 1 describes the information types covered in the full specification.

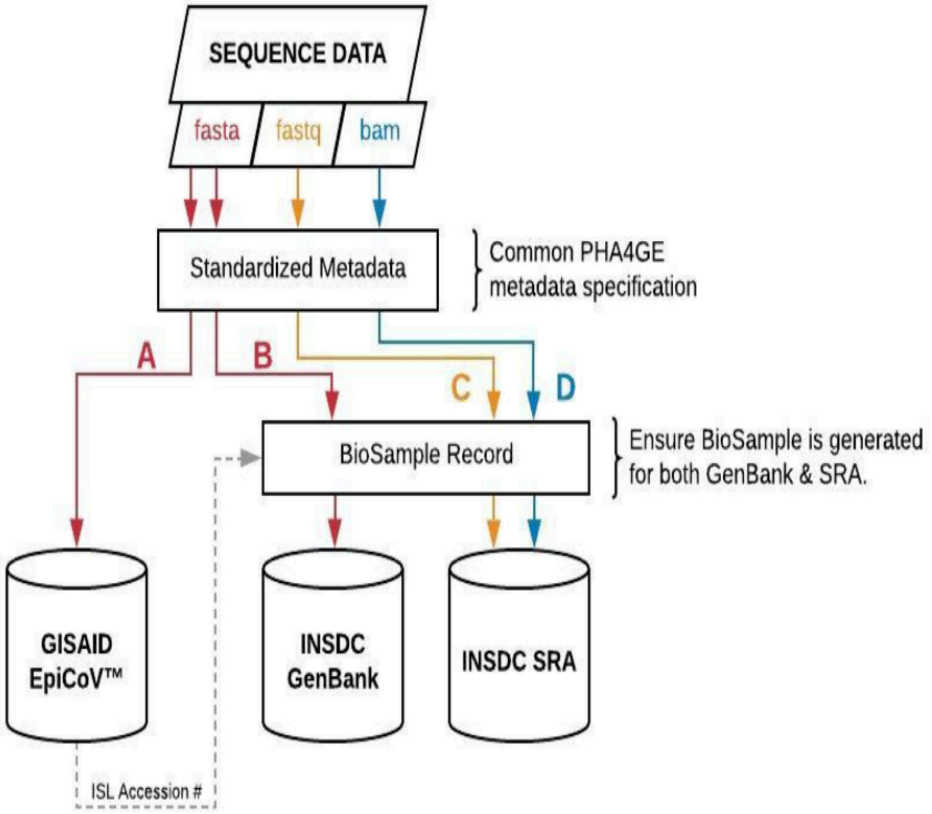

Figure 3: Overview of how the PHA4GE SARS-CoV-2 contextual data specification can be integrated into public repository submission. The PHA4GE collection template provides a one-stop shop for different data types that are important for global surveillance. The protocols provided as part of the specification package describe how PHA4GE fields can be mapped to different repository submission forms. Consensus sequences (FASTA), accompanied by a subset of PHA4GE fields, can be submitted to the GISAID EpiCoV database (A). Consensus sequences (FASTA) (B) as well as raw/processed data (FASTQ, BAM) (C, D) can be submitted to INSDC databases (e.g., GenBank, SRA) with different subsets of PHA4GE fields as part of a BioSample record. BioSamples are propagated throughout INSDC databases.

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4. Possibilities and Challenges

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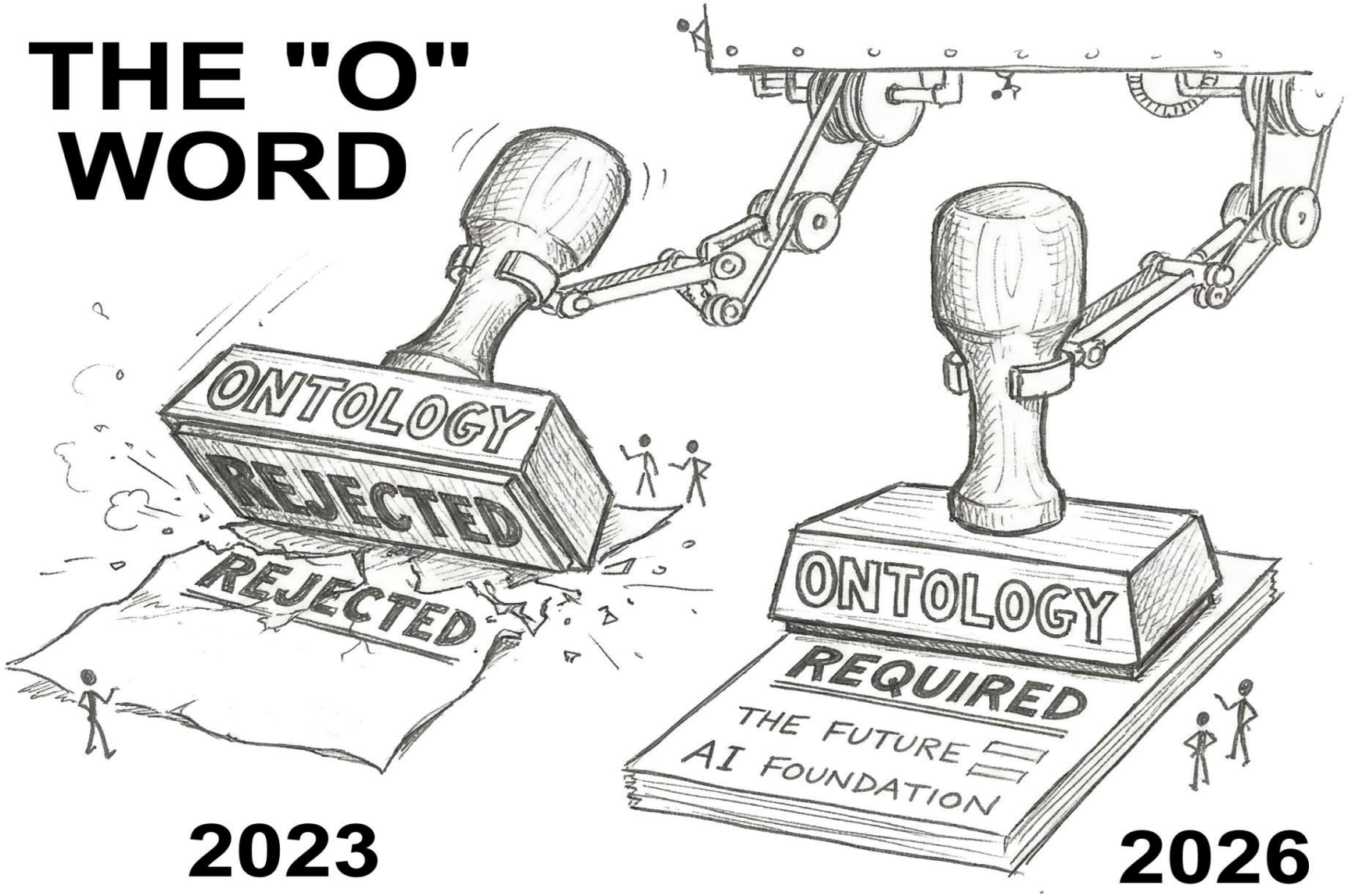
THE "O" WORD



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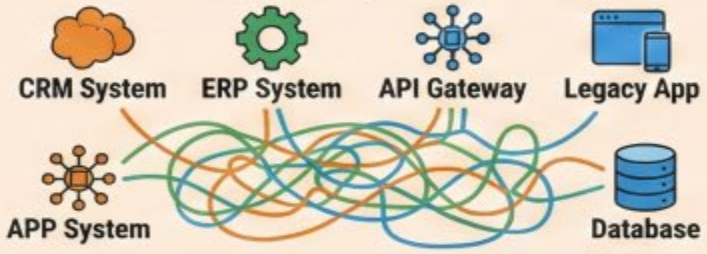
The Emergent Ontology & ChatINT.ai: Operationalizing Enterprise Meaning

The Challenge: Top-Down Ontology

Distributing meaning across systems is **DIFFICULT.**
Operationalization is a significant hurdle.

The Insight: Implicit Ontology



IMPLICIT ONTOLOGY
(Existing Artifacts - 'Warts and all')

Business logic is already here in APPs, APIs, SCHEMAs, INTEGRATIONS.

Independent decisions cause inconsistency & drift.

A Practical Path: Emergence from Artifacts

Meet organizations where they are.

Each system contributes raw material.

Accumulation & Clarity

As artifacts accumulate, the structure clears.

Teams already define meaning in code & config.

This is modeling in practice.

Evolving with the Business

Captures existing effort.

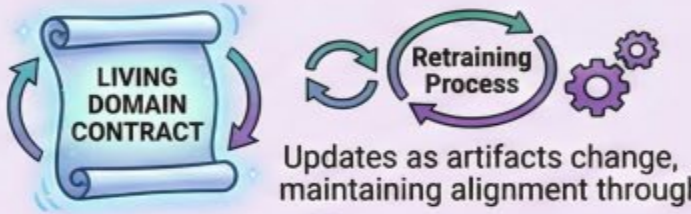
An accurate, continuously updated representation of semantic understanding.

ChatINT.ai: The Platform

ChatINT.ai

Turns real-world artifacts into a **Living Domain Contract.**

Living Domain Contract & Retraining



Updates as artifacts change, maintaining alignment through.

The Result: Operationalized Semantic Layer

Ontology defines meaning.
ChatINT.ai operationalizes that meaning and keeps it aligned through change.

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TOP SOFTWARE COMPANIES ACKNOWLEDGE THE LIMITATIONS AND RISKS OF AI

OpenAI

Why language models hallucinate

APPLE

Machine Learning Research

The Illusion of Thinking:

Microsoft

The Alternative: RKE BIOMIMETIC MODELING

Real-world Science is Critical to R&D, Innovation, Decision Processes and Learning

Scientific Method	Human in the Lead	RKE Architecture	RKE Outputs
Observe	Define Problem	Prototyping Platform: 1. Biomimetic modeling 2. In-memory model explorer 3. Sparse & diverse data	• Explore options and impacts • Expose premises • Model theories • Test solutions
Experiment	Theory of Value		
Learn	Preliminary Analysis (PA)	PA App: Explore dark data	Output scenarios and relationships
Apply	Adapt/Update Ontology	Production Engine: Model critical use cases	Output keystone insights & evidence
	Deploy Engine	Container image: User orchestration	Dynamic discovery & contextualization

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Thank you!

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