Are We Confident in the Reliability of Information?

A Generic Theory of Authentication to Support IS Practice and Research

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http://rogerclarke.com/ID/PGTA {.html, .pdf}

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Context

- Digitalisation's impacts on 'Digital Economy and Society'
- Ongoing misconceptions inherent in IS thinking

Motivation

- Effective representation of relevant phenomena to overcome Id Management blunders, past and present
- A framework that reflects the intellectual complexities and identifies the proponent's 'metatheoretic assumptions'
- A model that's pragmatic, and supports instrumentalism
  – for IS practice, and for IS-relevant research

==>> A Pragmatic Metatheoretic Model

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A Pragmatic Metatheoretic Model

'Metatheory'

Ontology – the study of existence
Epistemology – the study of knowledge
Axiology – the study of value

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http://www.rogerclarke.com/ID/PMM.html
(ACIS #32 in 2021)

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A Pragmatic Metatheoretic Model

'Metatheory'

Ontology – the study of existence
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'Pragmatism'

In philosophy, 'concerned with understanding and action'
not just describing and representing

In IS practice, approximates and articulates 'common sense'

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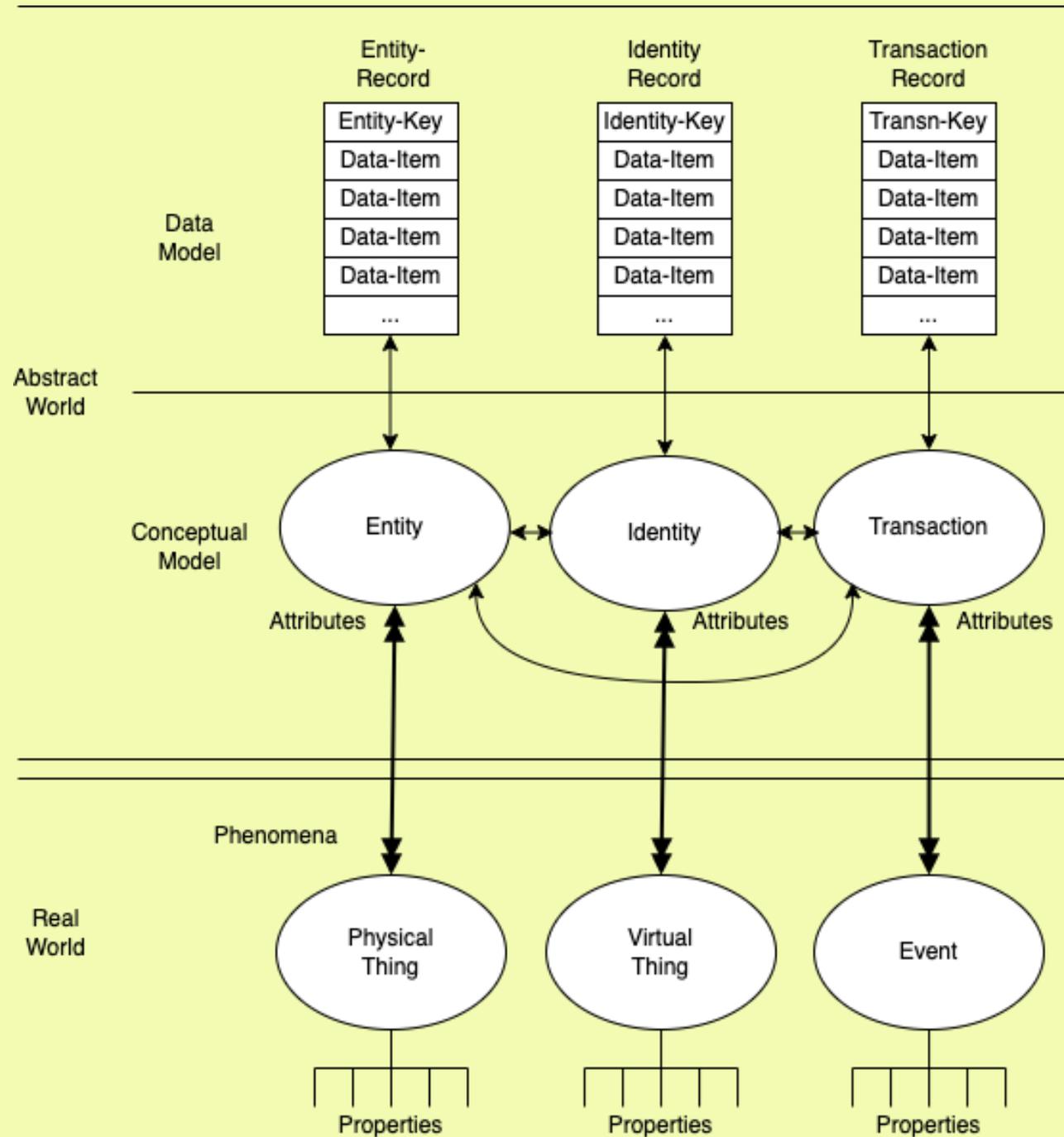and articulates 'common sense'

Metatheoretic Assumptions

Conscious / Unconscious

Explicit / Undeclared

Metatheoretic Commitments

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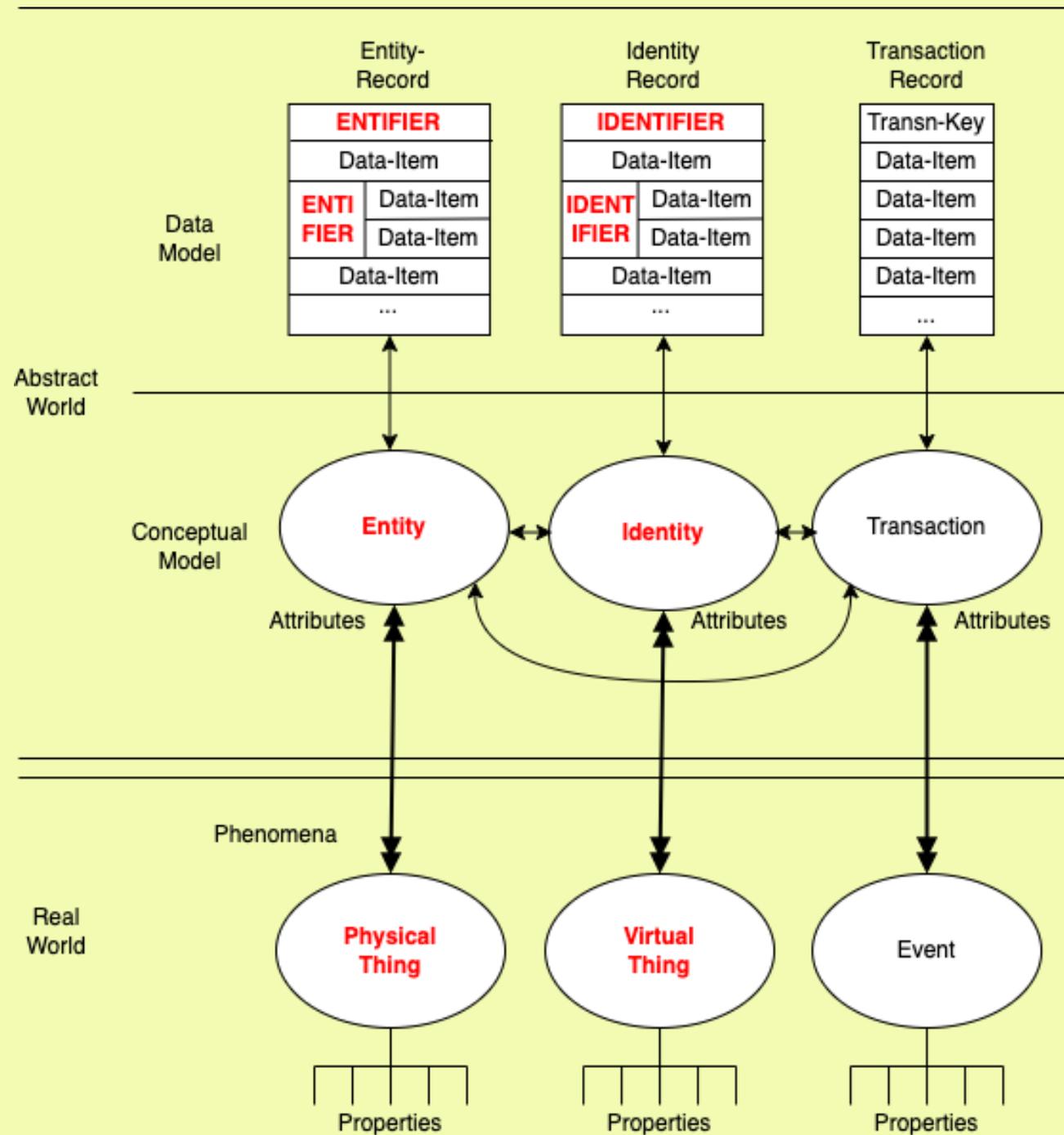http://www.rogerclarke.com/ID/PMM.html
(ACIS #32 in 2021)

Metatheoretic Commitments

- **Pragmatism**
  For understanding and action, not just describing and representing, and hence oriented towards IS Practice and Practice-Relevant Research

- **The Conception of an IS**
  "A set of interacting artefacts and human activities that performs one or more functions involving the handling of data and information"

- **Socio-Technical View**
  Interweaving of artefacts with human activity means that neither a technical nor social view provides a sufficient basis for understanding

- **Ontology**
  Realism <u>and</u> Idealism, blended, dependent on circumstances

- **Epistemology**
  Empiricism <u>and</u> Apriorism, blended, dependent on circumstances
  In IS, assumptions of humanly-accessible Truth are seldom justifiable

- **Axiology**
  Teleological and Instrumentalist, supporting effective, efficient and adaptable IS serving the needs of the sponsor but also all stakeholders

Key Elements
of the
Pragmatic
Metatheoretic
Model

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Key Differences about the Pragmatic Metatheoretic Model

Entity-Record	Identity Record	Transaction Record
ENTIFIER	**IDENTIFIER**	Transn-Key
Data-Item	Data-Item	Data-Item
ENTI FIER Data-Item	**IDENT IFIER** Data-Item	Data-Item
Data-Item	Data-Item	Data-Item
Data-Item	Data-Item	Data-Item
...	...	...

Data Model

Abstract World

Conceptual Model

Entity ⟷ Identity ⟷ Transaction

Attributes   Attributes   Attributes

Real World

Phenomena

Physical Thing   Virtual Thing   Event

Properties   Properties   Properties

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Physical Things and Virtual Things

- **Inanimate Objects** (Inventory-Items, Equipment)
  - Containers ⊃ Pallet-Loads ⊃ Boxes ⊃ Cartons

- **Active Objects**
  - Mobile-Phone/Handy/Cellulare   ⊃   **SIM-Cards**
  - Computer   ⊃   **Processes**
  - Car   ⊃   **Convoy-Lead, Get-Away Car, Speed-Check,** ...

- **Organisations** (Companies, Associations, Govt Agencies, ...)

- **Humans and The Roles Humans Play**

  Seller, buyer, supplier, receiver, debtor, creditor, payer, payee, principal, agent, franchisor, franchisee, lessor, lessee, copyright licensor, copyright licensee, employer, employee, contractor, contractee, trustee, beneficiary, tax-assessor, tax-assessee, business licensor, business licensee, plaintiff, respondent, investigator, investigatee, defendant, ...

Authentication

OED 1, 3a, 3b, 4a, 4b, 5, 6

to { validate, approve, prove, confirm,
establish as genuine/authentic, verify } ...

... { something/anything, a statement, an account, truth,
existence, a reputed fact, a document, an artefact,
an artwork, a user identity, a process identity }

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an artwork, a user identity, a process identity }

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Foundations of Authentication Theory

- *An Assertion is an expression of knowledge about one or more elements of the pragmatic metatheoretic model*

- May be made by a party, implied by context, inferred by a party, or postulated by a party. Assertions may be about:
  - Particular Phenomena in the Real World;
  - Particular elements of an Abstract World;   or
  - Relationships between Real- and Abstract-World elements

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    'The number of Things in a particular storage-bin is correctly recorded in a particular Data-Item-Value'

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  'The number of Things in a particular storage-bin is correctly recorded in a particular Data-Item-Value'

- *Authentication is a process that establishes an appropriate degree of confidence in the reliability of an Assertion*

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Foundations of Authentication Theory

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  'The number of Things in a particular storage-bin is correctly recorded in a particular Data-Item-Value'

- *Authentication is a process that establishes an appropriate degree of confidence in the reliability of an Assertion*

  'A physical stock-count of Things in a particular storage-bin identified a mis-match against the relevant Data-Item-Value'

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Further Concepts in Authentication Theory

- **Authentication Process**
Abstract World: Check logic and language
Abstract-to-Real World: Observe/measure, compare

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Further Concepts in Authentication Theory

- **Authentication Process**
  Abstract World: Check logic and language
  Abstract-to-Real World: Observe/measure, compare

- **Evidence**
  Data that assists in an Authentication Process

- **Authenticator**
  An item of Evidence, e.g. a document (in any medium)

- **Credential**
  An Authenticator with the imprimatur of an authority

- **Token**
  A recording medium on which useful data is stored
  e.g. (Id)Entifiers, Attributes, Authenticators, Credentials

Authentication Quality Management

- Checks of the Authentication Process

- Checks of the Evidence used in the Process

- Effort proportional to the harm arising, and the likelihood of error, i.e. False Positives (Assertions wrongly accepted) and False Negatives (Assertions wrongly rejected)

- Higher Investment in Safeguards where parties are motivated to engineer False Positives or False Negatives

- Care with:
  - Means for contesting or repudiating assertions
  - Which party bears the onus of proof
  - Which party bears the risks, costs and inconvenience

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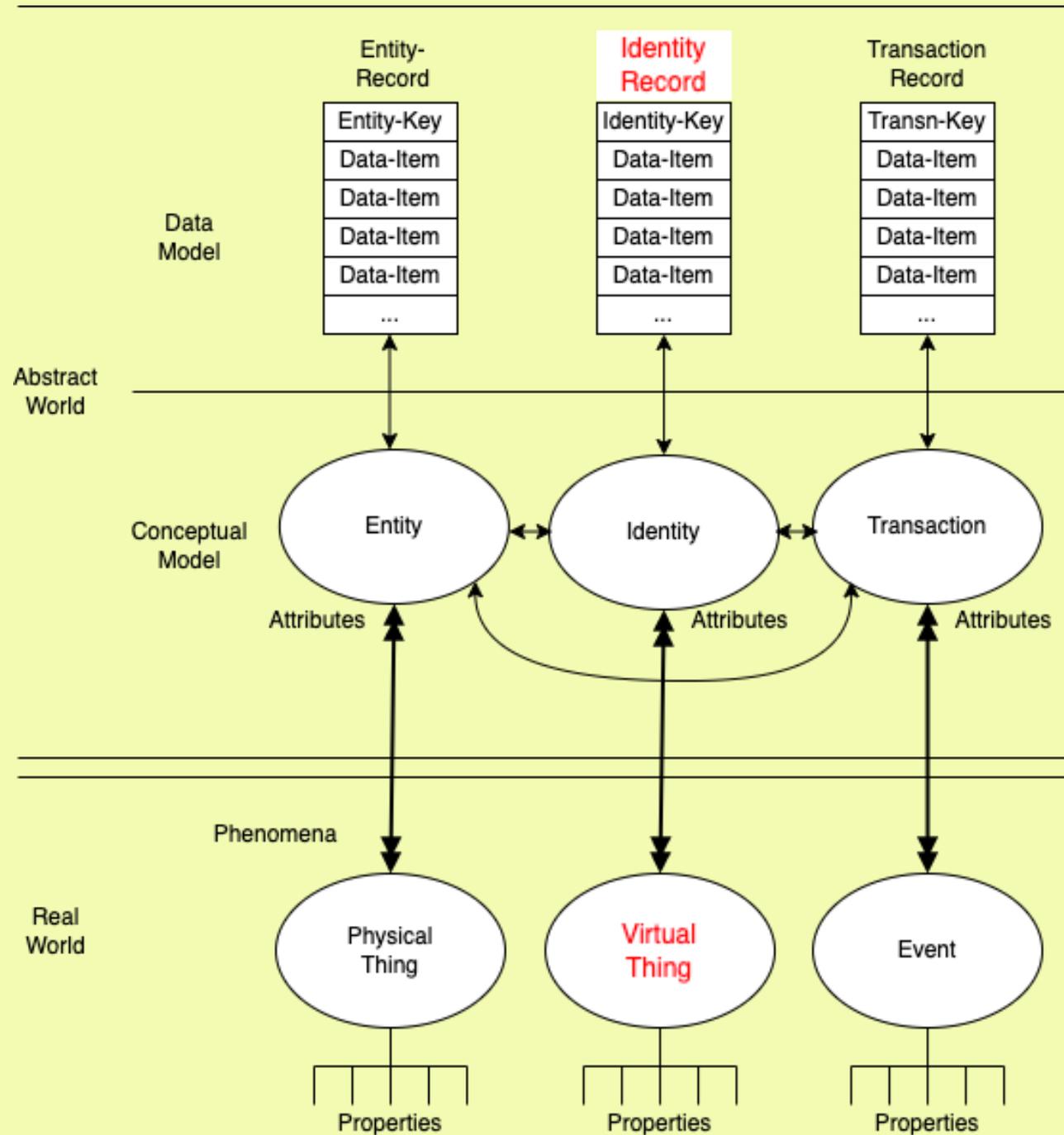Pty Ltd

Categories of Assertion

(1) **(Id)Entity**

(2) (Id)Entity Match

(3) **Property** (Simple)

(4) Property (Complex)

(5) Principal-Agent

(6) Monetary **Asset-Value**

(7) Non-Monetary Asset-Value

(8) **Content** Integrity

(1)   (Id)Entity Assertion

- *A particular Physical / Virtual Thing is appropriately associated with one or more (Id)Entity-Records*
'This physical person's or client's profile information is displayed on the screen in front of me'

- *The Data-Item-Values in a particular (Id)Entity-Record are appropriately associated with a particular Thing*
'This data relates to this human /artefact / software-agent'

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(1) (Id)Entity Assertion

*A particular **Thing** is appropriately associated with one or more **(Id)Entity-Records***

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Data Model

Entity-Record	Identity Record	Transaction Record
Entity-Key	Identity-Key	Transn-Key
Data-Item	Data-Item	Data-Item
Data-Item	Data-Item	Data-Item
Data-Item	Data-Item	Data-Item
Data-Item	Data-Item	Data-Item
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Entity — Identity — Transaction

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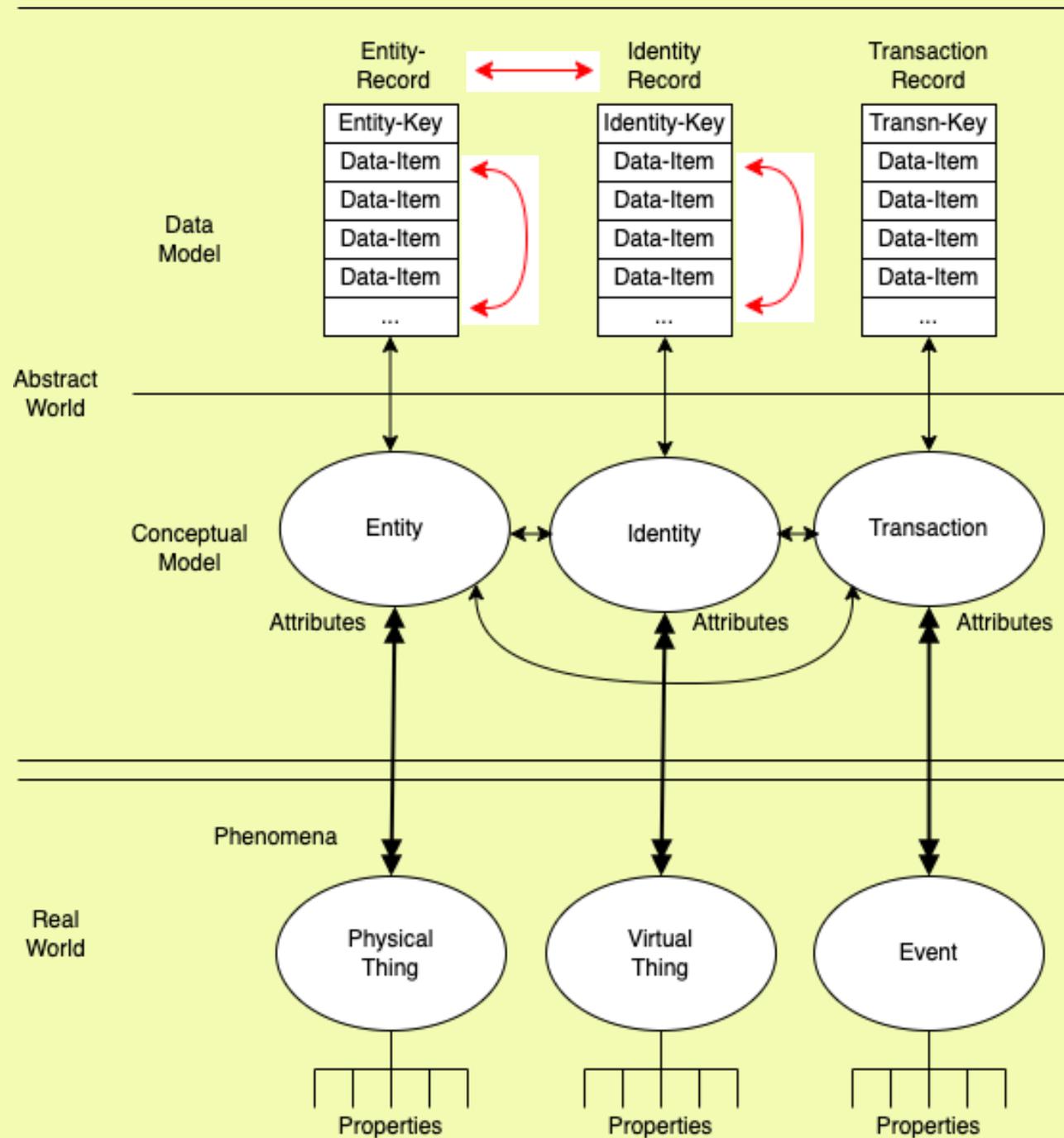
(1) (Id)Entity Assertion

- *A particular Physical / Virtual Thing is appropriately associated with one or more (Id)Entity-Records*
  'This physical person's or client's profile information is displayed on the screen in front of me'

- *The Data-Item-Values in a particular (Id)Entity-Record are appropriately associated with a particular Thing*
  'This data relates to this human /artefact / software-agent'

(2) (Id)Entity Match Assertion

- *This (Id)Entity-Record is appropriately associated with this other (Id)Entity-Record*
  'This record in the Motor Vehicle Insurance database matches to this record in the Home & Contents database'

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Clarke (2023), presented at the Bled eConference
http://www.rogerclarke.com/ID/IEA-Bled.html

(2) (Id)Entity Match Assertion

Two different (Id)Entity-Records are appropriately associated with one another

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(3)   Simple Property Assertion

- *A particular Data-Item-Value in a particular (Id)Entity Record is appropriately associated with, <u>and</u> reliably represents, a particular Property of a particular Thing*
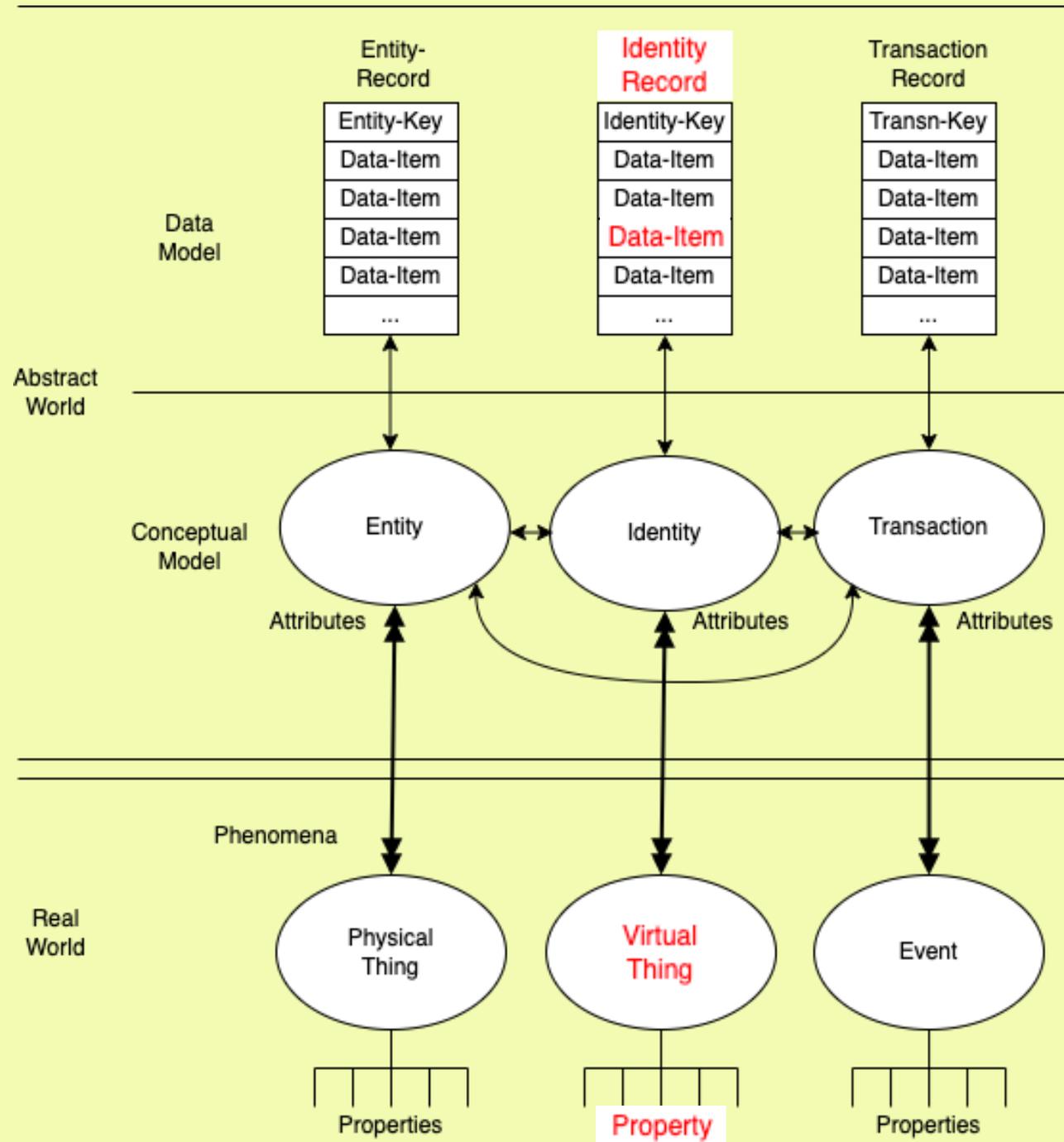
  'This gem is a diamond and weighs 1 carat'

  'We have 13 widgets because the inventory system says we have'

  'This customer is a frequent-buyer who gets a loyalty discount'

  'This person is old enough to enter the night club'

  'This person has a degree from XYZ University'

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A particular Data-Item-Value in a particular (Id)Entity Record is appropriately associated with, and reliably represents, a particular Property of a particular Thing

Entity-Record

Entity-Key
Data-Item
Data-Item
Data-Item
Data-Item
...

Identity Record

Identity-Key
Data-Item
Data-Item
Data-Item
Data-Item
...

Transaction Record

Transn-Key
Data-Item
Data-Item
Data-Item
Data-Item
...

Data Model

Abstract World

Conceptual Model

Entity ↔ Identity ↔ Transaction

Attributes   Attributes   Attributes

Phenomena

Real World

Physical Thing   Virtual Thing   Event

Properties   Property   Properties

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(3)   Simple Property Assertion

- *A particular Data-Item-Value in a particular (Id)Entity Record is appropriately associated with, <u>and</u> reliably represents, a particular Property of a particular Thing*

  '<u>This customer</u> is a frequent-buyer who gets a loyalty discount'

  '<u>This person</u> is old enough to enter the night club'

  '<u>This person</u> has a degree from XYZ University'

- *Authenticate that the Data-Item-Value is associated with the correct Thing <u>but</u> don't record (or even collect) the (Id)Entifier unless there's a good reason why it's needed*

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(4)   Complex Property Assertion

- *A particular Thing is inferred to have a particular Property, on the basis of <u>multiple</u> particular Data-Item-Values in one or more particular (Id)Entity Records,*

  <u>and</u> on the assumption that those Data-Item-Values are appropriately associated with that Thing and reliably represent that Property

  'This borrower is behind on their loan repayments'

  'This welfare recipient has been overpaid
  because they understated their income'

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(5)   Principal-Agent Assertion

- *A particular Thing has a particular Property, based on one or more particular Data-Item-Values in one or more particular (Id)Entity Records,*

  which are appropriately associated with that Thing and

  which reliably convey that <u>the particular Thing has the authority to act on behalf of another particular Thing</u>

  'This human/legal-person/software-agent is the approved representative of this customer/client/defendant'

Evidence to Support the Authentication Process Property Assertions (3)-(5)

- **Rely on Data already held**

  - 'Trade Customer', 'Old-Age Pensioner', ...

- **Apply logical processes to Data already held**

  - A claim of being owed a refund for a failed delivery

  - A claim to having reached a particular age
    or period of association with an organisation

- **Rely on new Data checked against another source**

  - A claim of an educational or skills qualification
    against a testamur, or a database listing graduates

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(6)   Monetary-Asset Value Assertion

- *A particular Thing is inferred to have a particular (economic) value, on the basis of its Properties*

  and/or one or more Data-Item-Values in one or more particular (Id)Entity Records,

  <u>and</u> the assumption that those Data-Item-Values are appropriately associated with that Thing and reliably represent particular Properties

  'This banknote is legal tender'

  'Our bank has confirmed deposit of the funds into our account'

  'The credit-card transaction has been approved'

  'It says my blockchain wallet has received digital currency'

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(6)   Monetary-Asset Value Assertion

- *A particular Thing is inferred to have a particular (economic) value, on the basis of its Properties and/or one or more Data-Item-Values in one or more particular (Id)Entity Records,*
  <u>and</u> the assumption that those Data-Item-Values are appropriately associated with that Thing and reliably represent particular Properties

  'This banknote is legal tender'

  'Our bank has confirmed deposit of the funds into our account'

  'The credit-card transaction has been approved'

  'It says my blockchain wallet has received digital currency'

- *Authenticate the Value <u>but</u> don't record (or even collect) parties' (Id)Entifiers without good reasons to do so*

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(7)   Non-Monetary-Asset Value Assertion

- *A particular Thing is inferred to have a particular (economic) value, on the basis of its Properties*

  and/or one or more Data-Item-Values in one or more particular (Id)Entity Records,

  <u>and</u> the assumption that those Data-Item-Values are appropriately associated with that Thing and reliably represent particular Properties

  'This consumer-durable / livestock / ticket / motor vehicle / collectible / real estate / parcel of shares/loans/insurance ...
  is worth the value that I / others place on it / attribute to it'

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(8)   Content Integrity Assertion

- *A Real World Thing is reliably represented by an Abstract World Entity-Instance-Attribute-Value or an Entity-Record-Data-Item-Value*

  'The number of Widgets Class A that we have in stock is 37, as recorded in the Current-Stock-Count Data-Item in the stock file'

  'The message I've received is identical to that which was sent'

(8)   Content Integrity Assertion

- *A Real World Thing is reliably represented by an Abstract World Entity-Instance-Attribute-Value or an Entity-Record-Data-Item-Value*

  'The number of Widgets Class A that we have in stock is 37, as recorded in the Current-Stock-Count Data-Item in the stock file'

  'The message I've received is identical to that which was sent'

  'The text in the message means what I think it means'

  'The audio / image / video in the message is authentic'

Implications

- The Pragmatic Metatheoretic Model suggests that several changes in approach are needed in IS thinking

- Authentication is about the reliability of Assertions

- A broadened Authentication notion encourages focus on Assertions that are relevant to purpose, and whose reliability can be effectively and efficiently assessed

- Property Assertions and Value-Assertions are in many cases more important, easier, cheaper and less intrusive to assess than (Id)Entity Assertions

- Contingency theories are needed that show when each category of Assertions needs to be prioritised

- The scope of IS needs to extended to Assertions of Fact, in text, audio, image and video, and the Authentication of their semantic content integrity

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Implications for IS Practice and Theory

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The Authentication of Identity Assertions

Agenda

- Motivation

- A Pragmatic Metatheoretic Model to support IS practice and relevant research

- The Theory of Assertion Authentication

- The Rich Set of Assertion Categories

- Authentication Processes

- Implications for IS Practice and Theory

Are We Confident in the Reliability of Information?

A Generic Theory of Authentication to Support IS Practice and Research

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Approach

- **Pure Research**
  'I want to discover and understand what is'

- **Applied Research**
  'I have a research tool, so I'll use it' (hammer, so nail)

- **Instrumentalist Research**
  There's a problem, so I'll try to solve it

- **'Pragmatism'**
  - In philosophy, 'concerned with understanding and action', not merely describing and representing
  - In IS practice, approximates and articulates a layman's 'common sense' interpretation

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A <u>Pragmatic</u> Epistemological Model

- "An open attitude toward any kind of epistemological foundation that might work"

- "Epistemological and methodological diversity"

- "Disciplined methodogical pluralism"

- **Empiricist orientation, if mostly non-human entities**
  Guidance systems for aircraft and spacecraft
  Heavily-automated production control /inventory systems

- **Recognition of innateness, for systems with human involvement or with significant impact on humans**

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Employee Attributes

- **Human Entity**

  - Emergency Contact-Name, Bank a/c for Salary
    Do they <u>really</u> need a biometric/brand/embedded chip?

- **Human Identity**, persistent, but change over time

  - Position, Start-Date, End-Date, Permissions

- **Human Identity**, occasional and may be shared
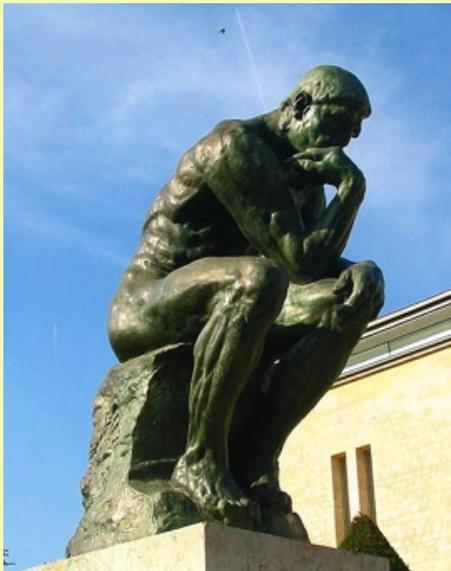
  - Fire Warden, Zone, Training Certs, Permissions

Spares from Prior Presentations

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Ontology / Existence or 'Being'

Phenomena – Matter, Things, Events, Properties

Materialism
Matter exists, independently
of whether a human detects it

Cogito ergo est
I think it is, therefore it is

Idealism
Everything exists in the human mind.
The 'real world' I think I see is only an idea.
That idea may be shared, but not identically

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Epistemology – Different Forms of Knowledge

- **'Codified Knowledge'**   (Empiricist / Positivist)
  Expressed
      In text, defined dialect, flowcharts, formulae, blueprints, ...
  Disembodied, but communicable among people
  Capable of delivering a coherent body of information to
  individuals in particular contexts

- **'Tacit Knowledge'**   (Innate or Reasoned)
  Exists in a particular person
  Informal and intangible
  Not readily communicated

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Axiological Aspects

- The study of **Value(s)**

  - A **'Virtue'** dimension of 'good / bad'
    (Loose even mystical criteria?)

  - A **'Deontic'** approach, related to duty / obligation
    on a 'mandated / optional / forbidden' dimension

  - A **'Utilitarian' or 'Consequentialism'** approach
    based on impacts or outcomes,
    which depends of clarity of purpose (Teleology)

- Positivism assumes a common denominator ('Utils'?)

- Antipositivism rejects that as fantasy

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Axiology in IS

- Dominance of a narrow interpretation, based on **Economic** and **Financial** factors – **'Shareholder Value'**

- **Social** and **Environmental** factors?
  Triple-bottom-line reporting / 'people, planet and profits'
  Corporate Social Responsibility (CSR)

- **Human** values?
  - Hedonism
  - Conservation/ism: Conformity, Tradition, Security
  - Openness to Change: Self-Direction, Stimulation
  - Self-Enhancement: Achievement, Power
  - Self-Transcendence: Benevolence, Universalism

- **Evident in**:   Multiview, Soft Systems Methodology, Participatory Systems Design, Value-Sensitive Design

Stakeholder Theory

- Postulated in 1963/83 as **a counterpoint to Shareholder**

- "Any party that can affect, or is affected by, the achievement of the organisation's objectives"

- **Participants** – But in IS often conflated with 'User'

- **Non-Participants / 'Usees'**

- Characteristics:
    - **P – O – W – E – R**
    - Legitimacy
   - Urgency

Researcher Perspective Theory

- **c. 90%** of papers on research of relevance to IS practice are **Single-Perspective, i.e. all other stakeholders' interests are constraints on the primary stakeholder**

- **c. 90% of those papers privilege the System Sponsor**

- Far less Single-Perspective other-than-System-Sponsor

- Little Dual-Perspective Research (cf. win-win!?)

- Very little Multi-Perspective Research (cf. win-win-win) (even in supply chain and network studies!?)

- **IS Researchers score a Fail on axiological insight**

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Clarke at Bled (2016)
Clarke & Davison, JAIS (2019)

A <u>Pragmatic</u> Axiological Model

- "An open attitude toward any kind of axiological foundation that might work"

- "Axiological diversity"

- "Disciplined axiological pluralism"

- Single-Perspective

  - System-Sponsor   90%

  - Other Stakeholder   5%

  - Dual-Perspective   3%
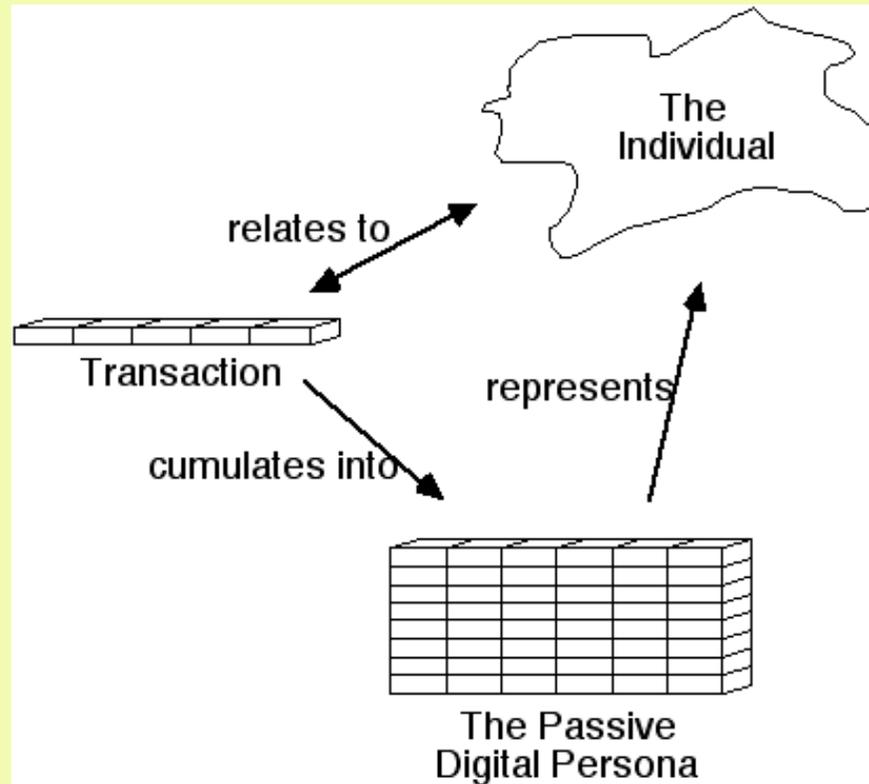
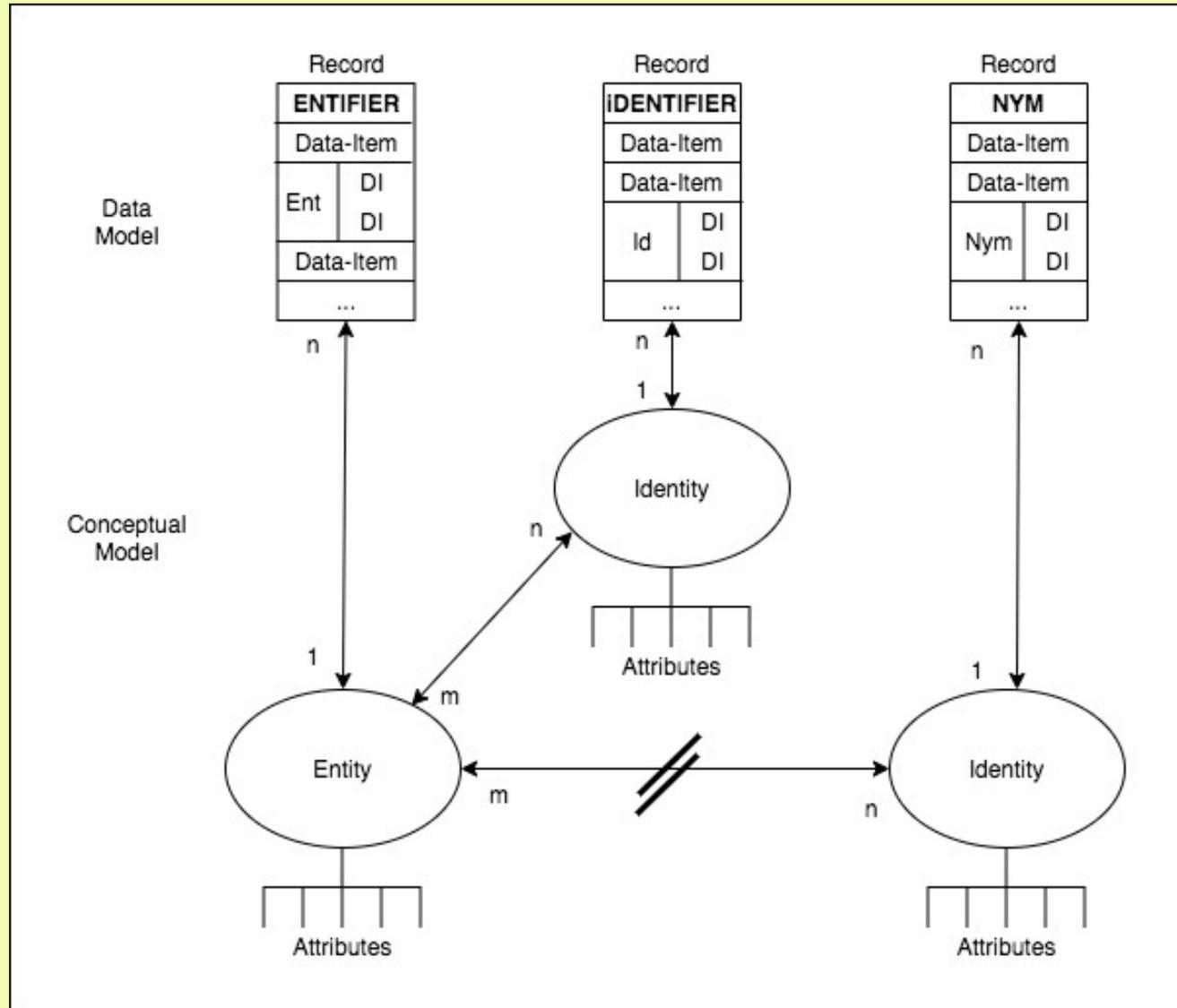 - Multi-Perspective   2%

Application to (Id)Entity Management
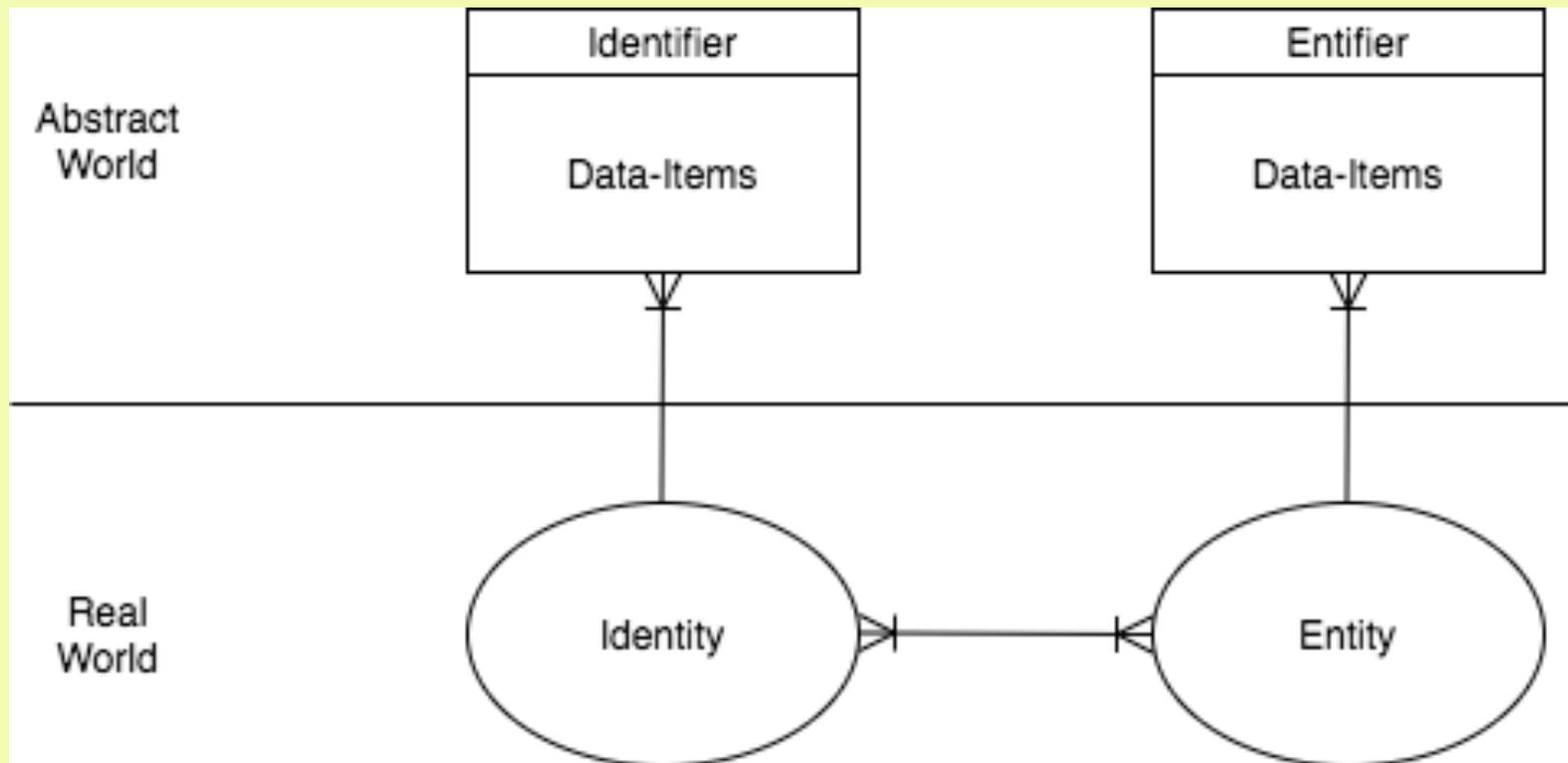
The Digital Persona

A model of the public personality of an (Id)Entity, based on Data, maintained by Transactions, for use as **a proxy for the (Id)Entity**

Clarke (1994, 2014)

The Digital Surveillance Economy (JIT, 2019)

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(Id)Entities, (Id)Entifiers and Nyms

Pseudonym, Anonym, Persistent Nym

- **Personal Data De-identification** purports to prevent association of Personal Data with the relevant human (Id)Entity (if any)

- **Personal Data Re-identification** purports to reliably associate Data with the relevant human (Id)Entity, <u>despite</u> prior attempts at de-identification

- **Personal Data Falsification** is a process whereby Personal Data is changed so as to render it valueless for any purpose relating to the administration of relationships between organisations and particular individuals

  It **converts Empirical Data**, that reflects an Attribute of a Real-World human (Id)Entity, **into Synthetic Data** that represents a plausible Phenomenon, but not a real one

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http://www.rogerclarke.com/DV/RFED.html (Bled 2019)

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Contemporary Weaknesses the Model Addresses

** **Conventional Id Management fails** because **it conflates**:
Identities-Entities, Identifiers-Entifiers, Identification-Entification

- Conventional IS models have **unreliable association** of data records with human (id)entities

- Conventional IS have **mediocre correspondence** between Data-Item-Values and human phenomena

- **Conventional IS feature naive reuse and merger of data** ignoring purpose-specific QA, definitional incompatibility

- **Conventional IS depend on inaccurate digital personae** Impersonation, composite ids, masquerade, spoofing, id fraud, ...

- Organisations overlook **human (id)entity values**, risking mis-matched designs, resistance, low ROI

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Authentication Process Quality Factors

- Effectiveness

- Implementation Ease

- Ease of Use

- User Attitude and Acceptance

Zviran & Erlich (2006)

- Accuracy

- Robustness

- User Acceptance

- Accessibility

- Feasibility

- Applicability

- Responsiveness

- Non-Reputability [sic: Non-Refutability]

- Maintainability

Way & Yuan (2009)

(6)   (Id)Entity Match Assertion

- *This Id-Record is appropriately associated with this other Id-Record*
  'The record containing this tax-file-identifier matches to the record containing this driver's licence number'

- *This Entity-Record is appropriately associated with this other Entity-Record*
  'This description of recovered stolen goods is of the same diamond necklace as this description of stolen goods'
  'This DNA sample is from the same person as is represented by this DNA sample data from a particular family history database'

- *This Id-Record is appropriately associated with this Entity-Record*
  'This process is running in this computing device'
  'The record for this client-number corresponds to this fingerprint-based record'

- *This Transaction-Record is appropriately associated with this (Id)Entity-Record*

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A particular (Id)Entity Record is appropriately associated with this other (Id)Entity Record

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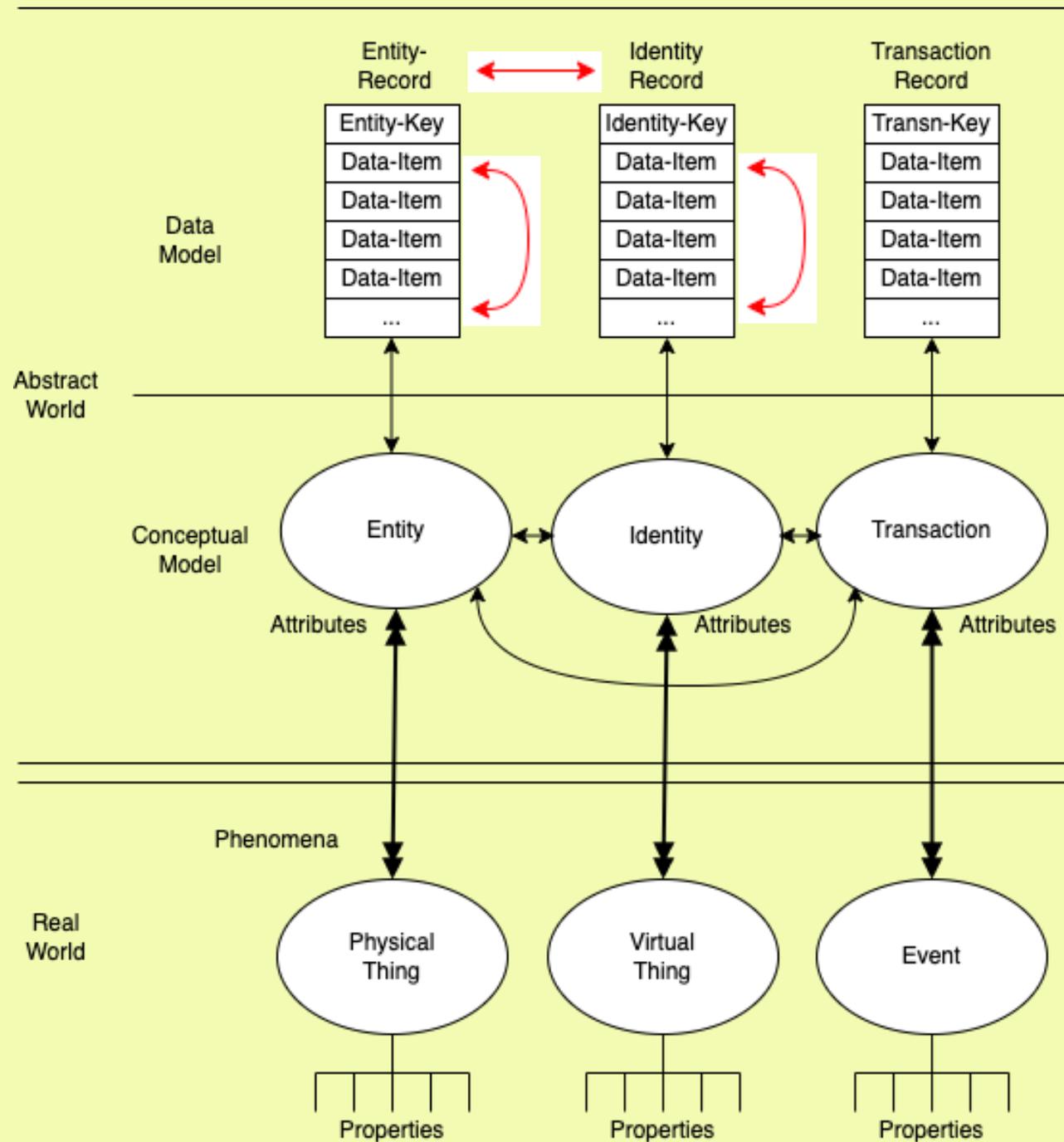
Evidence to Support the Authentication Process

Identity Assertion (1)

- Association is achieved by means of an Identifier

  ~~Rely on Proof of Identity (PoI)~~

  Rely on **Evidence of Identity (EoI)**:

  - 'What you **know**' (i.e. Data of some kind)
  - 'What you **have**' (Credential, Token containing one)

Entity Assertion (2)

- Each association is achieved by means of an Entifier
- Rely on **Evidence of Entity (EoE)**:

  - 'what you **are**' (i.e. Biometric, natural or implanted)

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Implications

1) **The Effectiveness of Identity Management**

   - Distinguish (Id)Entity / (Id)Entifier

   - Understand that Evidence is not 'Proof'

   - Use Evidence appropriate to Assertion-Category

2) **The Effectiveness of Other Business Processes**

   - Recognise the risks of reliance on the Digital Persona and the abandonment of 'high-touch' Authentication

3) **The Economics of IS Design**

   - Avoid Expensive (Id)Entity Authentication when Property, Location or Value Authentication may do

4) **Stakeholder Interests**

   - Recognise the intrusiveness and costs for other actors

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