International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

X.1081

Amendment 1

(10/2009)

SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

Information and network security – Telebiometrics

The telebiometric multimodal model – A framework for the specification of security and safety aspects of telebiometrics

Amendment 1: Object identifier assignments and hierarchy theory principles

Recommendation ITU-T X.1081 (2004) – Amendment 1

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Recommendation ITU-T X.1081

The telebiometric multimodal model – A framework for the specification of security and safety aspects of telebiometrics

Amendment 1

Object identifier assignments and hierarchy theory principles

Summary

Amendment 1 to Recommendation ITU-T X.1081 allocates eight arcs under the object identifier arc {joint-iso-itu-t(2) telebiometrics(42)} allocated for the work on telebiometrics, with top level OID-IRI value "/Telebiometrics". Under the arc allocated to Recommendation ITU-T X.1081, new arcs are allocated to measures (quantity, units, symbols), fields of study (physics, chemistry, biology, culturology, psychology) and modalities (tango, video, audio, chemo, radio, calor).

Source

Amendment 1 to Recommendation ITU-T X.1081 (2004) was approved on 29 October 2009 by ITU-T Study Group 17 (2009-2012) under Recommendation ITU-T A.8 procedures.

This text includes new Appendix V which was agreed on 25 September 2009 by ITU-T Study Group 17 (2009-2012).

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1) Clause 2

Insert new normative references at the end of clause 2 (before the NOTE) as follows:

[ITU-T X.660] Recommendation ITU-T X.660 (2008) | ISO/IEC 9834-1:2008, *Information technology – Open Systems Interconnection – Procedures for the operation of OSI Registration Authorities: General procedures and top arcs of the International Object Identifier tree*.

[ITU-T X.680.x] Recommendation ITU-T X.680.x series (2008) | ISO/IEC 8824.x:2008, *Information technology – Abstract Syntax Notation One (ASN.1)*.

2) New clause 12

Insert new clause 12 as follows:

12 Object identifier assignments

12.1 Under the procedures of [ITU-T X.660.x], the object identifier:

```
{joint-iso-itu-t(2) telebiometrics(42)}
```

has been allocated for the work on telebiometrics, with the top level oid-iri value `"/Telebiometrics"`.

12.2 Beneath the **"/Telebiometrics"** arc, allocations have been made as shown in Figure 2 below:

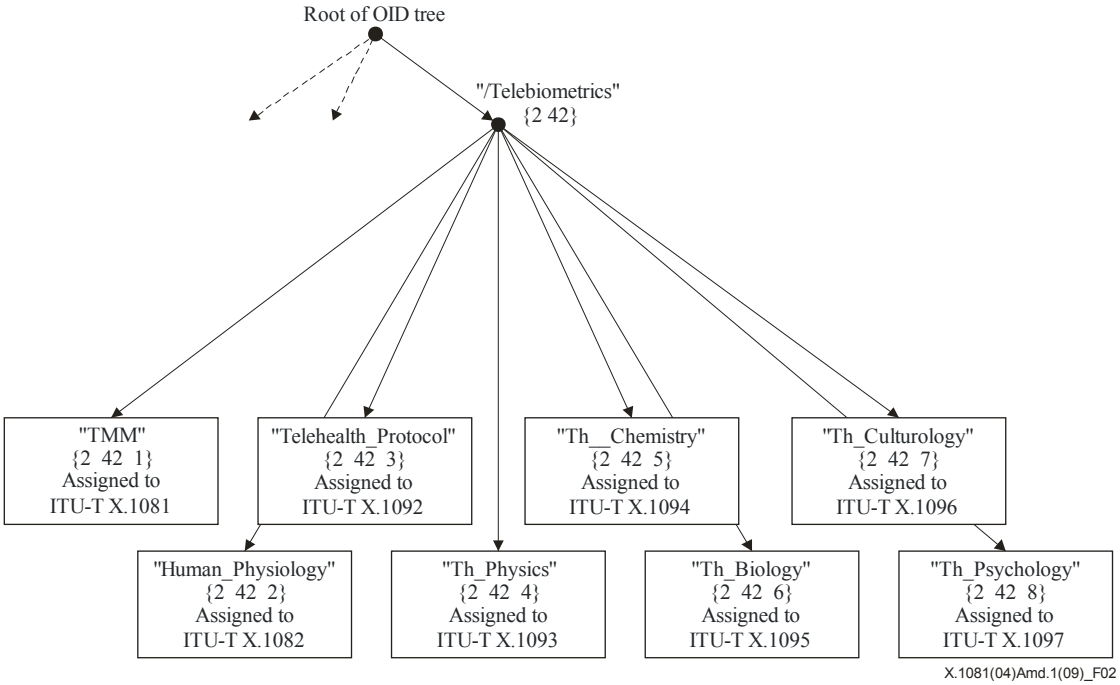

Figure 2 – Top-level arc allocations for telebiometrics

12.3 Annex A provides an ASN.1 module that defines object identifier values, and **OID-IRI** values (using **RELATIVE-OID-IRI** as appropriate) for the associated nodes.

12.4 The arc **{joint-iso-itu-t(2) telebiometrics(42) tmm(1) modules(0)}** is allocated for module definitions in this Recommendation. This, and its sub-arcs, are not shown in Figure 2.

12.5 Further allocations of arcs under the node allocated to ITU-T X.1081 are shown in Figure 3.

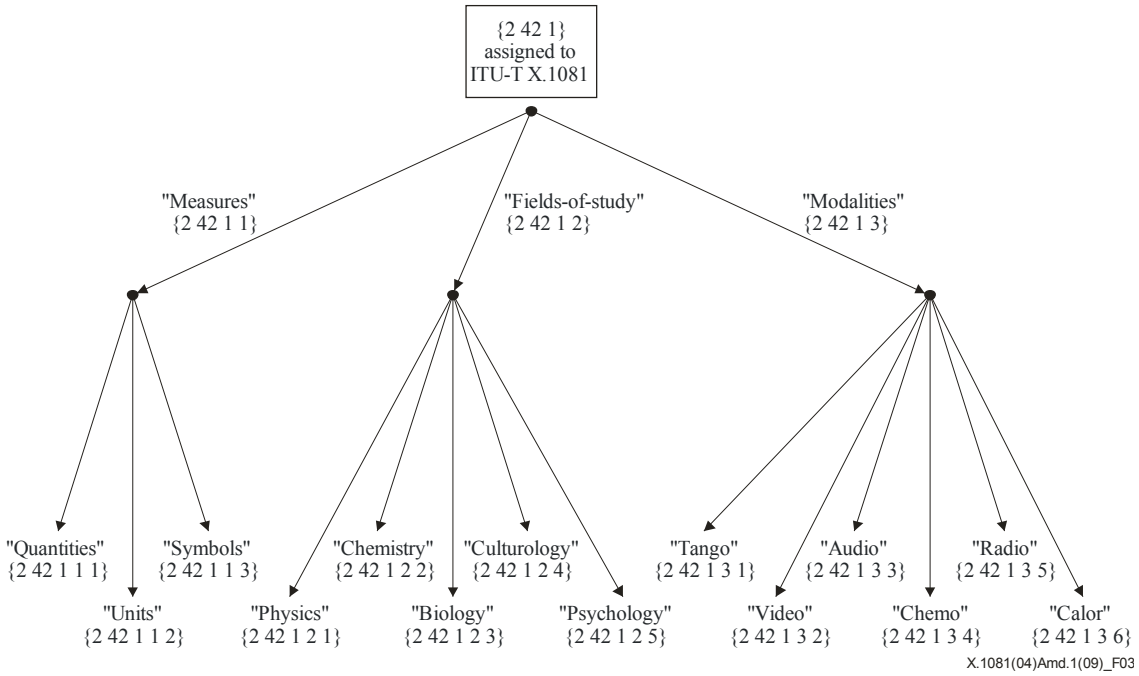

Figure 3 – Allocations made by ITU-T X.1081

12.6 The ASN.1 module in Annex A defines object identifier values and **`OID-IRI`** (or **`RELATIVE-OID-IRI`** values) for the nodes identified in Figure 2.

3) New Annex A

Insert a new Annex A before Appendix I as follows:

Annex A

Formal ASN.1 OID allocations

(This annex forms an integral part of this Recommendation)

A.1 General

This annex provides the formal allocation of top-level OID arcs beneath the "**/Telebiometrics**" arc, together with arcs beneath that for ITU-T X.1081 allocation.

A.2 ASN.1 module

NOTE – This module is normative text in ITU-T X.1081. Relevant parts are imported into modules in ITU-T X.1082 and into the ITU-T X.1092 series as necessary.

```
Telebiometrics
{joint-iso-itu-t(2) telebiometrics(42) tmm(1) modules(0) main(0) version(0)}
"/Telebiometrics/TMM/Modules/Main_Module/First_Version"
DEFINITIONS::=
BEGIN
-- *1* OBJECT IDENTIFIER names for top-level biometric nodes
            id-telebio OBJECT IDENTIFIER ::= {joint-iso-itu-t(2)
            telebiometrics(42)}
            id-tmm OBJECT IDENTIFIER ::= {id-telebio tmm(1)}
            id-hum-phys OBJECT IDENTIFIER ::= {id-telebio human-physiology(2)}
            id-th OBJECT IDENTIFIER ::= {id-telebio telehealth(3)}

-- *2* OID-IRI or RELATIVE-OID-IRI names for top-level telebiometric nodes
            -- Note that all RELATIVE-OID-IRI names are relative to the last OID-
            IRI value specified in this module
            iri-telebio OID-IRI ::= "/Telebiometrics"
            iri-tmm RELATIVE-OID-IRI ::= "TMM"
            iri-hum-phys RELATIVE-OID-IRI ::= "Human_Physiology"
            iri-th RELATIVE-OID-IRI ::= "Telehealth"

-- *3* OBJECT IDENTIFIER allocations specific to ITU-T X.1081
            id-measures OBJECT IDENTIFIER ::= {id-tmm metric(1)}
            id-fields-of-study OBJECT IDENTIFIER ::= {id-tmm scientific(2)}
            id-modalities OBJECT IDENTIFIER ::= {id-tmm sensory(3)}
-- *3.1* OIDs for measures
            id-quantities OBJECT IDENTIFIER ::= {id-measures quantities(1)}
            id-units OBJECT IDENTIFIER ::= {id-measures units(2)}
            id-symbols OBJECT IDENTIFIER ::= {id-measures symbols(3)}
-- *3.2* OIDs for fields of study
            id-physics OBJECT IDENTIFIER ::= {id-fields-of-study physics(1)}
            id-chemistry OBJECT IDENTIFIER ::= {id-fields-of-study chemistry(2)}
            id-biology OBJECT IDENTIFIER ::= {id-fields-of-study biology(3)}
            id-culturology OBJECT IDENTIFIER ::= {id-fields-of-study
            culturology(4)}
            id-psychology OBJECT IDENTIFIER ::= {id-fields-of-study
            psychology(5)}
-- *3.3* OIDs for modalities
            id-tango OBJECT IDENTIFIER ::= {id-modalities tango(1)}
```

```
            id-video OBJECT IDENTIFIER ::= {id-modalities video(2)}
            id-audio OBJECT IDENTIFIER ::= {id-modalities audio(3)}
            id-chemo OBJECT IDENTIFIER ::= {id-modalities chemo(4)}
            id-radio OBJECT IDENTIFIER ::= {id-modalities radio(5)}
            id-calor OBJECT IDENTIFIER ::= {id-modalities calor(6)}

-- *4* RELATIVE-OID-IRI allocations specific to ITU-T X.1081
--    These are all relative to iri-tmm
            iri-measures RELATIVE-OID-IRI ::= "Measures"
            iri-fields-of-study RELATIVE-OID-IRI ::= "Fields_of_study"
            iri-modalities RELATIVE-OID-IRI ::= "Modalities"
-- *4.1* OID-IRIs for Fields of Study
            iri-quantities RELATIVE-OID-IRI ::= "Measures/Quantities"
            iri-units RELATIVE-OID-IRI ::= "Measures/Units"
            iri-symbols RELATIVE-OID-IRI ::= "Measures/Symbols"

-- *4.2* OID-IRIs for Fields of Study
            iri-physics RELATIVE-OID-IRI ::= "Fields_of_Study/Physics"
            iri-chemistry RELATIVE-OID-IRI ::= "Fields_of_Study/Chemistry"
            iri-biology RELATIVE-OID-IRI ::= "Fields_of_Study/Biology"
            iri-culturology RELATIVE-OID-IRI ::= "Fields_of_Study/Culturology"
            iri-psychology RELATIVE-OID-IRI ::= "Fields_of_Study/Psychology"

-- *4.3* OID-IRIs for ModalitiesFields of Study
            iri-tango RELATIVE-OID-IRI ::= "Modalities/Tango"
            iri-video RELATIVE-OID-IRI ::= "Modalities/Video"
            iri-audio RELATIVE-OID-IRI ::= "Modalities/Audio"
            iri-chemo RELATIVE-OID-IRI ::= "Modalities/Chemo"
            iri-radio RELATIVE-OID-IRI ::= "Modalities/Radio"
            iri-calor RELATIVE-OID-IRI ::= "Modalities/Calor"
END
```

4) Introduction

Insert at the end of the Introduction the following paragraph:

Appendix V, "Hierarchy theory principles", summarizes the hierarchy theory and is supplemented by the extensive bibliography that references most of the major papers in this area.

5) New Appendix V

Insert a new Appendix V as follows:

Appendix V

Hierarchy theory principles

(This appendix does not form an integral part of this Recommendation)

In order to allow for further development and applications of this Recommendation, this theory is introduced for clarification purposes in this world of complexity, together with a useful bibliography.

V.1 Hierarchies have two known logical forms

V.1.1 The first logical form is the compositional hierarchy (including a synchronic map of the command hierarchy), which in applications is called the 'scale hierarchy'. The picture of macromolecules inside of a living cell inside of an organism is a familiar image of one important application. This form is suited to synchronic modelling of systems as they are at any given moment.

V.1.2 The second logical form is the subsumption hierarchy (including a diachronic model of the trajectory of a given command), which is called the 'specification hierarchy'. The Linnaean hierarchy in biological systematics has this form. This form is suitable to diachronic modelling of emergent forms.

V.1.3 The following table compares the logical properties.

The two columns show the two hierarchies.

Each line distinguishes the signifying elements of the two hierarchies:

Taxonomy	**Meronomy**
General/specific	Whole/part
is-a-kind-of	is-a-part-of
Subsumption	Composition
Inheritance	Containment
Specification	Modularity

V.2 General properties

Hierarchies are examples of 'partial ordering' in logic. That is, the items being ordered could be ordered in other ways as well. Hierarchies order entities, processes or realms into a system of levels. The ordering principle ('is-a-part-of' or 'is-a-kind-of') is transitive across levels. In both of these hierarchies, when used to model systems, higher levels control (regulate, interpret, harness) lower levels, whose behaviours are made possible by properties generated at still lower levels. So higher levels provide boundary conditions on the behaviours of lower levels; behaviours initiated by still lower level configurations (see below for the usage of 'higher' and 'lower'). It is important to realize that only some users of hierarchical forms would insist that particular levels exist in actuality. Levels are discerned from hierarchical analysis, aimed at constructing/discovering nature's 'joints'

with respect to given projects. Hierarchies thus provide models of systems that are susceptible to analysis into different levels.

V.2.1 To use the compositional hierarchy we need to stipulate a focal level, as well as a lower and a higher, making up a 'basic triadic system'; as, e.g., when the behaviour of living cells is initiated by chemical events, and controlled by organismic events. The three-level form ensures stability because with it in place (a third level always anchoring relations between the other two), the focal level cannot be reduced either upward or downward by assimilation into a contiguous level. Here it should be noted that this hierarchy has been invoked to explain how the world manages to be as stable as it is. The triadic form reflects the putative way in which levels would have evolved, by interpolation between primal highest and lowest ones, as when biology would have emerged as organizational forms between chemical activities in an environmental energy dissipative configuration.

V.2.2 In the subsumption hierarchy the highest relevant level is always the one in focus, with all the lower levels of the hierarchy providing cumulative initiating conditions simultaneously upon it. This reflects the fact that this hierarchy is implicitly developmental, with the levels being viewed as having emerged consecutively from the lowest or most general (or generally present), up – as with, e.g., biology emerging from chemistry, both historically and at any given moment. The two-level form is unstable, allowing new levels to emerge at the top of the hierarchy. Use of this form provides us with a model allowing for emergent changes in the world.

Hierarchical analysis is always driven by a given problem or project.

V.3 Formal relations between levels

V.3.1 The compositional hierarchy is one of parts nested within wholes, as, e.g., [... [species [population [organism [gene [...]]]]]], where [higher level [focal level [lower level]]]. The logic reflects Russell's logical types. In principle the levels just keep going, receding at both ends from the focal level. (It may be noted that this structure probably is rooted in our visual experiences.)

If the parts are functional in some given analysis, they are referred to as components, if not they are constituents. As one goes down the hierarchy, the relative number of constituents per level increases, giving a measure of the 'span' of the hierarchy.

V.3.2 The subsumption hierarchy is one of classes and subclasses, as e.g., {material world {biological world {social world}}}, where {lower level(s) {highest level}}. The focus of analysis is always the highest level, which is the innermost level of the hierarchy. The logic reflects Ryle's categories. Higher levels inherit all the properties of the lower levels.

V.3.3 A note on levels terminology: The levels in a subsumption hierarchy have been referred to as 'integrative levels' inasmuch as the higher levels integrate the lower levels' properties and dynamics under their own rules. 'Levels of reality' and 'ontological levels' have been used in subsumption as well. One sees other labels, such as 'levels of organization' or 'levels of observation' used for either kind of hierarchy. The term 'scalar levels' or 'levels of scale' are used for the application of the compositional hierarchy to material systems for dynamical reasons (see clause V.5 below, 'Criteria').

V.4 Style of growth of the hierarchy

V.4.1 A compositional hierarchy adds levels by interpolation between existing levels. In this way, the system must be an expanding one. Therefore, an assumption required for application of this hierarchy would be the Big Bang (or other expanding system). The actual process of formation of a level would involve the cohesion of entities out of lower level units guided by higher level boundary conditions. This process is little understood since this hierarchy has largely been used for synchronic analyses.

V.4.2 In the subsumption hierarchy, new levels would emerge from the current highest one. So this system too can grow – but not in space. Growth here is by the accumulation of informational constraints, modelled as a process of refinement by way of adding specification. New levels, marked by subclasses reflect thresholds of system structural reorganization.

V.5 Criteria

V.5.1 In application of the compositional hierarchy to actual natural systems, components at different levels must differ in size roughly by orders of magnitude. Otherwise components at different levels would interact dynamically, in which case there would not be different levels functionally.

V.5.2 Levels in a subsumption hierarchy mark the qualitative differences of different realms of being, as in 'physical realm' versus 'biological realm'. This hierarchy is open at the top; the innermost level is unbounded above, and so free to give rise to ever higher levels.

V.6 Complexity

V.6.1 A compositional hierarchy provides a model of 'extensional complexity', the sign of which is non-linear and chaotic dynamics, allowed by the fact that at any locale at any level in this hierarchy, there could be a mixture of different kinds of information (relations, variables, constants of different kinds, attractors) which are not governed by a single overall structure. It is useful here to contrast complexity with complication. A flat hierarchy with few levels could tend to show more complicated behaviour than a hierarchy with more levels, which would have more constraints imposed top-down.

V.6.2 A subsumption hierarchy embodies intentional complexity, which characterizes a system to the degree that it is susceptible to many different kinds of analyses.

V.7 Dynamical relations

V.7.1 A compositional hierarchy represents a single moment in space, so its dynamics represent homeostasis, not change. Large scale moments "contain" many small scale moments. It is often suggested that scalar levels fundamentally signal rate differences rather than component size differences. It may be noted that the two most often go together. The problem appears in cases that are said to be non-nested, where, e.g., a much slower rate in a component of a cycle would regulate the rate of the entire cycle. It would be rare, however, for such rates to differ by orders of magnitude, and so many of these examples are likely not hierarchical at all. If mere size differences rather than scale differences were allowed to be the criterion, then the constraint of nestedness would be lifted. In any case:

– Because of the order of magnitude differences between levels in the compositional hierarchy, dynamics at different levels do not directly interact or exchange energy, but transact by way of mutual constraint (i.e., via informational connections). The levels are screened off from each other dynamically. Because of this dynamical separation of levels, informational exchanges between levels are non-transitive, requiring interpretation at the boundaries between levels.

– So, if focal level dynamics are represented by variables in an equation, then the results of dynamics at contiguous levels would be represented by (non-recursive) constants. Larger scale dynamics are so slow with respect to those at the focal level, that the current value of their momentary result appears relatively unchanging at the focal level. Cumulated results of lower scale dynamics also appear relatively or statistically unchanging at the focal level, as it takes a very long time in lower scale moments to effect a change detectable at the focal

level – these points are the essence of dynamical 'screening off' in compositional hierarchy models.

– Note that, because of these relations, thermodynamic equilibria would be more rapidly achieved per unit volume at a lower scalar level, delivering an adiabatic principle relating to screening off. While change of any kind (development, acceleration, diffusion) is relatively more rapid at lower levels, absolute translational motion is more rapid at higher levels. Thus, higher levels provide modes of convection for the dissipation of energy gradients, which would otherwise proceed by slow conduction instead. Related to these matters, it should be noted that metabolic rates and development are absolutely much faster in smaller dissipative structures (organisms, fluid vortices, etc.), and their natural life spans are shorter than in larger scale ones.

– One sometimes sees the term 'heterarchy' posed in opposition to the scale hierarchy because of supposed failures of actual systems to conform to hierarchical constraints. One needs to recall here again that hierarchy is a conceptual construction, an analytical tool, and use of it does not imply that the world itself is actually hierarchically organized. It does seem to be so in many ways, but to suppose that this is the sole principle needed in understanding the world would be naive. It is one tool among many. But often this 'hetero' opposition to hierarchy is based merely on faulty understanding. For example, the tides are affected (partially controlled) by gravitational effects associated with the moon; yet the oceans are not nested inside the moon. As in classical thermodynamics, it is important to see the whole system correctly. The oceans are nested, along with the earth itself, within the solar system, and from the hierarchical point of view, these effects on the tides emanate from the solar system, not merely from the moon. Hierarchical constructs model events in the material world, defined as the realm of friction and lag in the affairs of chemical elements and their compositions.

V.7.2 Dynamics in a subsumption hierarchy are entrained by development, which is modelled as a process of refinement of a class, or increased specification of a category. It is important to note that this process is open-ended in the sense that there could be many coordinate subclasses of a given class. That is, the potentials arising within any class form a tree. So, in {physical realm {material realm {biological realm}}}, or {mammal {primate {human}}} each hierarchy follows just one branch of a tree. Rylean categories can branch into new distinctions (and this forms a link with the scalar hierarchy because this would give rise as well to new logical types). Evolution (unpredictable change) is one many, and thus we have been able to picture organic evolution using the Linnaean hierarchy.

The fact that functionally this is a two-level hierarchy makes it susceptible to change, because, without the anchoring provided by a third level, it could be reduced to a single level. How is its direction into new subclasses ensured (giving rise to the hierarchy)? In models of the material world this is afforded by the fact that information, once in place (or once having had an effect), marks a system irrevocably. Marks in material systems are permanent. If a system continues to exist, it must march forward if it changes; there can be no reversal of evolution. Since change in the material world is entrained by the second law of thermodynamics, we have here a link between the two hierarchy models because the second law can be seen to be a result of universal expansion being too fast to allow the global equilibration of matter. As noted above, this expansion is also what affords the interpolation of new levels in a compositional hierarchy.

So, development of a subsumptive hierarchy model requires a two-level basic form. Yet these hierarchies involve more than just two levels. Why do not the more general levels prevent change, as by the weight of their accumulated information? Here we are led to note another aspect of development, which is perfectly general. The amount of change required to launch a new level is ever smaller as a hierarchy develops – refinements are just that. The more general levels do continue to exert their influence; e.g., biology is a kind of chemistry, and humans are a kind of

mammal. The key to understanding this situation is that in the subsumption hierarchy informational relations between levels are transitive. Thus, physical dynamics are fully active players in a biological system. This means that development in this hierarchical model using only two contiguous levels can be fully understood. New levels may branch off anywhere in the hierarchy, potentially giving rise to collections of coordinate subclasses.

V.8 Informational relations and semiotics

V.8.1 As noted above, informational relations between levels in a compositional hierarchy are non-transitive. The levels are screened off from each other dynamically, and influence each other only indirectly, via transformed informational constraints. Signals moving from one level to another are transformed at boundaries between the levels. When this is not the case, as when a signal from a higher level occasionally transits to a much lower level, that level suffers damage (as when an organism is hit by lightning, or, going the other way, if a given cell affects the whole organism, this could only be if its effect is promoted by the likes of cancer). Here, we can note again the idea that levels different in scale dynamics deliver stability to a system, via the screening-off effect.

The interpolation of a new level between two others can be viewed as involving the appearance of a capability at the uppermost level (via fluctuation, self-organization and/or selection) for making a significant (to it) interpretation of events at what then becomes the lowermost level of the three. The upper level effectively disposes – facilitates cohesion among – some of what the lower level proposes. This requires energetic screening off between levels. As the arena of the upper level's interpretants, the new level acts as a filter or buffer between upper and lower. This allows to see levels succeeding each other by a classification procedure whereby topological difference information is converted to (or coheres as) typological distinction information in an essentially top-down procedure.

V.8.2 In a subsumption hierarchy the lower levels also make possible the emergence of a new realm, in an epigenetic process. And here too the process is top-down, but in a different sense, involving finality. Thus, e.g., it can be seen that organism sociality implies biology in the sense of material implication or conceptual subordination. Then, as organism sociality implies biology, biology implies chemistry, and so, because this is a process of refinement, only a very narrow set of possibilities could imply organism sociality. That is, chemistry could give rise to many kinds of supersystems, biology to fewer, and sociality to even fewer as the epigenetic system develops. Developments (in distinction from evolution) are always entrained by final causes, and approach them asymptotically with each emergence of a new realm. Involved here, as in all developments, is the process of senescence, a condition of information overload (recall that information in this hierarchy is transitive across levels), leading to overconnectivity, leading in turn to functional underconnectivity, leading in its turn to inflexibility and habit driven responses (loss of requisite variety), leading ultimately to loss of adaptability (inability to produce interpretants of novel situations).

The following sources emphasize the historically important, logically basic, and recent references that seem to bring in new departures.

Bibliography

NOTE – Started (*) references deal with the subsumption hierarchy, either exclusively or along with the compositional hierarchy.

[b-Ahl] Ahl, V., and Allen, T.F.H. (1996), *Hierarchy Theory: A Vision, Vocabulary, and Epistemology,* Columbia University Press.

[b-Allen] Allen, T.F.H., and Starr, T.B. (1982), *Hierarchy: Perspectives For Ecological Complexity,* University of Chicago Press.

[b-Aronson] * Aronson, L.R. (1984), *Levels of integration and organization: a reevaluation of the evolutionary scale*, In G. Greenberg and E. Tobach, (eds.), Behavioral Evolution and Integrative Levels, Erlbaum.

[b-Auger] Auger, P. (1989), *Dynamics and Thermodynamics in Hierarchically Organized Systems,* Pergamon Press.

[b-Auletta] Auletta, G., Ellis, G.F.R., and Jaeger, L. (2008), *Top-down causation by information control: from a philosophical problem to a scientific research programme*, Journal of the Royal Society Interface, doi:10.1098/rsif/2008.0018.

[b-Barkley] Barkley Rosser, J. Jr., Folke, C., Günther, F., Isomaki, H., Perrings, C., and Puu, T. (1994), *Discontinuous change in multilevel hierarchical systems*, Systems Research, 11: 77-94.

[b-Bertalanffy] Bertalanffy, L. von (1968), *General System Theory: Foundations, Development, Applications.* George Braziller, (see especially the Introduction).

[b-Blitz] * Blitz, D. (1992), *Emergent Evolution,* Springer.

[b-Bonabeau] Bonabeau, E., Dorigo, M., and Theraulaz, G. (1999), *Swarm Intelligence: From Natural to Artificial Systems,* Oxford University Press.

[b-Campbell] Campbell, D.T. (1974), *"Downward causation" in hierarchically organized biological systems*, In F.J. Ayala and T. Dobzhansky (eds.), Studies in the Philosophy of Biology*,* University of California Press.

[b-Collier] Collier, J. (1989), *Supervenience and reduction in biological hierarchies*, Canadian Journal of Philosophy, 14: 209-234.

[b-Conrad] Conrad, M. (1983), *Adaptability: The Significance of Variability from Molecule to Ecosystem,* Plenum Press.

[b-Feibleman] * Feibleman, J.K. (1954), *Theory of integrative levels*, British Journal for the Philosophy of Science, 5: 59-66.

[b-Floridi] Floridi, L. (2008), *The method of levels of abstraction*, Minds and Machines, 18: 303-329.

[b-Jolley] * Jolley, J.L. (1973), *The Fabric of Knowledge: A Study of the Relations Between Ideas,* Barnes and Noble.

[b-Jamshidi] Jamshidi, N., and Palsson, B.Ø. (2008), *Top-down analysis of temporal hierarchy in biochemical reaction networks*, PLoS Computational Biology, 4:e1000177.doi:10-1371/journal.pcbi.1000177/.

[b-Kolasa] Kolasa, J., and Pickett, S.T.A. (1989), *Ecological systems and the concept of biological organization*, Proceedings of the National Academy of Sciences, 86: 8837-8841.

[b-Lemke] Lemke, J.L. (2000), *Opening up closure: semiotics across scales*, In J.L.R. Chandler and G. Van de Vijver (eds.), Closure: Emergent Organizations and Their Dynamics. Annals of the New York Academy of Sciences, 901: 100-111.

[b-Mahner] Mahner, M., and Bunge, M. (1997), *Foundations of Biophilosophy,* Springer-Verlag, pp. 177-180.

[b-Mandelbrot] Mandelbrot, B. (1983), *The Practical Geometry of Nature,* W.H. Freeman & Co.

[b-Maurer] Maurer, B.A. (1999), *Untangling Ecological Complexity: The Macroscopic Perspective,* University of Chicago Press.

[b-Mesarovic] Mesarovic, M.D., Macko, D., and Takahara, Y. (1970), *Theory of Hierarchical, Multilevel, Systems,* Academic Press.

[b-Morrison] Morrison, P., and Morrison, P. (1982), *Powers of Ten,* Scientific American Books.

[b-Nicolis] Nicolis, J.S. (1986), *Dynamics of Hierarchical Systems: An Evolutionary Approach,* Springer.

[b-Odum] Odum, H.T., and Odum, E.C. (2000), *Modeling For All Scales: An Introduction to System Simulation,* Academic Press.

[b-Paine] Paine, R.W., and Tani, J. (2005), *How hierarchical control self-organizes in artificial adaptive systems*, Adaptive Behavior, 13: 211-225.

[b-Pattee] Pattee, H.H. (1973), *The physical basis and origin of hierarchical control*, In H.H. Pattee (ed.), Hierarchy Theory: The Challenge of Complex Systems, George Braziller.

[b-Petterson] Petterson, M. (1996), *Complexity and Evolution,* Cambridge University Press.

[b-Polanyi] * Polanyi, M. (1968), *Life's irreducible structure*, Science, 160: 1308-1312.

[b-Poli] * Poli, R. (2006), *The theory of levels of reality and the difference between simple and tangled hierarchies*, In G. Minati, E. Pessa, and M. Abrams (eds.), Systemics of Emergence: Research and Development, Springer.

[b-Queiroz] Queiroz, J., and El-Hani, C.H. (2001), *Towards a multi-level approach to the emergence of meaning process in living systems*, Acta Biotheoretica, 54: 179-206.

[b-Ratze] Ratze, C., Gillet, F., Müller, J.-P., and Stoffel, K. (2007), *Simulation modelling of ecological hierarchies in constructual dynamical systems*, Ecological Complexity, 4: 13-25.

[b-Sabelli] * Sabelli, H.C., and Carlson-Sabelli, L. (1989), *Biological priority and psychological supremacy: a new integrative program derived from process theory*, American Journal of Psychiatry, 146: 1541-1551.

[b-Salthe1] * Salthe, S.N. (1985), *Evolving Hierarchical Systems: Their Structure and Representation,* Columbia University Press.

[b-Salthe2] * Salthe, S.N. (1988), *Notes toward a formal history of the levels concept*, In. G. Greenberg and E. Tobach (eds.), Evolution of Social Behavior and Integrative Levels, Erlbaum.

[b-Salthe3] * Salthe, S.N. (1991), *Two forms of hierarchy theory in Western discourses*, International Journal of General Systems, 18: 251-264.

[b-Salthe4] * Salthe, S.N. (1993), *Development and Evolution: Complexity and Change in Biology,* MIT Press.

[b-Salthe5] Salthe, S.N. (2002), *Summary of the principles of hierarchy theory*, General Systems Bulletin, 31: 13-17.

[b-Salthe6] Salthe, S.N. (2006), *Two frameworks for complexity generation in biological systems*, In C. Gershenson and T. Lenaerts (eds.), Evolution of Complexity. ALifeX Proceedings, Bloomington, IN: Indiana University Press. http://ecco.vub.be/EDO/Salthe.pdf.

[b-Salthe7] Salthe, S.N. (2009), *Hierarchy Theory Principles*, Contribution for ITU-T/SG 17, inserted as Appendix V of Recommendation ITU-T X.1081.

[b-Simon] Simon, H.A. (1962), *The architecture of complexity*, Proceedings of the American Philosophical Society, 106: 467-482.

[b-Sommers] * Sommers, F. (1963), *Types and ontology*, Philosophical Review, 72: 327-363.

[b-Soodak] Soodak, H., and Iberall, A. (1978), *Homeokinetics: a physical science for complex systems*, Science, 201: 579-582.

[b-Weiss] Weiss, P.A. (1971), *The basic concept of hierarchic systems*, In P.A. Weiss (ed.), Hierarchically Organized Systems in Theory and Practice, Hafner.

[b-Woodger] Woodger, J.H. (1929), *Biological Principles: A Critical Study,* Harcourt.

[b-Zhirmunsky] Zhirmunsky, A.V., and Kuzmin, V.I. (1988), *Critical Levels in the Development of Natural Systems,* Springer-Verlag.

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