Contents

Part I. Knowledge Representation with MultiNet

1. Introduction 1

2. Historical Roots 13

3. Basic Concepts 17
3.1 General Remarks 17
3.2 Classificatory Knowledge 22
3.2.1 Sorts and Features 22
3.2.2 Multidimensional Layer Attributes 24
3.2.3 Immanent vs. Situational Components of Meaning ... 28
3.2.4 Classification of Questions 36
3.3 Structural Means of Representation 38
3.3.1 Relations and Functions 38
3.3.2 Inferential Relationships – Axiomatic Rules 40

4. Semantic Characterization of Objects 45
4.1 The Hierarchical Order of Objects 45
4.2 Material Characterization of Objects 52
4.3 Qualitative Characterization of Objects 57
4.3.1 General Remarks 57
4.3.2 Assignment of Properties to Objects 58
4.3.3 Attribute-Value Characterizations 64
4.3.3.1 Instances, Attributes, and Values 65
4.3.3.2 Generic Concepts and Their Attributes 67
4.4 Possession, Attachment, and Association 73
4.4.1 Possession 73
4.4.2 Assignment of Objects to Objects (Attachment) 75
4.4.3 Association 80

4.5 Different Manifestations of Objects 82

5. Semantic Characterization of Situations 85
5.1 The General Structure of Situations 85
5.2 Events [Dynamic Situations] 90
5.2.1 Participants and C-Roles [Valency Frames] 90
5.2.2 Conceptual Subordination of Situations 96
5.2.3 Circumstances 103
5.3 States [Static Situations] 104

6. The Comparison of Entities 113
6.1 Typical Relations of Comparison 113
6.2 The Semantic Treatment of Comparison 119
6.2.1 The Absolute or Positive 119
6.2.2 The Comparative 121
6.2.3 The Superlative 127

7. The Spatio-temporal Characterization of Entities 131
7.1 General Remarks on Space and Time 131
7.2 Local Relations 133
7.3 Temporal Relations 145
7.4 Situations and Times 154

8. Modality and Negation 163
8.1 The Modal Characterization of Situations 163
8.2 Negation 165
8.3 Modalities in a Narrower Sense 188

9. Quantification and Pluralities 197

10. The Role of Layer Information in Semantic Representations 219
10.1 General Remarks 219
10.2 Degree of Generalization: GENER 220
10.3 Facticity: FACT 221
10.4 Determination of Reference: REFER 223
10.5 Variability: VARIA 225

11. Relations Between Situations 233
11.1 Semantic Interpretation of Conjunctions 233
11.1.1 General Remarks 233
11.1.2 Subordinating Conjunctions (Subordinators) 234

11.1.3 Coordinative Conjunctions (Coordinators) 238
11.2 Conditions and Reasons 247
11.2.1 Language Phenomena and Representational Means ... 247
11.2.2 Causality 256
11.2.3 Conditional Relations 263
11.3 Counterfactuals 270
11.4 Contextual Restrictions and Situational Embedding 274
11.5 The Rhetorical Structure Theory (RST) 277

12. Lexicon and Knowledge Representation 279
12.1 Linguistic Knowledge and World Knowledge 279
12.2 The Semantic Component of the Lexicon 282

13. Question Answering and Inferences 305
13.1 Logical Principles 305
13.2 Classes of Questions and Inferential Answer Finding 317
13.3 Associatively Guided Question Answering 324

14. Software Tools for the Knowledge Engineer / Sample Applications 331
14.1 Knowledge Management as an Engineering Task 331
14.2 MWR – the Workbench for the Knowledge Engineer 332
14.3 NatLink – A Semantic Interpreter for MultiNet 337
14.4 LIA – the Workbench for the Computer Lexicographer 345
14.5 VILAB – The Virtual Laboratory 353

15. Comparison Between MultiNet and Other Semantic Formalisms 357
15.1 Introductory Remarks 357
15.2 MultiNet and Other Network Representations 358
15.2.1 Structured Inheritance Networks 358
15.2.2 The Semantic Network Processing System (SNePS) .. 364
15.2.3 Sowa's Conceptual Structures (SCS) 367
15.2.4 Scripts and the Conceptual Dependency Theory 371
15.3 MultiNet and Logic-Oriented Semantic Formalisms 374
15.3.1 General Remarks 374
15.3.2 The Discourse Representation Theory 376
15.3.3 Description Logics 378
15.3.4 The Generalized Quantifier Theory 381
15.4 Comparison Between MultiNet and Frame Representations ... 384
15.4.1 General Remarks 384
15.4.2 The Knowledge Representation Language KRL 384

15.4.3 The Knowledge Base Project CYC 387

Part II. The Representational Means of MultiNet

16. Overview and Representational Principles 395
16.1 MultiNet Within the Context of Knowledge Processing 395
16.2 The Paradigm of Multilayered Extended Semantic Networks . 398
16.3 Conventions of Description 400

17. Means for Expressing Classification and Stratification 409
17.1 Sorts and Features 409
17.2 Layers 417
17.2.1 General Remarks on the Typology of Layer Attributes 417
17.2.2 Degree of Generality (Attribute **GENER**) 418
17.2.3 Determination of Reference (Attribute **REFER**) 421
17.2.4 Variability (Attribute **VARIA**) 423
17.2.5 Facticity (Attribute **FACT**) 425
17.2.6 Quantification (**QUANT**) vs. Cardinality (**CARD**) ... 427
17.2.7 Type of Extensionality (Attribute **ETYPE**) 429
17.2.8 The Classification of Nominal Concepts 430
17.3 Encapsulation of Concepts 433

18. Relations and Functions 439
18.1 Overview 439
18.2 Relations 446
18.2.1 AFF: C-Role – Affected Object 446
18.2.2 AGT: C-Role – Agent 447
18.2.3 ANLG2/3: Similarity Between Entities 449
18.2.4 ANTE: Relation of Temporal Succession 450
18.2.5 ANTO: Antonymy Relation 451
18.2.6 ARG1/2/3: Argument Specification at the Metalevel .. 452
18.2.7 ASSOC: Association 454
18.2.8 ATTCH: Attachment of Objects 455
18.2.9 ATTR: Assignment of Attributes to Objects 456
18.2.10 AVRT: C-Role – Averting from an Object 457
18.2.11 BENF: C-Role – Beneficiary 459
18.2.12 CAUS: Causality, Relation Between Cause and Effect 460
18.2.13 CHEA: Sortal Change: Event – Abstract Concept 462
18.2.14 CHPA: Sortal Change: Property – Abstract Concept .. 463

18.2.15 CHPE: Sortal Change: Property – Event 465
18.2.16 CHPS: Sortal Change: Property – State 466
18.2.17 CHSA: Sortal Change: State – Abstract State 467
18.2.18 CHSP1/2/3: Sortal Change Between Situational Concepts and Properties 468
18.2.19 CIRC: Relation Between a Situation and a Concomitant Situation 472
18.2.20 CNVRS: Lexical Relation Between Converse Concepts 473
18.2.21 COMPL: Complementarity 474
18.2.22 CONC: Relation Expressing a Concession 475
18.2.23 COND: Conditional Relation 476
18.2.24 CONF: Relation Expressing the Conformity with an Abstract Frame 478
18.2.25 CONTR: Relation of Contrast 479
18.2.26 CORR: Qualitative or Quantitative Correspondence .. 480
18.2.27 CSTR: C-Role – Causator 481
18.2.28 CTXT: Relation Specifying a Restricting Context 482
18.2.29 DIRCL: Local Destination or Direction 484
18.2.30 DISTG/2/3: Relations Specifying a Difference 485
18.2.31 DPND: Dependency Relation 486
18.2.32 DUR: Relation Specifying a Temporal Extension 488
18.2.33 ELMT: Element Relation 489
18.2.34 EQU: Equivalence Relation 491
18.2.35 EXP: C-Role – Experiencer of an Event 492
18.2.36 EXT: Relation Between Intension and Extension 494
18.2.37 FIN: Temporal End 495
18.2.38 GOAL: Generalized Goal 496
18.2.39 HSIT: Constituents of a Hypersituation 497
18.2.40 IMPL: Implication Relation Between Situations 498
18.2.41 INIT: Initial Situation or Entity 500
18.2.42 INSTR: C-Role – Instrument 501
18.2.43 JUST: Justification of a Situation 502
18.2.44 LEXT: Relation Specifying a Local Extent 503
18.2.45 LOC: Location of a Situation 504
18.2.46 MAJ/MAJE: 'Greater than (or Equal to)'-Relation ... 505
18.2.47 MANNR: Relation Specifying the Manner 506
18.2.48 MCONT: C-Role – Relation Between a Mental Process and Its Content 507
18.2.49 MERO: Meronymy Relation 508

18.2.50 METH: C-Role – Method 509
18.2.51 MEXP: C-Role – Mental Experiencer 510
18.2.52 MIN/MINE: 'Smaller than (or Equal to)'-Relation ... 512
18.2.53 MODE: Generalized Mode of a Situation 512
18.2.54 MODL: Relation Specifying the Modality of a Situation 514
18.2.55 NAME: Assignment of a Name to an Object 515
18.2.56 OBJ: C-Role – Neutral Object as Participant 517
18.2.57 OPPOS: C-Role – Relation Specifying an Opposition . 519
18.2.58 ORIG: Mental or Informational Origin 520
18.2.59 ORIGL: Relation Specifying the Local Origin 521
18.2.60 ORIGM: Relation Specifying the Material Origin 522
18.2.61 ORNT: C-Role – Orientation to an Object 524
18.2.62 PARS: Relation Between Part and Whole 525
18.2.63 POSS: Relation of Possession 527
18.2.64 PRED/PREDR/PREDS: Predicative Concept Governing a Plurality 528
18.2.65 PROP: Relation Between Object and Property 530
18.2.66 PROPR: Relation Between a Plurality and a Semantically Relational Property 531
18.2.67 PURP: Relation Specifying a Purpose 532
18.2.68 QMOD: Quantitative Modification 533
18.2.69 REAS: General Reason for a Situation 534
18.2.70 RPRS: Representational Form or Manifestation of an Object 535
18.2.71 RSLT: C-Role – Result 537
18.2.72 SCAR: C-Role – Carrier of a State (Passive) 538
18.2.73 SETOF: Relation Between the Extensional of a Plurality and the Governing Predicative Concept 539
18.2.74 SITU: Situational Embedding or Abstract Location ... 541
18.2.75 SOURC: Generalized Source or Origin 542
18.2.76 SSPE: C-Role – Entity Specifying a State 543
18.2.77 STRT: Relation Specifying the Temporal Beginning .. 544
18.2.78 SUB: Subordination of Concepts Representing Objects 546
18.2.79 SUB0: Generalized Subordination Relation 547
18.2.80 SUBM/SUBME: Subsumption of Sets (Set Inclusion) 548
18.2.81 SUBR: Metarelation for the Description of Relations . 549
18.2.82 SUBS: Subordination of Situations 551
18.2.83 SUBST: Relation Specifying a Substitute for an Entity 553
18.2.84 SUPPL: Supplement Relation 555

18.2.85 SYNO: Synonymy Relation 556
18.2.86 TEMP: Relation Specifying a Temporal Frame 557
18.2.87 VAL: Relation Between Attribute and Value 558
18.2.88 VALR: Relation Between Attributes and Their Value Restriction 561
18.2.89 VIA: Relation Specifying a Spatial Path 562
18.3 Functions 565
18.3.1 *ALTN1/2: Construction of Alternative Pluralities ... 565
18.3.2 *COMP: Function for the Comparison of Properties .. 566
18.3.3 *DIFF: Set Difference 568
18.3.4 *FLP$_J$: Functions Generating Locations 570
18.3.5 *INTSC: Intersection of Sets 572
18.3.6 *ITMS/*ITMS-I: Function for Enumerating Sets and Its Counterpart at the Intensional Level 573
18.3.7 *MODP: Function for the Modification of Properties . 575
18.3.8 *MODQ: Function for the Modification of Quantities . 577
18.3.9 *MODS: Modification of a Situational Concept 577
18.3.10 *NON: Family of Functions Specifying Negation 579
18.3.11 *OP$_J$: Arithmetic Operations 581
18.3.12 *ORD: Function Defining Ordinal Numbers 582
18.3.13 *PMOD: Modification of Objects by Associative Properties 583
18.3.14 *QUANT: Function Generating Quantities 585
18.3.15 *SUPL: Function Characterizing the Superlative 585
18.3.16 *TUPL: Function Generating Tuples 587
18.3.17 *UNION: Union of Sets 588
18.3.18 *VEL1/2: Disjunctive Composition of Situations 590

A. Table of Abbreviations 593

B. Overview of the Representational Means 595

C. Semantic Templates for the Meaning of Relations 601

D. Characterization of Arcs with Regard to Their Knowledge Type 605

E. Classes of Typical Axioms 609
E.1 R-Axioms (Categorical Knowledge) 609
E.2 R-Axioms (Default Knowledge) 610
E.3 R-Axioms (Definitions of Relations) 611

E.4 Axioms Concerning the Preextensional Level 612
E.5 B-Axioms (Categorical Knowledge) 612
E.6 R-Axioms and B-Axioms (Spatio-temporal Relations) 614
E.7 Axiom Schemata (B-Axioms) 615
E.8 Axiom Schemata (R-Axioms) 616

Bibliography 617
List of Figures 629
Index 637