# Towards an Ontology of Traceable Impact Management in the Agriculture Food Chain

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# Abstract

The pursuit of quality improvements and accountability in the agricultural food supply chain has become increasingly vital, necessitating a comprehensive approach that encompasses product quality and its impact on various stakeholders and their communities. Such an approach offers numerous benefits in increasing product quality and eliminating superfluous measurements while appraising and alleviating the broader societal and environmental repercussions. A traceable impact management model provides an impact structure and a reporting mechanism that identifies each stakeholder's role in the total impact of food production and consumption stages.

The model aims to increase traceability's utility in understanding the impact of changes on communities affected by food production and consumption, aligning with current and future government requirements, and addressing the needs of communities and consumers. This holistic approach is further supported by an ontological model that forms the logical foundation and a unified terminology. The model promotes global traceability, emphasizing quality and the extensive impact of championing accountability, sustainability, and responsible practices.

With these combined efforts, the agriculture food chain moves toward a global tracking and tracing process that not only ensures product quality but also addresses its impact on a broader scale, fostering accountability, sustainability, and responsible food production and consumption.

# Introduction

Urban Data Centre

School of Cities

University of Toronto

# Urban Data Centre

## About

- Research group and Centre of Excellence for Urban Data Research at the School of Cities, University of Toronto.
- Our vision is to be a world leader in urban data research and development with the goal of helping smart cities achieve sustainable, resilient, inclusive and equitable outcomes.
- We leverage the potential of urban data to enhance smart cities' design, planning and operations. To achieve this, we break down traditional data 'silos' within cities to give them greater interoperability and control over their digital infrastructure.
- Urban data is crucial to the design and planning of smart cities and will become ‘mission critical’ in the management and operations of smart city digital platforms, systems and services.
- Most importantly, the need to share urban data across city services and external stakeholders is key to gaining insights, informing decisions, and improving the delivery of programs and services that are equitable and inclusive for well-run cities.

https://urbandatacentre.ca

# Urban Data Centre

## Relevant Projects

- Smart City Indicators: ISO/IEC 21972
  - Representing textual descriptions of Indicators using a semantically precise representation.
  - For Urban-related UN SDGs
- Smart City Standard: ISO/IEC 5087 Series
  - The Standards for City Data workstream addresses the challenges of data incompatibility by offering a precise, unambiguous representation of information and knowledge commonly shared across city divisions.
  - Partners: Toronto Water
- Common Impact Data Standard:
  - A standardized way to represent a Social Purpose Organization's Impact model (i.e., definition) and the impact (i.e., effect) their implementation has on its stakeholders.
  - Partners: Common Approach, HelpSeeker Inc, Sametrica.
- Canadian Urban Data Catalogue:
  - A catalogue infrastructure for urban datasets: https://data.urbandatacentre.ca/
  - A metadata standard for enabling awareness and discovery of relevant urban datasets.
  - Partners: a network of urban data librarians and curators across Canada.

# Challenge

# Challenge

- How do we determine why stakeholder outcomes are not being achieved given existing food supply chains?
    - E.g., Food security: what are the outcomes?
        - Available fresh produce and meats
        - Self sufficiency through local agriculture
        - Determinates of health (nutrition, environmental factors)

- Key takeaways:
    - Impact tracing does not stop at the production, use, or consumption of goods and services.
    - Includes **outcomes** of these activities:
    - E.g. waste management, energy usage, societal impact, etc.

# Challenge

What does an ontology provide?

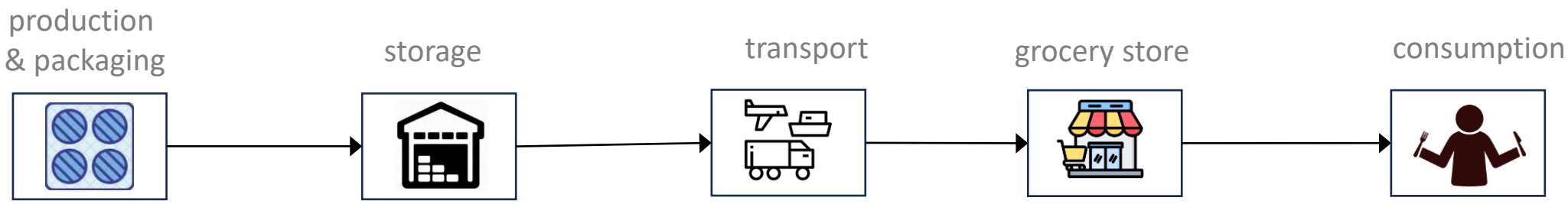
1. Representation with which to qualify a problem in the supply chain.
2. Logical foundation elucidating concepts and quality.
3. Conceptual model of traceability and data artifacts.
4. Shared terminology and axioms for traceability.
5. Methodologies for ontology engineering.
6. Graphical representation to enable decision support.
7. Ontology as the foundation for traceability software.

(Kim, 1995)

# Example

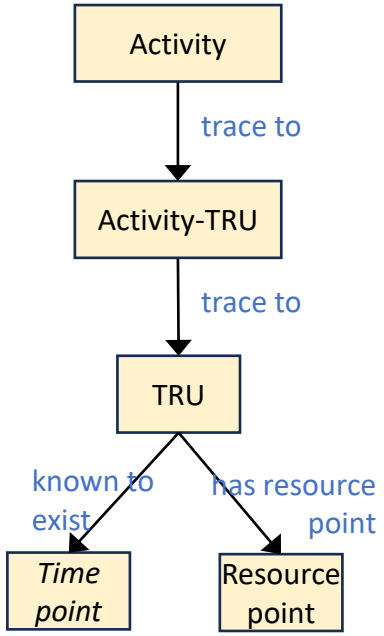
- To produce hamburger patties takes a network of energy producers, farmers, manufacturers, transporters, retailers, and consumers.

- Use Case:
  - National beef patty supply chain owns and operates cattle ranch and a meat production plant.
  - Process 200 kg of beef into 30 packets of beef patties
  - Transport beef patties across 3,000 km from a cattle farm to grocery store.



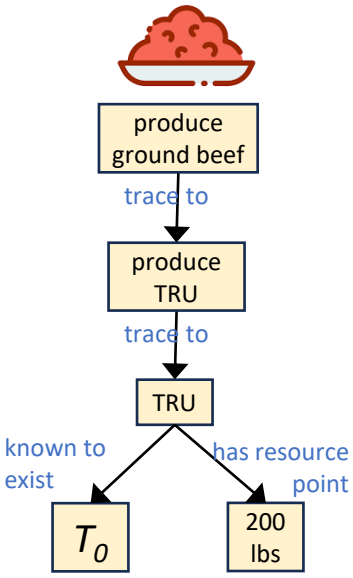
# Modelling the Supply Chain

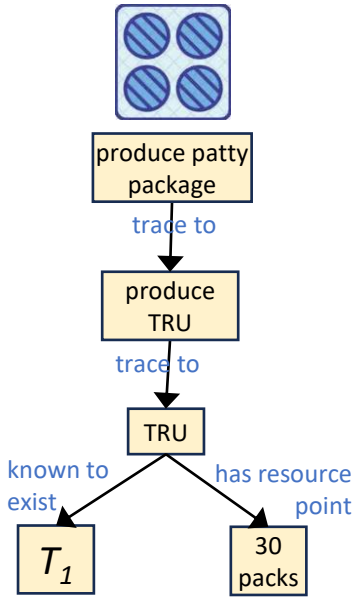
- **Activity**: a performed action.
- **TRU**: traceable resource unit
- **Activity-TRU**: an instance of an activity and TRU
- **Resource point**: quantity and unit-of-measure for the resources being produced, used, or consumed
- **Time point**: a point in time when the resource is produced, used, or consumed.

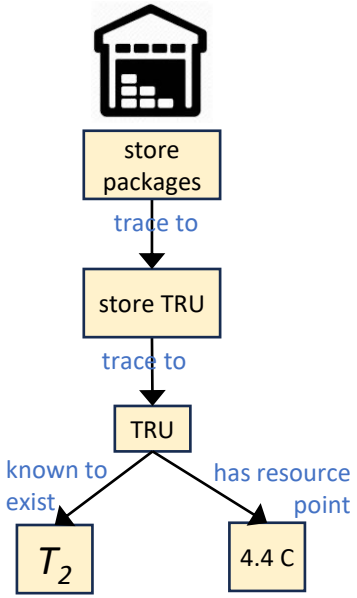


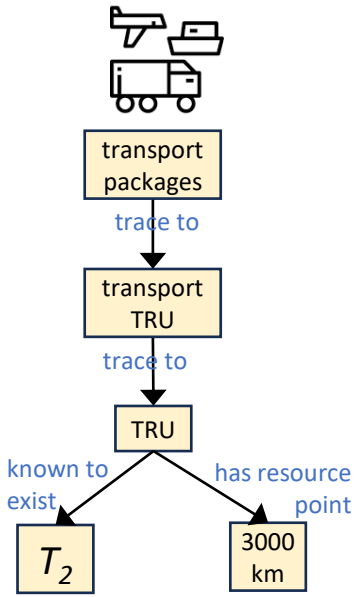

(Kim, 1998)

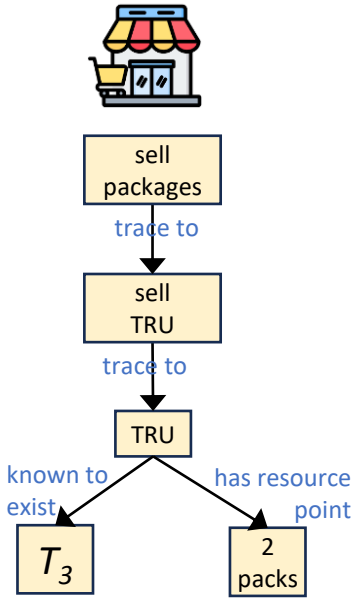
# Modelling the Supply Chain



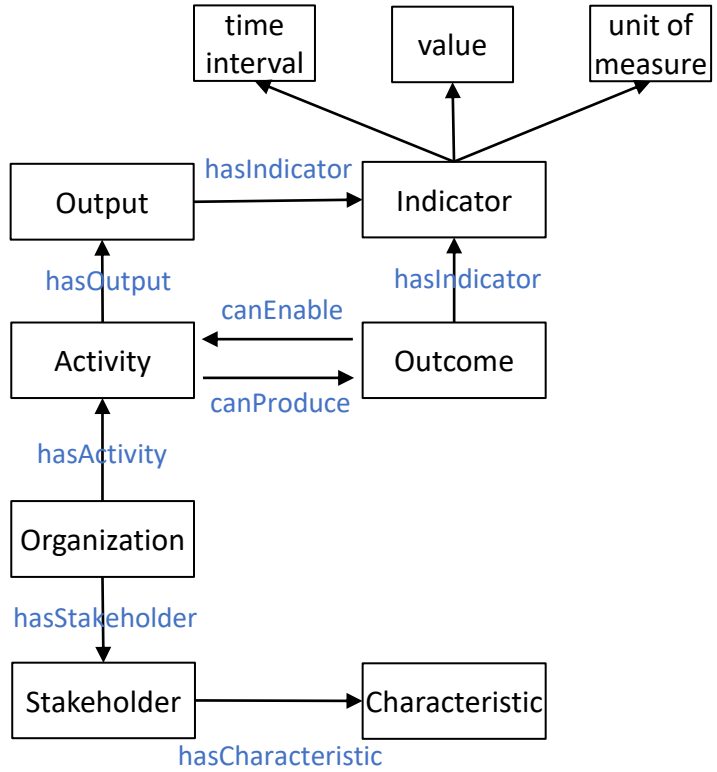



# Modelling Impact

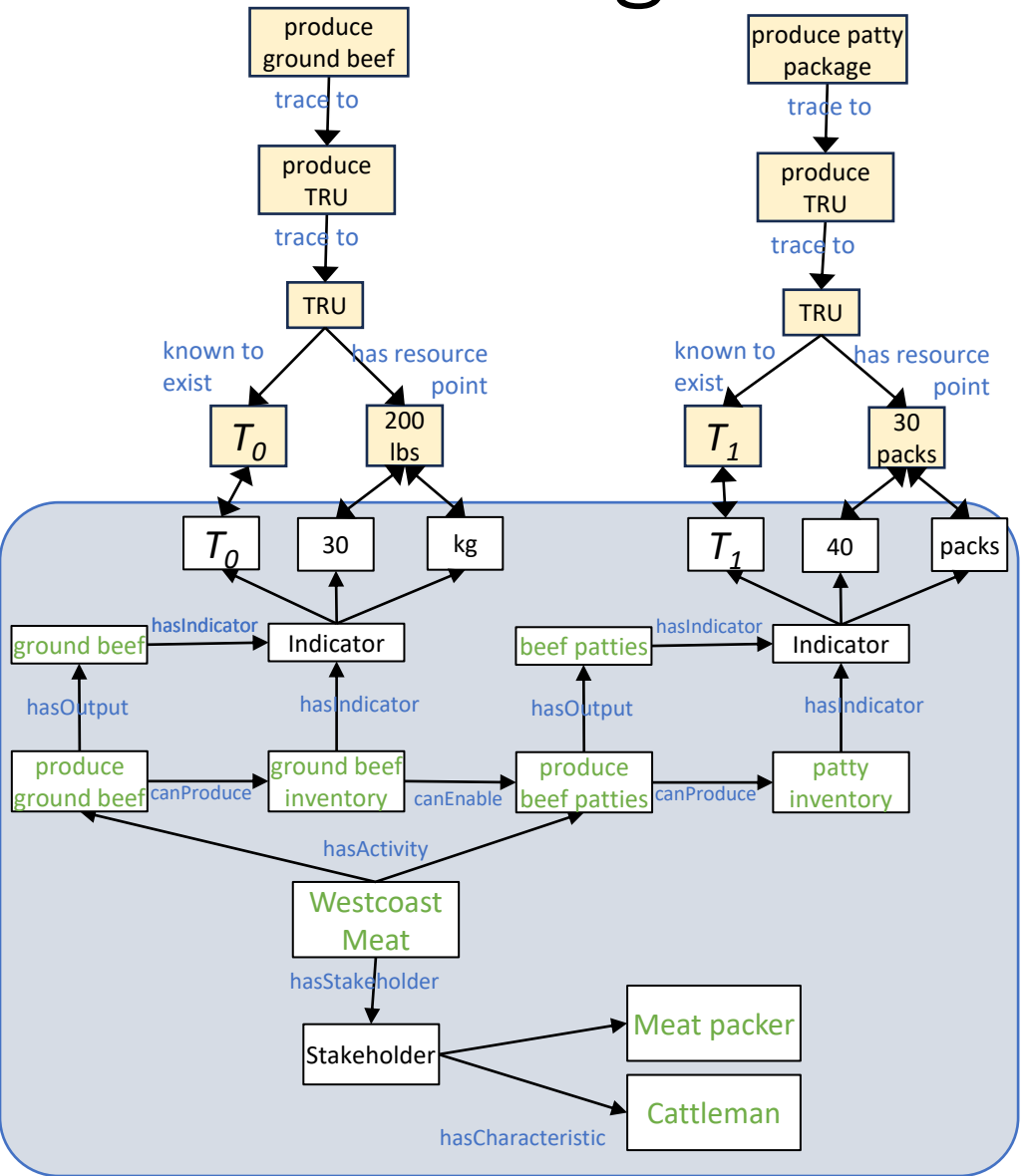
- **Organization**: Set of activities performed by agents.
- **Stakeholders**: Organization or Person type related to the outcome of an activity.
- **Characteristic**: A taxonomy of code or set of codes that identify the stakeholder.

- **Activity**: An action that occurs in the domain; can be enabled by or cause some Outcome.
- **Output**: A quantitative summary of an activity.
- **Outcome**: What stakeholders experience as a result of activities.

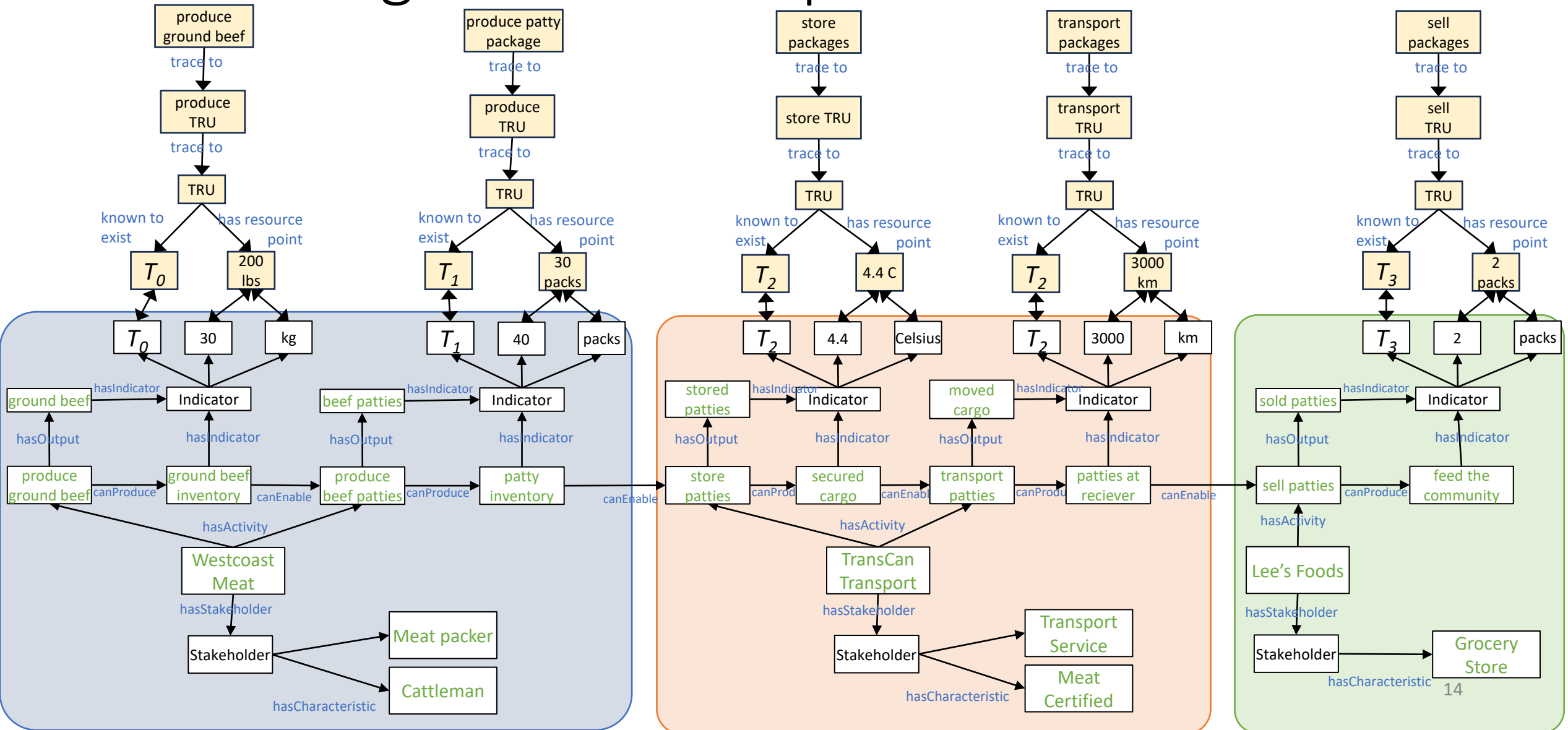
- **Indicators**: A quantity measure for an activity, with a location, a time interval, a value, and a units of measure.



# Modelling Traceable Impact



# Modelling Traceable Impact



# Traceable Impact Management in the Agriculture Food Chain

# Food Supply Chain Analysis

**Find actors and stakeholders**

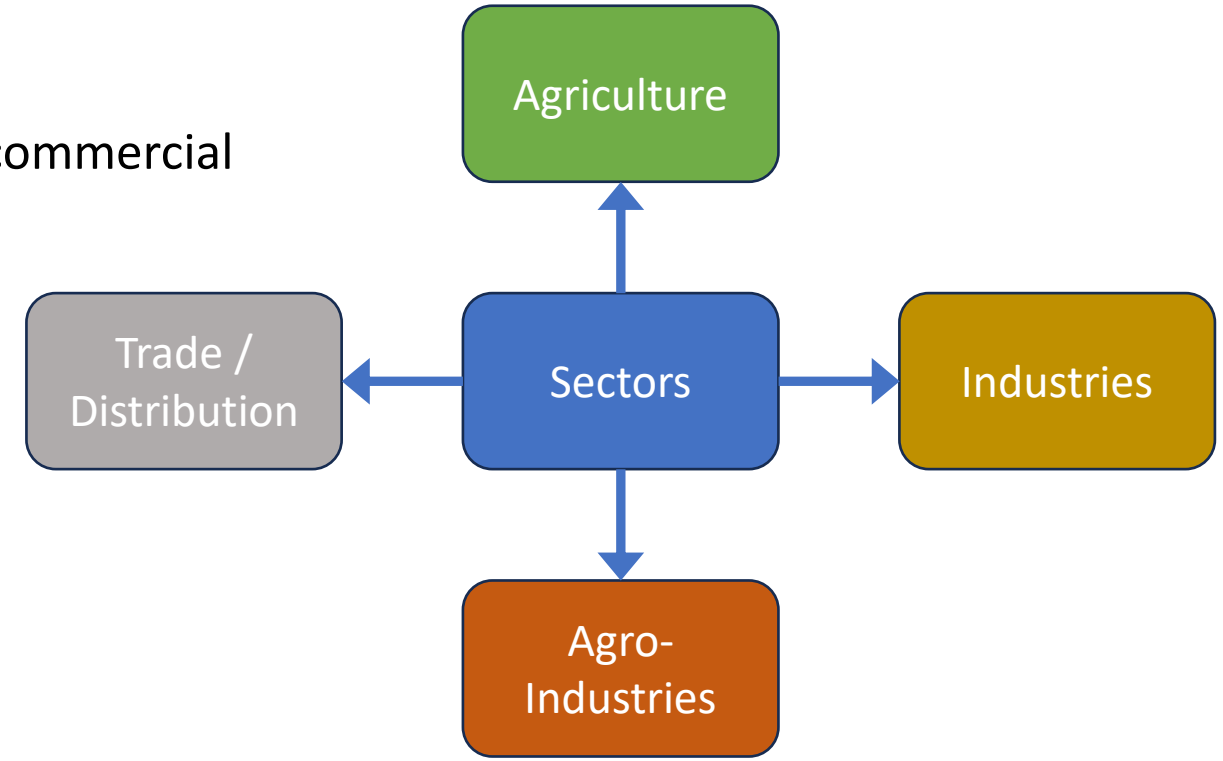
- food producers, processors, logistic companies, commercial organizations, customers

**Consolidators**

- Buy bundles or in bulk for resale

**Suppliers**

- feed, seeds, herbicides, etc
- packaging, flavouring, etc
- technical support: training, technical assistance, research, etc



# Food Supply Chain Data Modelling

**Levels of traceability abstraction**

- Internal (local) traceability includes a detailed view of an actor's own system:
  - product identification
  - resources: feed, seeds, herbicides, etc
  - packaging material and equipment
  - storage, management, and processing times

- Chain (global) traceability includes a less detailed view of partners in the system
  - arrival time
  - transport time
  - origin of product
  - in the case of meat product, animal or group identification

# Ontological Model of Impact Management

- The IMP reached a global consensus that impact can be measured across five dimensions: What, Who, How Much, Contribution and Risk.
- The Common Impact Data Standard extends these to capture steps taken by each stakeholder.

| Impact Dimension | Impact question each dimension seeks to answer |
|---|---|
| What | ▪ What outcome is occurring in the period? |
| Who | ▪ Who experiences the outcome? Who should be? |
| How much | ▪ How much of the outcome is occurring – across scale, depth, and duration? |
| Contribution | ▪ How big of a contribution the outcome makes? |
| Risk | ▪ What is the risk to people and the planet that impact does not occur as expected? |
| How | ▪ The processes by which an Organization delivers Outcomes to its Stakeholders. |

(Fox, 2021)

# Traceable Impact Management in the Agriculture Food Chain

Steps to creating an ontology for impact traceability

1. Defining an Impact Model for the Food Supply Chain.
   - Food Supply Chain Analysis and Modelling
   - Impact Management Modelling
   - Data Collection and Modelling
   - Conceptual model of traceability and data artifacts.
2. Reporting on the Impact Model.
   - Determining which products often have quality issues.
   - Tracing back to processes where these problems often originate.
3. Identify the contribution each part of the food supply chain has on the overall impact of food production and consumption.
   - Quality improvements and accountability in the food supply chain
   - Establishes the basis for efficient recall procedures to minimize losses.

(Kim, 1995)

# Thank you

Any Questions

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# References


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Pizzuti, T., & Mirabelli, G. (2015). The Global Track&Trace System for food: General framework and functioning principles. *Journal of Food Engineering*, *159*, 16–35. https://doi.org/10.1016/j.jfoodeng.2015.03.001

# 2. Food Supply Chain Modelling

Methodologies for a trace graph of food supply chain

- Petri-nets
- Structured Analysis and Design Techniques (SADT)
- Integration Definition (IDEF)
- Event-Driven Process Chain (EPC)
- Methodologies
  - UML activity diagrams, EDOC Business Processes, Activity Decision Flow (ADF)
- Business Process Modelling (BPM) initiatives and notations

# 3. Food Supply Chain Data Collection

- What data is possible to trace?
  - Actors for primary activities
  - Identification of product responsibilities, liabilities, origin
  - Service Product
    - product state, machinery, utensils
    - food additives, feed, fertilizer
  - Product Identification
    - Unique Identifier, RFID, NFC
    - Reuse of standards GSI, EPC

# 4. Food Supply Chain Data Modelling

- Store collected data in a data model
- Store data in a database for analysis
- Ensure data model can capture tracking activities
- Use standards when possible, e.g. GSI
- Capture labels, names, roles, and unique identifiers

# 5. Food Supply Chain Software

- Ensure software can
  - facilitate the management of the whole food supply chain
  - capture business processes
  - capture actor roles
  - capture model data variables at two levels:
    - local (detailed view of an actor's own system)
    - global (aggregate view partners in the food supply chain)

- Functions on product activities
  - monitor food product activities at critical points
    1) receiving shipments
    2) store/move product internally
    3) change, transform, manipulate products
    4) shipped and delivered products

# 5. Food Supply Chain Software

- Formal traceability
  - data on products sold
  - client points of reference
    - selling information, client characteristics, amount, price
- Traceability of storage
  - arrival time
  - waiting time
  - transformation time
  - packaging time
  - wait time
  - delivery time

# TOVE / ISO-5087

Ontology for modelling organizations and their activities.

# TOVE/5087

- Activities and Causality
  - **Activity-State**: An action is represented by the combination of an activity and its corresponding enabling and cased states
  - **Conditions**: What is the current status of an activity? What alternatives exist?
  - **Causality**: What conditions have to be satisfied to perform activity? What conditions will be satisfied when the activity has been performed?

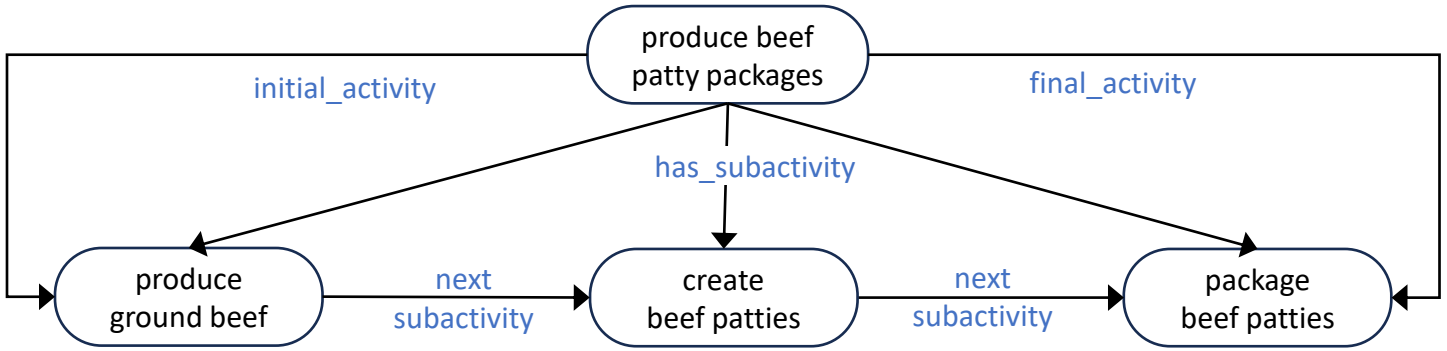
*Activity-State Model*


(Fox, 1993)

# TOVE/5087

- Activity Abstraction:
  - What **sub-activities** can the activity be divided into?
  - What **super-activities** is an activity part of?

*Activity Abstraction Model*

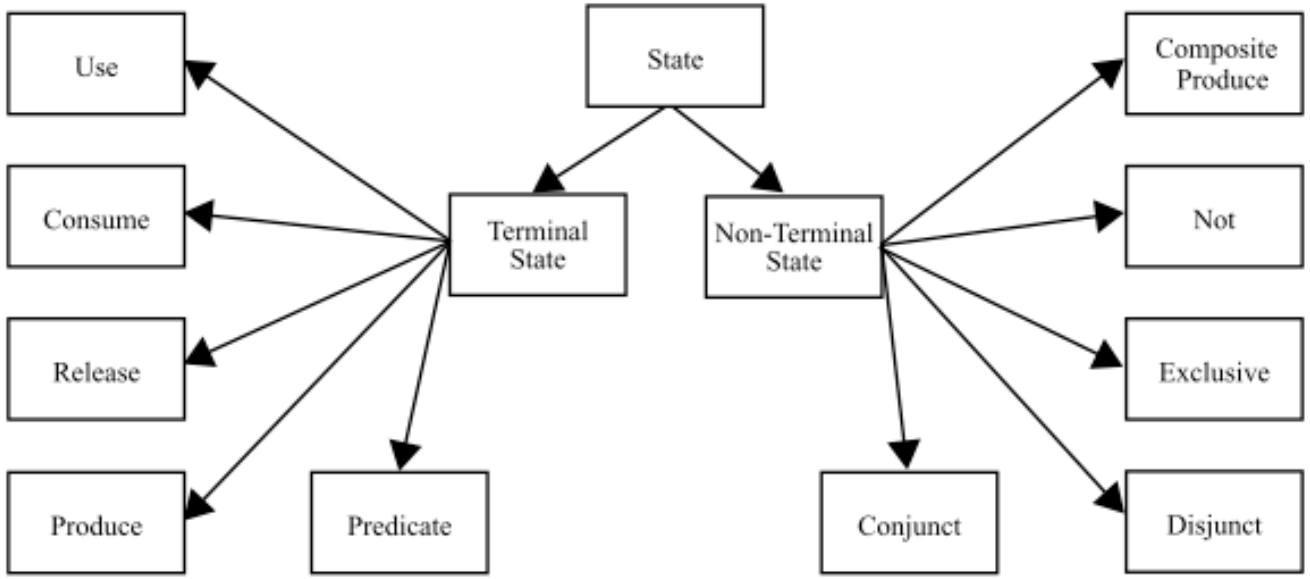



(Fox, 1993)

# TOVE/5087

- State Taxonomy
- **Terminal States**:
  - Signifies that a resource is to be used, but not consumed, by the activity, and will be released once the activity is completed.
- **Non-terminal States**:
  - Allows for the boolean combination of states.
  - Conjunctive/Disjunctive specifies that all substates / at least one substate must be satisfied.

*State Taxonomy*

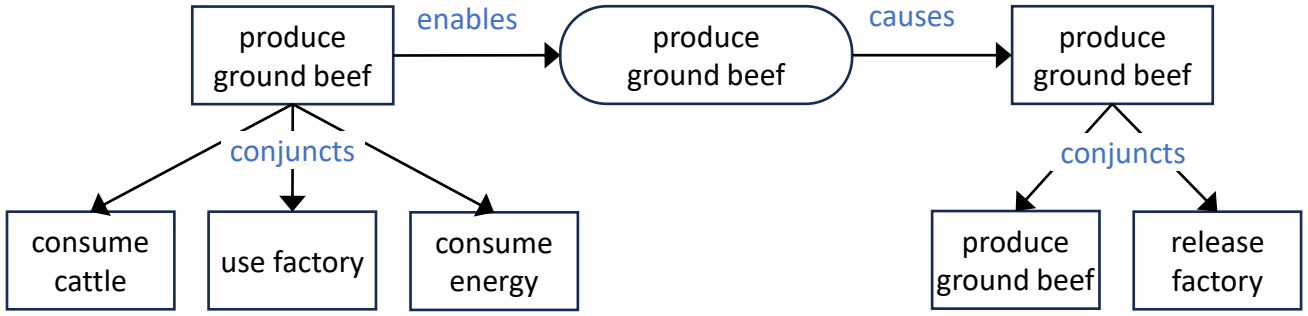



(Fox, 1993)

# TOVE/5087

- Activity Cluster
  - An activity, along with its enabling and caused states, is called an **activity cluster**.
  - **Condition**: The state tree linked by an **enables** relation to an activity specifies what has to be true in order for the activity to be performed.
  - **Causality**: The state tree linked to an activity by a **causes** relation defines what will be true of the world once the activity has been completed

*Activity-State Cluster Model*



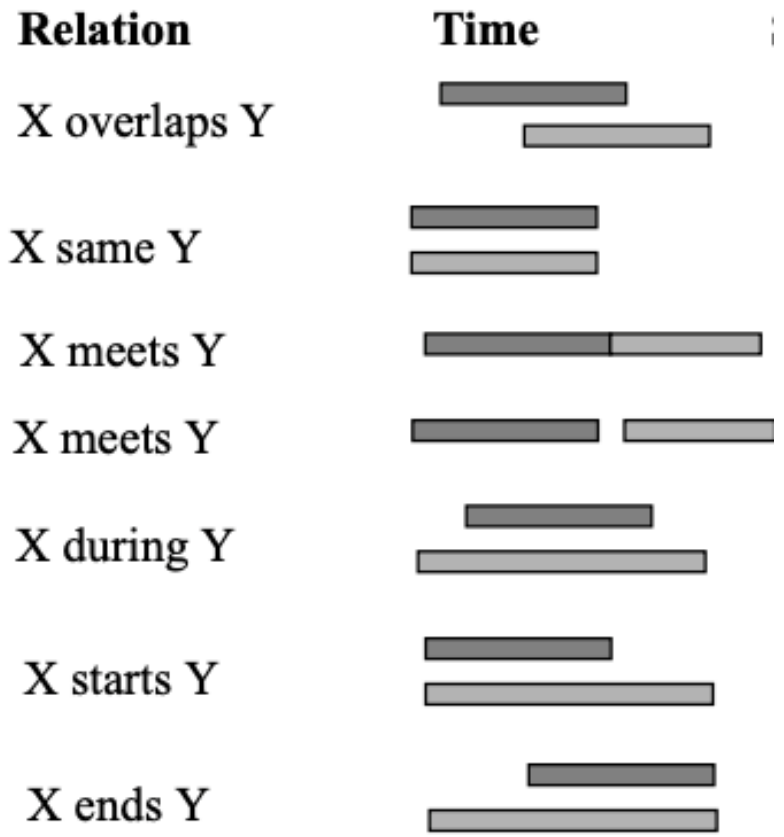

(Fox, 1993)

# TOVE/5087

- Time.
  - Time is represented by points, periods and relations.
  - A time-point lies within an interval. A time-period is bounded by a start and end time-point.

  - **Time Point**: When does the activity start?
  - **Time Period**: What is the start time and end time of the activity?
  - **Time Window**: What is the earliest/latest start/end time?
  - **Time Relation**: Is activity 1 before, after, or during activity 2?

*Time Model*

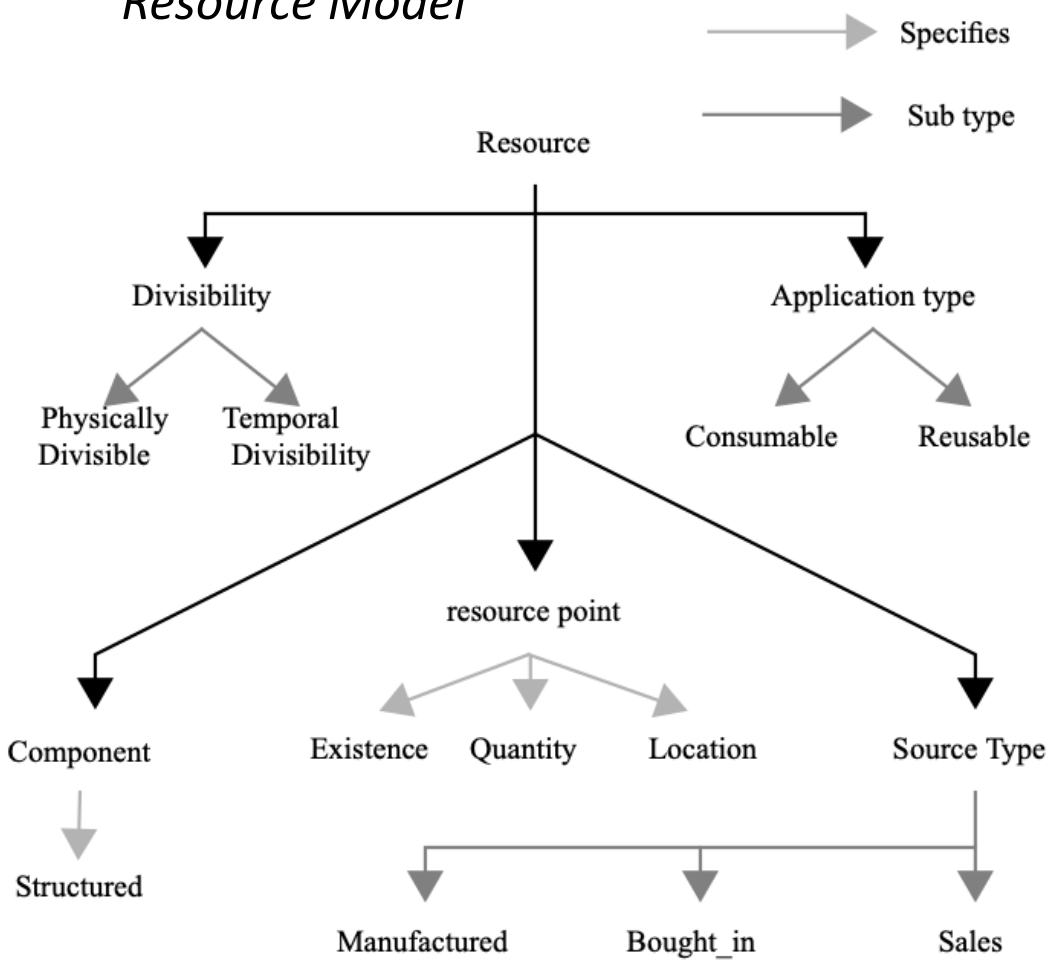



(Fox, 1993)

# TOVE/5087

- Resource:
  - **Existence**: How much of the resource exists at time t?
  - **Consumption**: Is the resource consumed by the activity? If so, how much?
  - **Divisibility**: Can the resource be divided and still be usable? Can two or more activities use the resource at the same time?
  - **Structure**: What are the subparts of resource R?
  - **Capacity**: Can the resource be shared with other activities?
  - **Location**: Where is resource R?
  - **Commitment**: What activities is the resource committed to at time t?

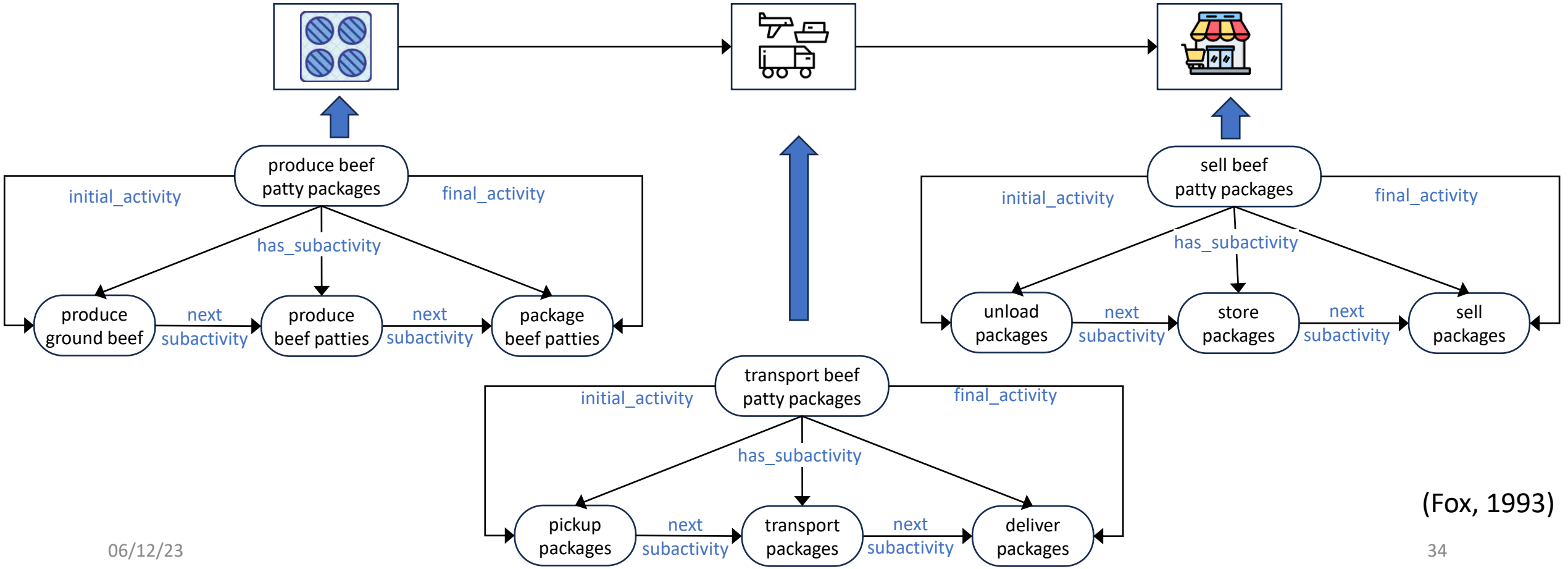
*Resource Model*




(Fox, 1993)

# TOVE/5087

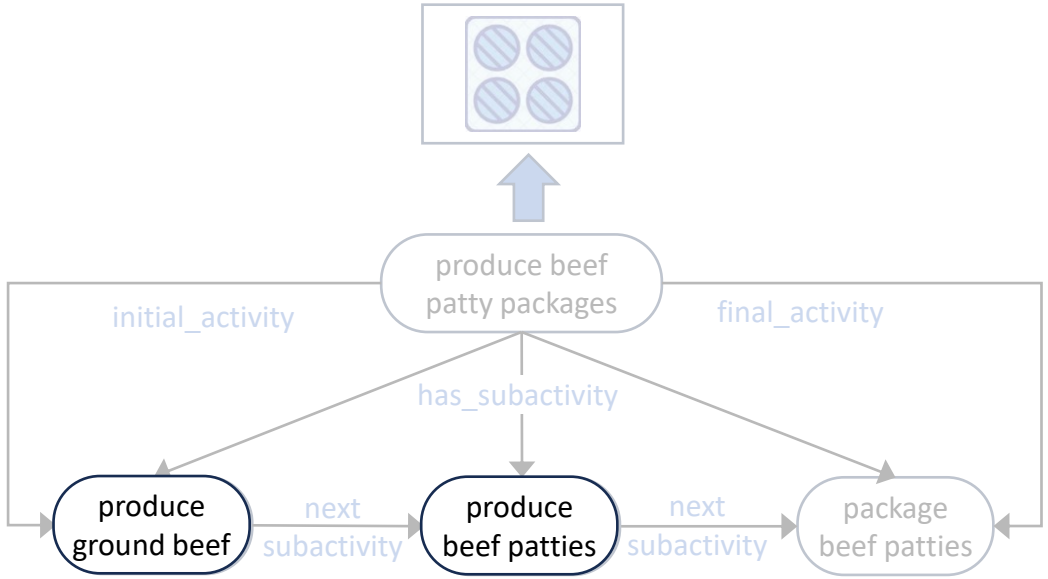
- **Activity Abstractions**: produce and deliver beef patties to retailers.

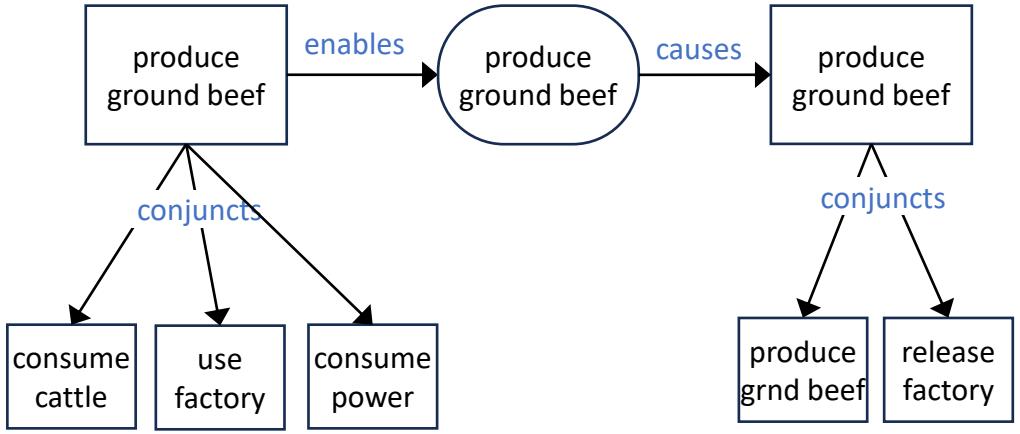


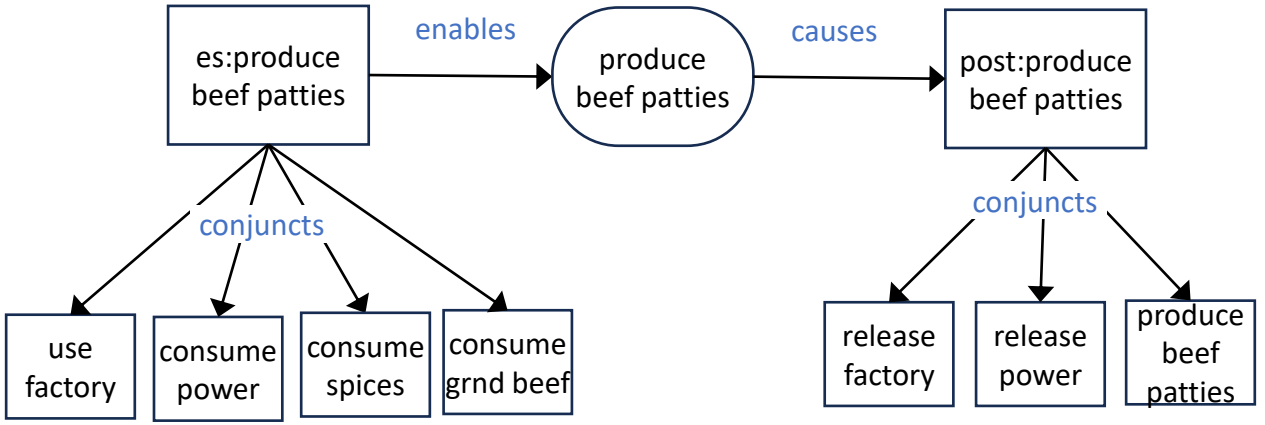

(Fox, 1993)

# TOVE/5087

- **Activity-State Cluster**:
  - convert cattle into ground beef
  - convert ground beef into beef patties
  - create beef patty packages



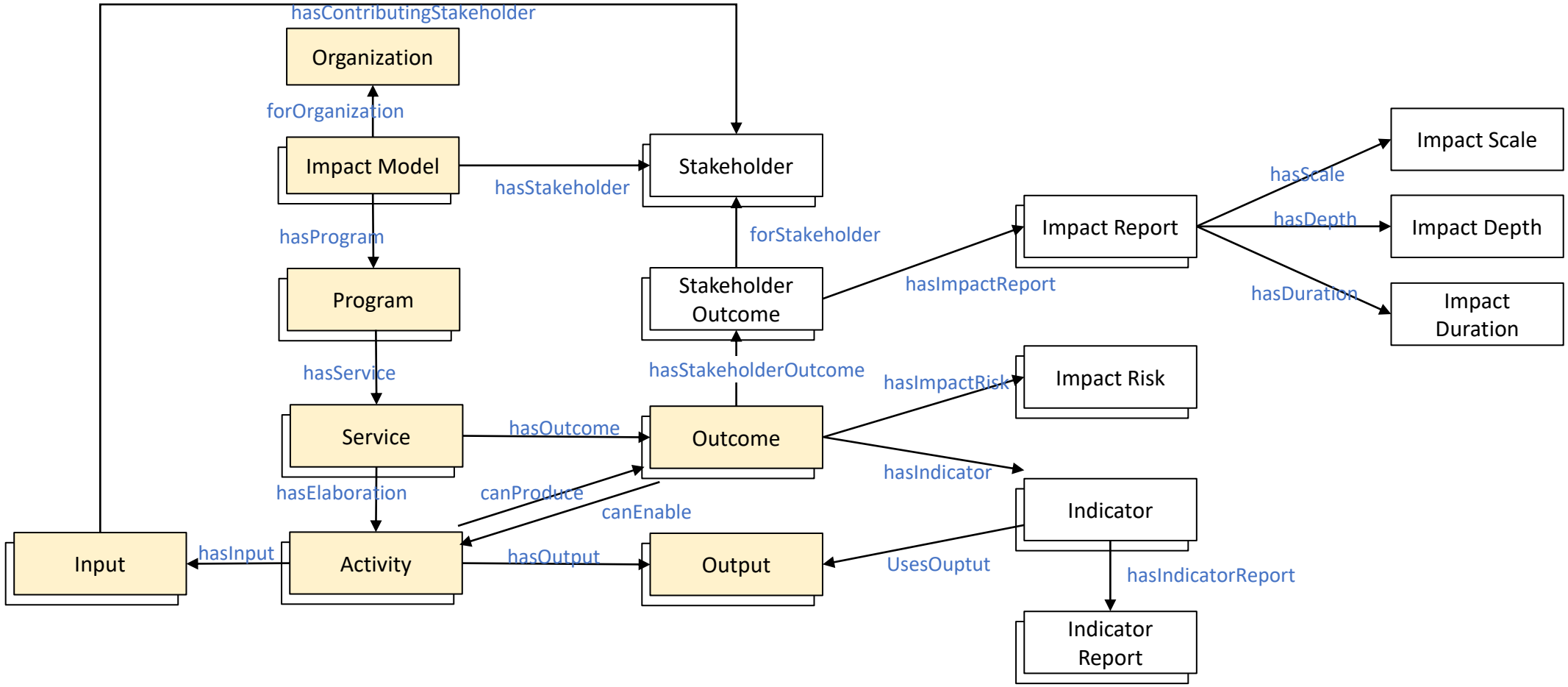

(Fox, 1993)

# Common Impact Data Standard

Standardized way to represent a social purpose organization's impact model (i.e., definition) and the impact (i.e., effect) their implementation has on its stakeholders.

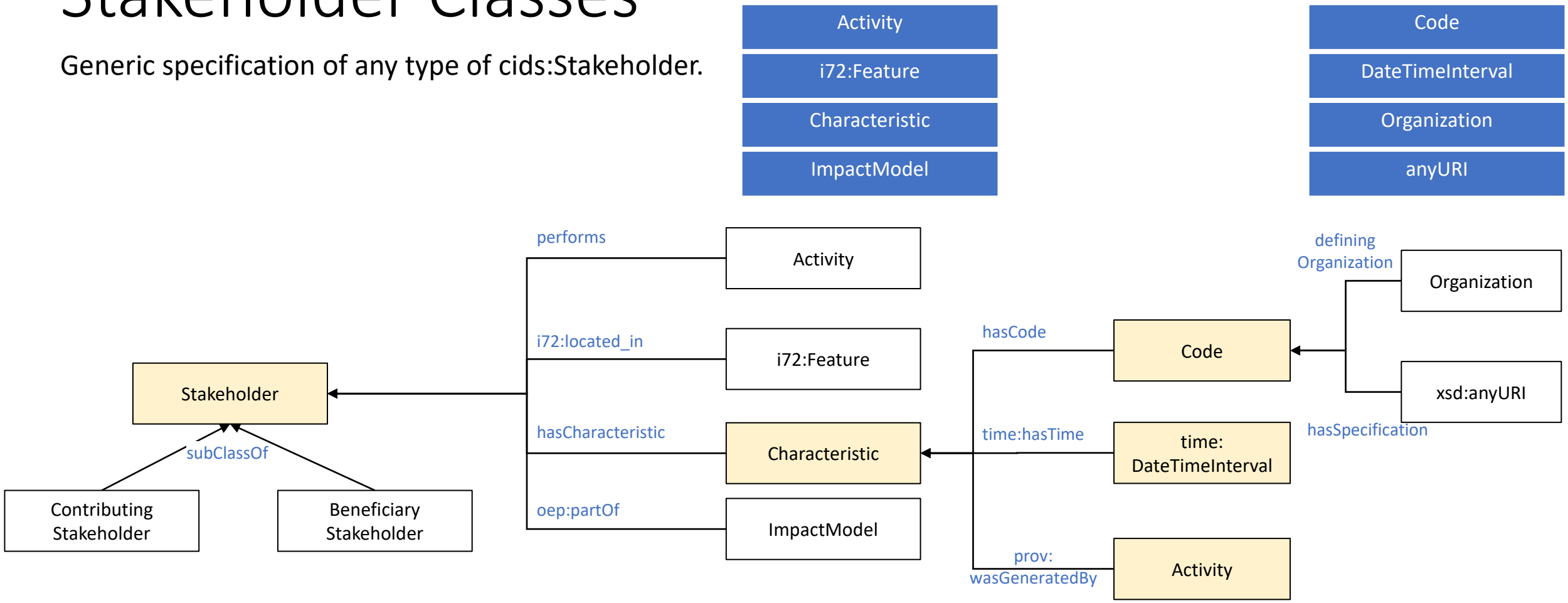
# Common Impact Data Standard: Overview

Core CIDS classes and a subset of the properties that connect them.

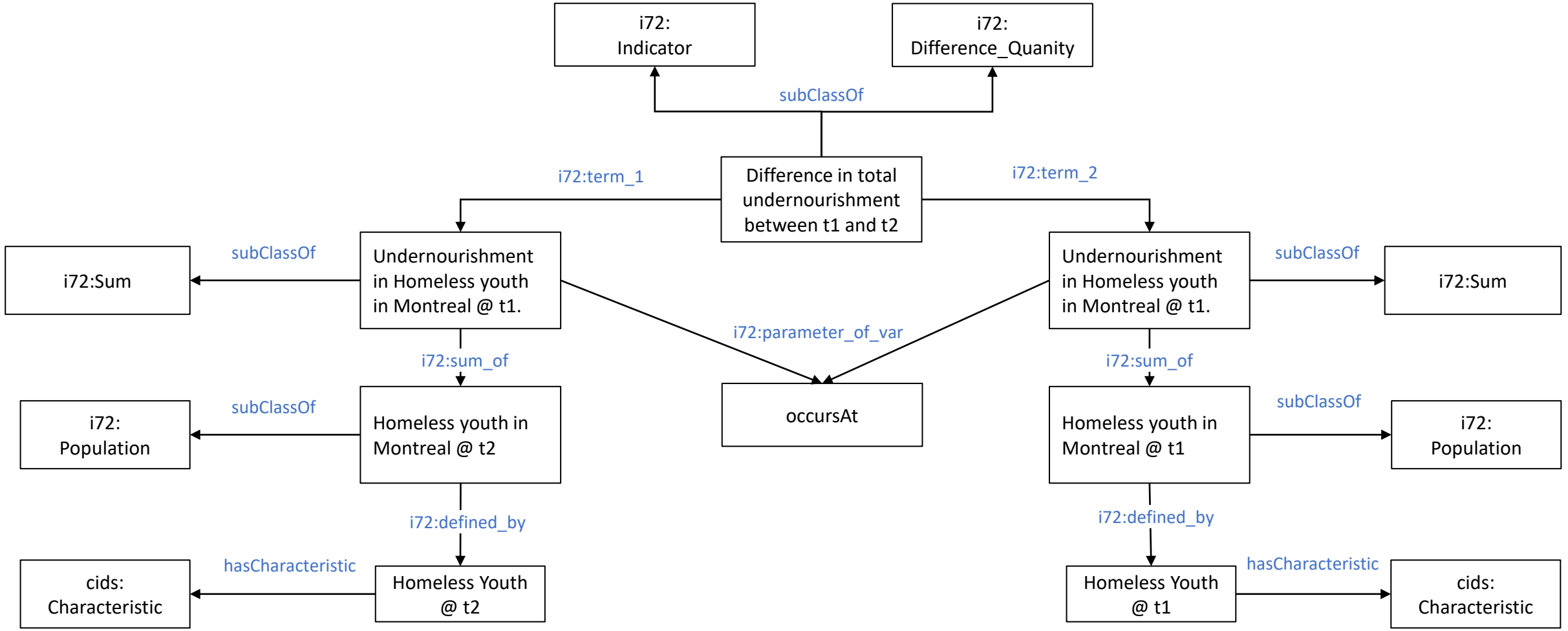


# Common Impact Data Standard: Stakeholder Classes

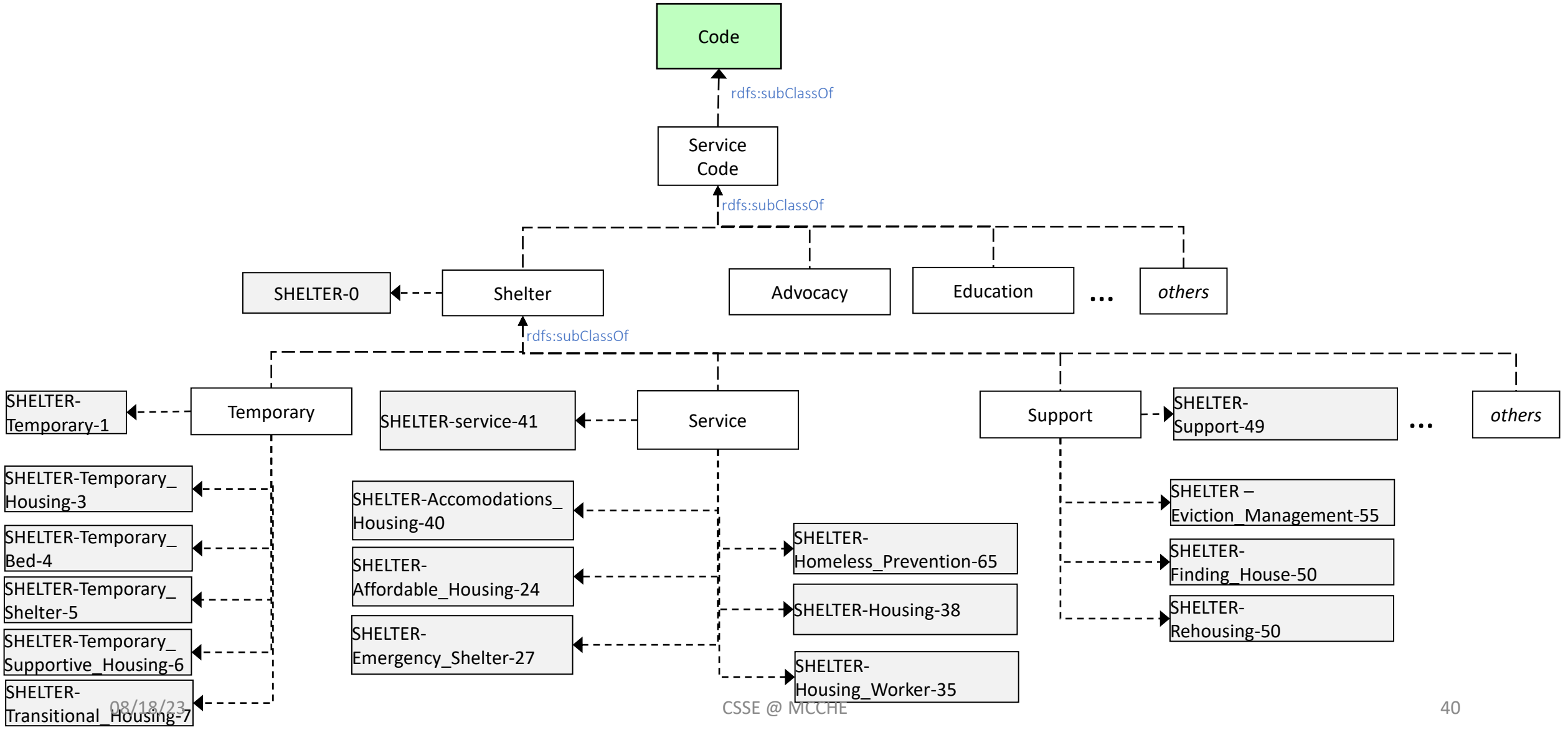
Generic specification of any type of cids:Stakeholder.

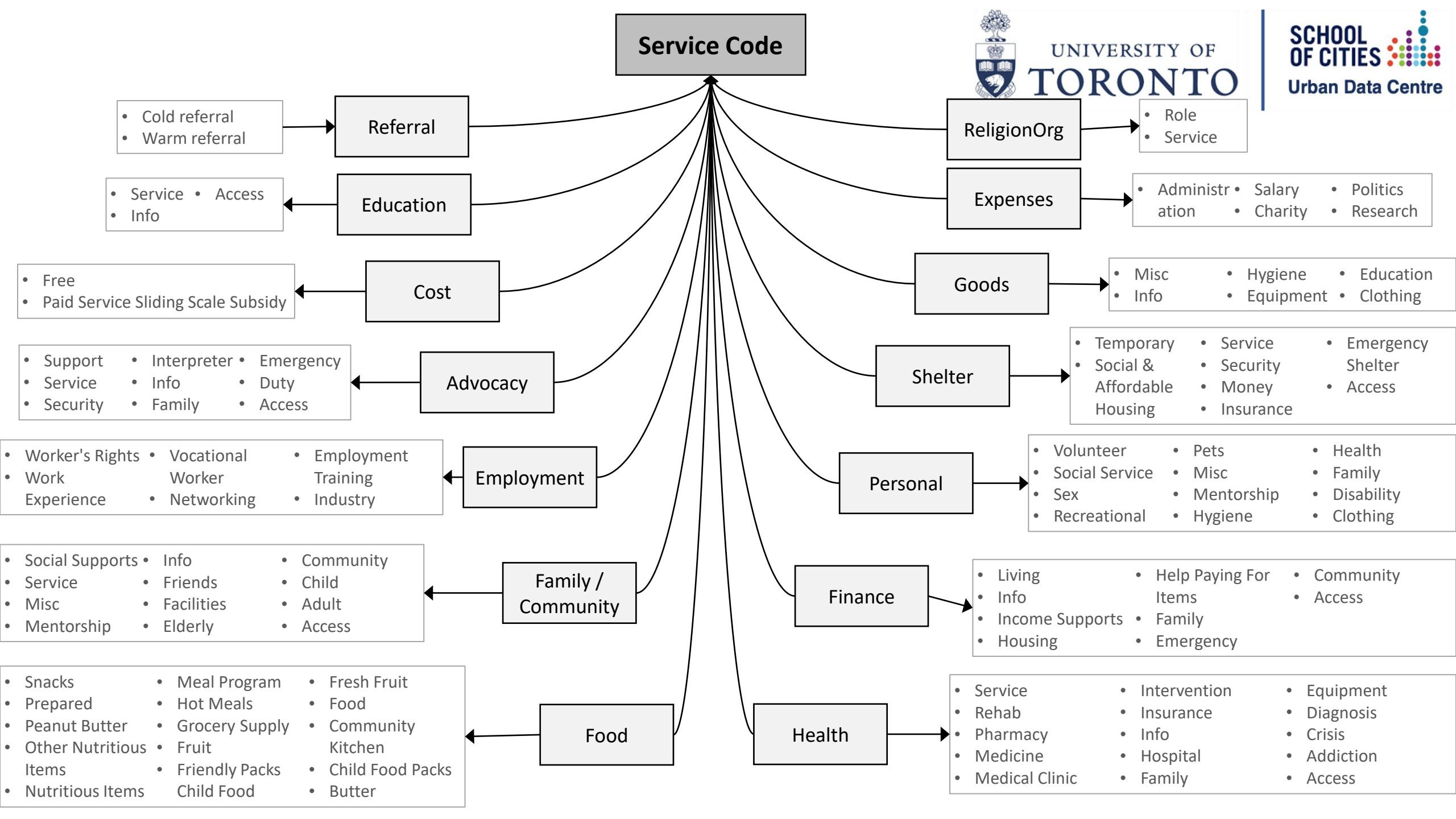


# UNSDG Indicator in CIDS: 2.1.1 Prevalence of undernourishment



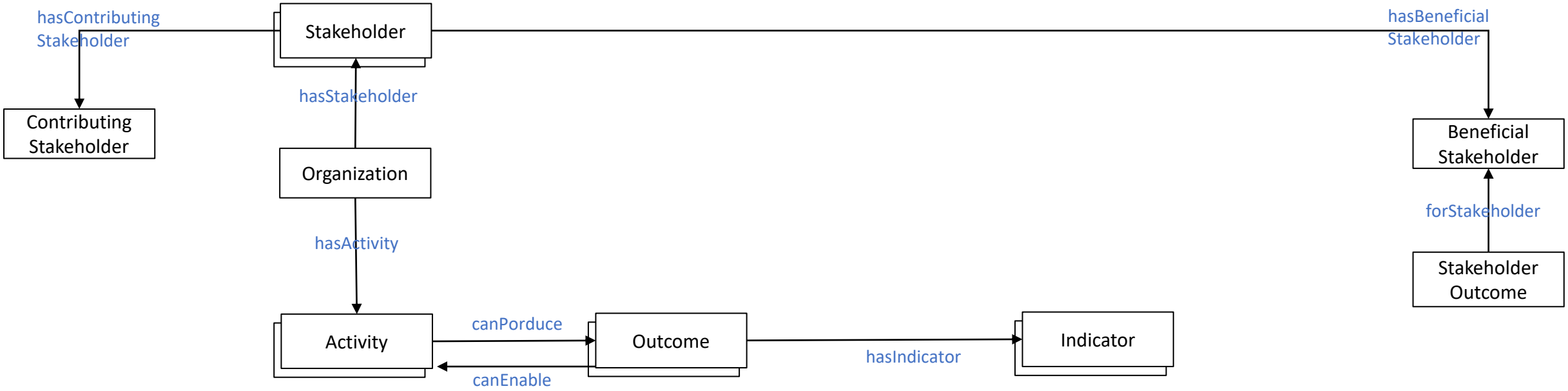
# Compass Code Taxonomy (Service)




Service Code
Referral
• Cold referral
• Warm referral
Education
• Service • Access
• Info
Cost
• Free
• Paid Service Sliding Scale Subsidy
Advocacy
• Support • Interpreter • Emergency
• Service • Info • Duty
• Security • Family • Access
Employment
• Worker's Rights • Vocational • Employment
• Work Experience Worker Training
• Networking • Industry
Family / Community
• Social Supports • Info • Community
• Service • Friends • Child
• Misc • Facilities • Adult
• Mentorship • Elderly • Access
Food
• Snacks • Meal Program • Fresh Fruit
• Prepared • Hot Meals • Food
• Peanut Butter • Grocery Supply • Community Kitchen
• Other Nutritious Items • Fruit • Child Food Packs
• Nutritious Items • Friendly Packs Child Food • Butter
Health
• Service • Intervention • Equipment
• Rehab • Insurance • Diagnosis
• Pharmacy • Info • Crisis
• Medicine • Hospital • Addiction
• Medical Clinic • Family • Access
Finance
• Living • Help Paying For Items • Community
• Info • Access
• Income Supports • Family
• Housing • Emergency
Personal
• Volunteer • Pets • Health
• Social Service • Misc • Family
• Sex • Mentorship • Disability
• Recreational • Hygiene • Clothing
Shelter
• Temporary • Service • Emergency Shelter
• Social & Affordable Housing • Security • Access
• Money
• Insurance
Goods
• Misc • Hygiene • Education
• Info • Equipment • Clothing
Expenses
• Administration • Salary • Politics
• Charity • Research
ReligionOrg
• Role
• Service
UNIVERSITY OF TORONTO
SCHOOL OF CITIES
Urban Data Centre

# Common Impact Data Standard

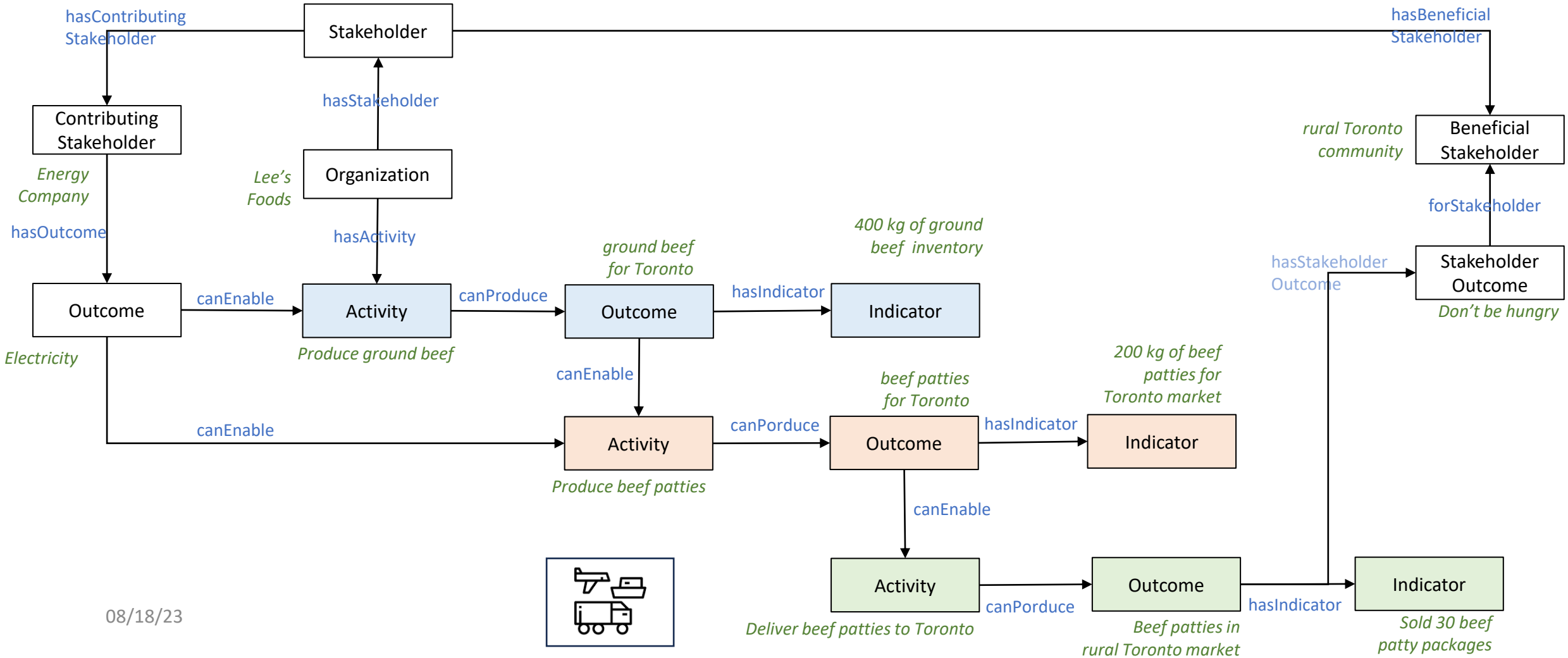
## Core classes




(Fox, 2021)

# Common Impact Data Standard

**Core Classes**: produce and deliver beef patties to a shelter.

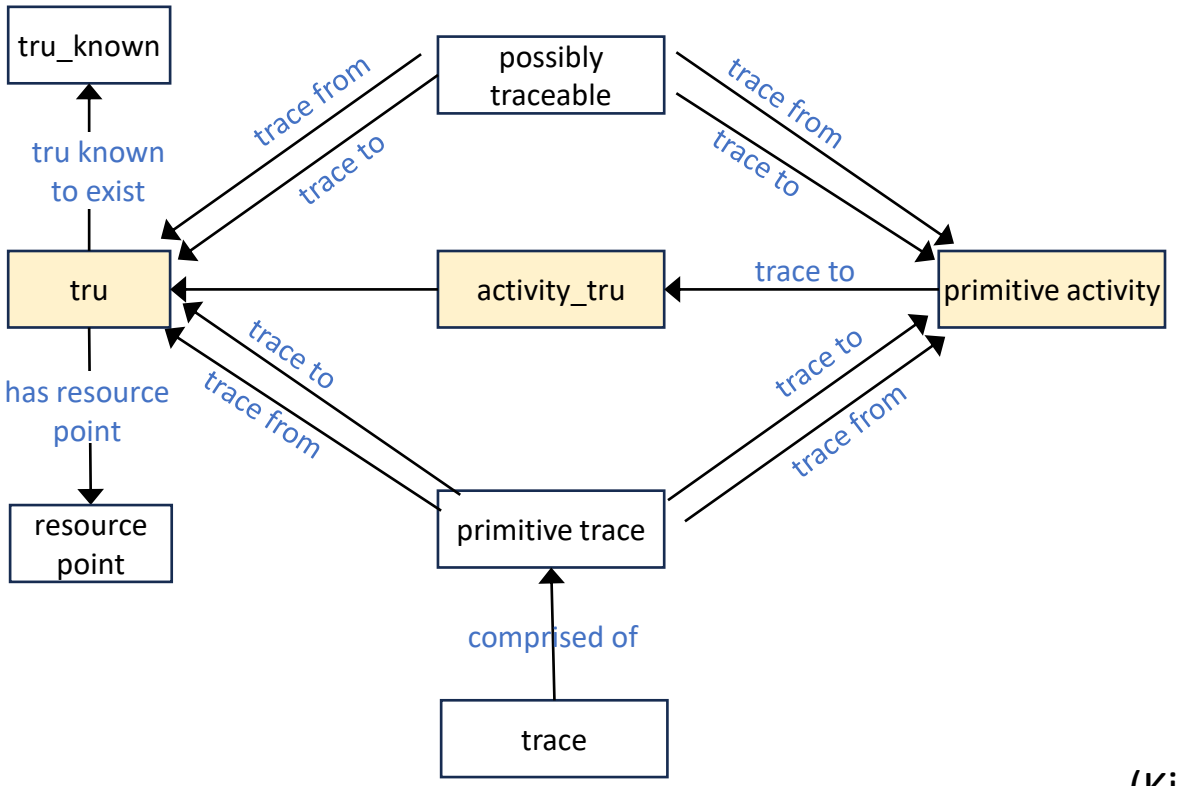


# TOVE + Common Impact Data Standard + Traceability

Tracing impact of an organization's activities using TOVE/5087 and CIDS.

# CIDS + Traceability

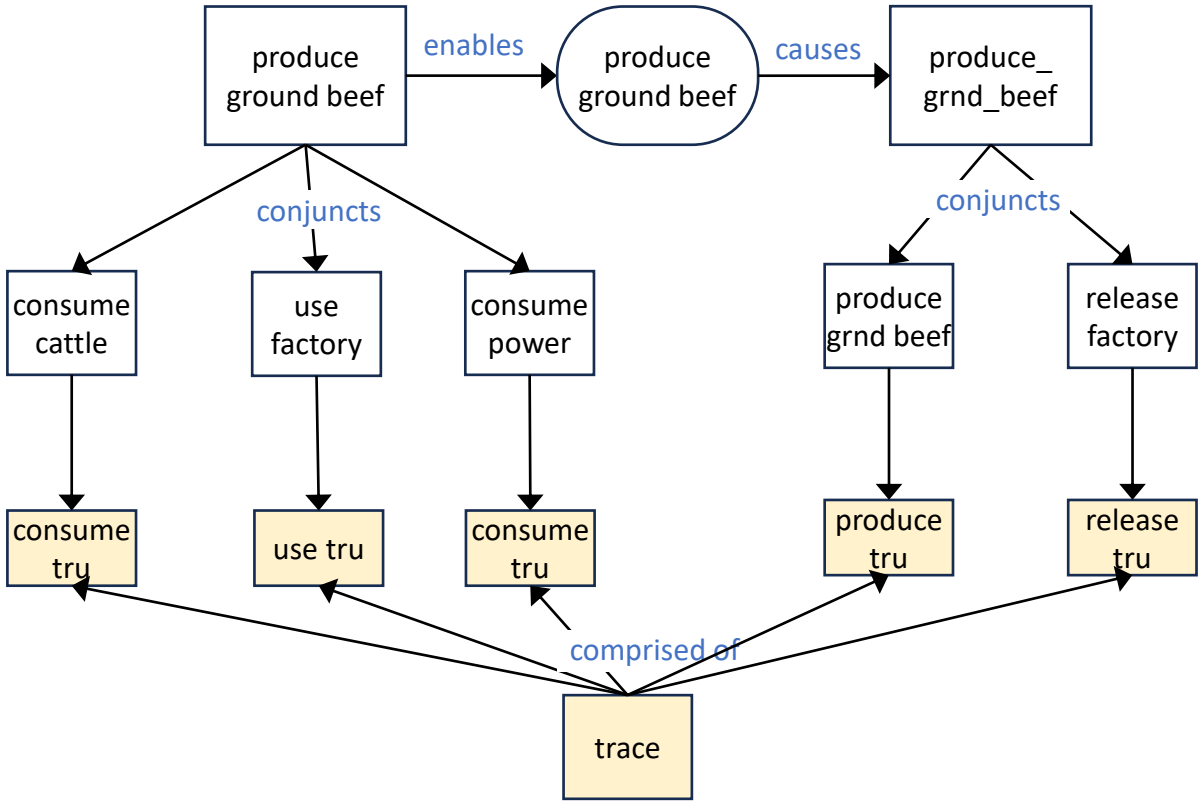
- Traceability: core concepts
  - traceability resource unit (TRU)
    - TRU known
    - Activity-TRU
    - Possibly traceable
  - Trace
    - Primitive trace




(Kim, 1998)

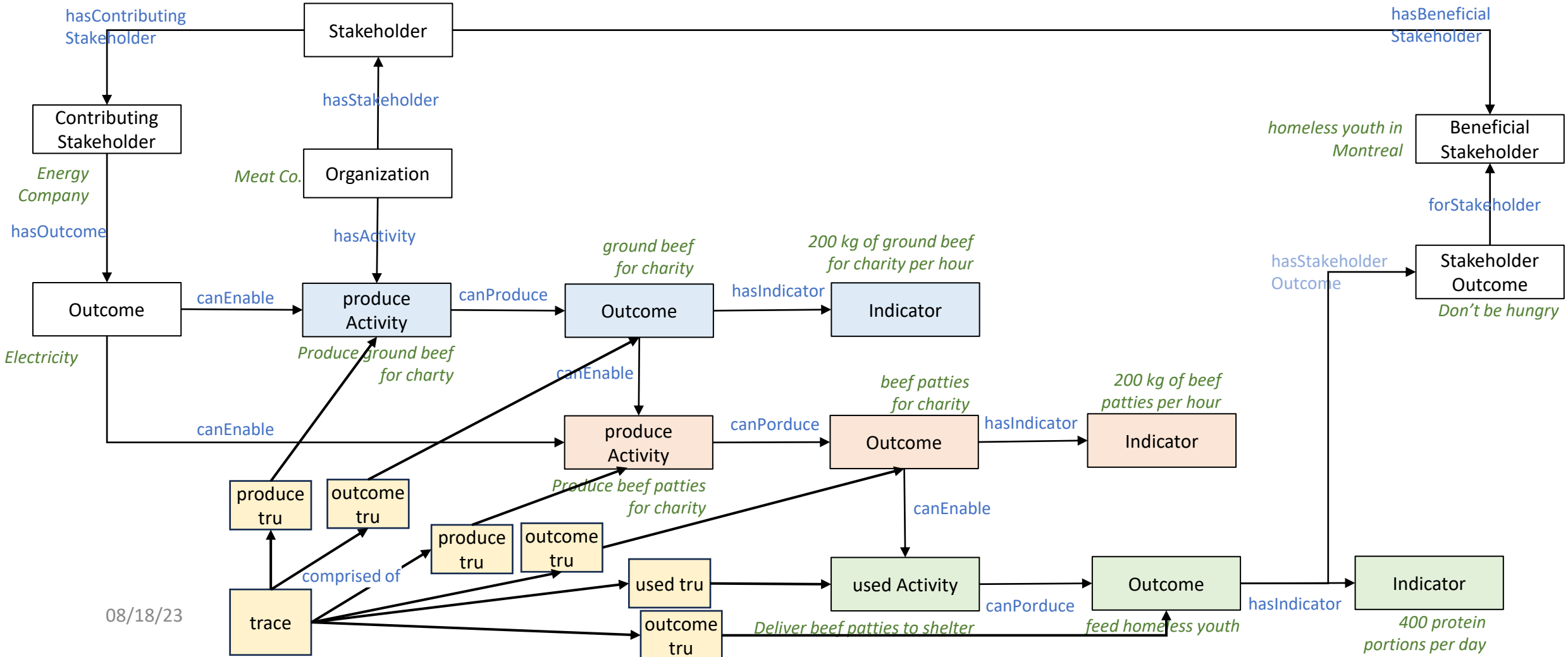
# CIDS + Traceability

- **Traceability of Activity-State Clusters**: produce ground beef



# CIDS + Traceability

**Traceability of Activities and Outcomes**: produce and deliver beef patties.



# Traceable Impact Management in the Agriculture Food Chain