FODA: Twenty Years of Perspective on Feature Models

Kyo Chul Kang

SPLC 2009
August 24-28, 2009
San Francisco, CA, USA

Pohang University of Science and Technology (POSTECH)

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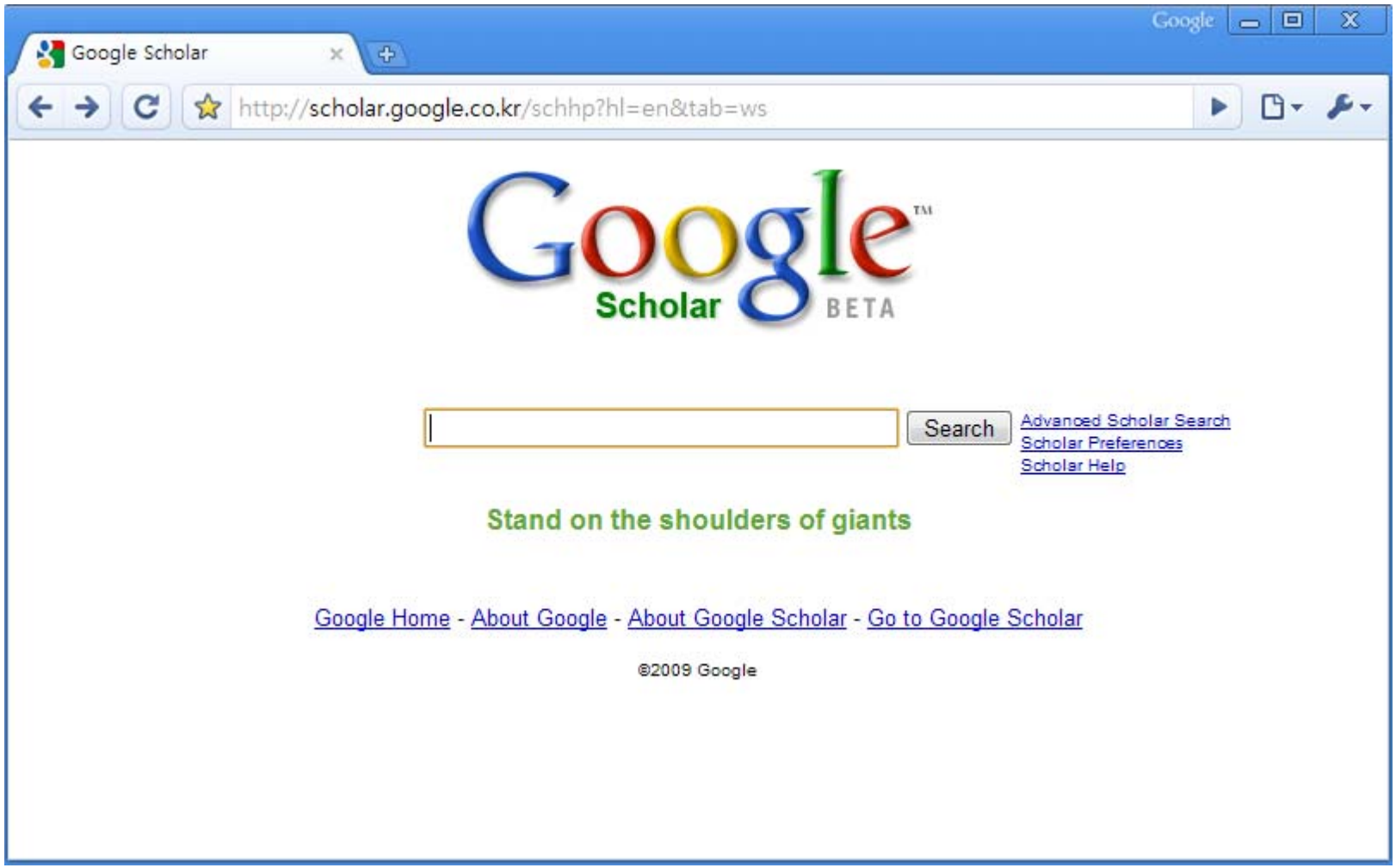
Prologue



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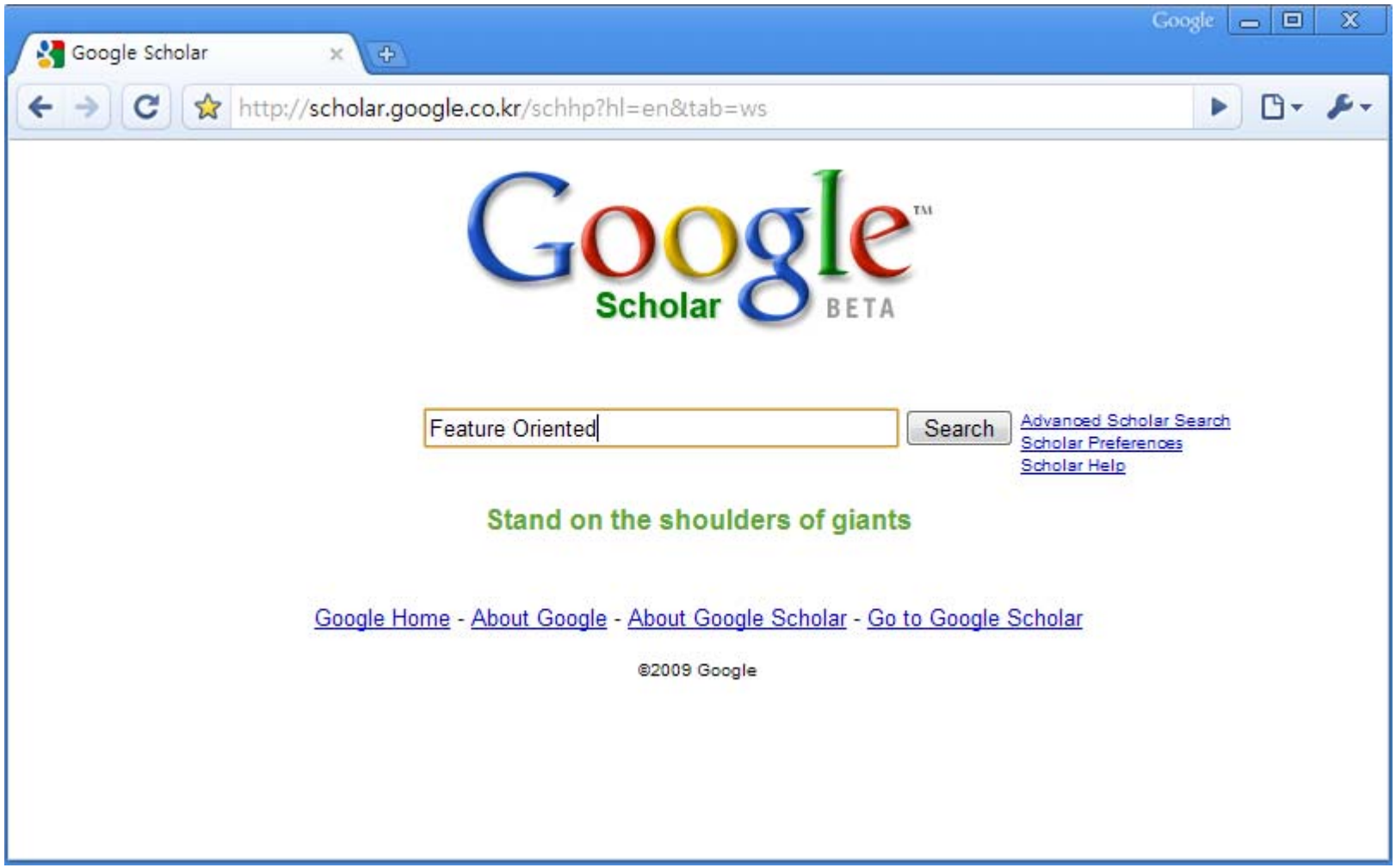

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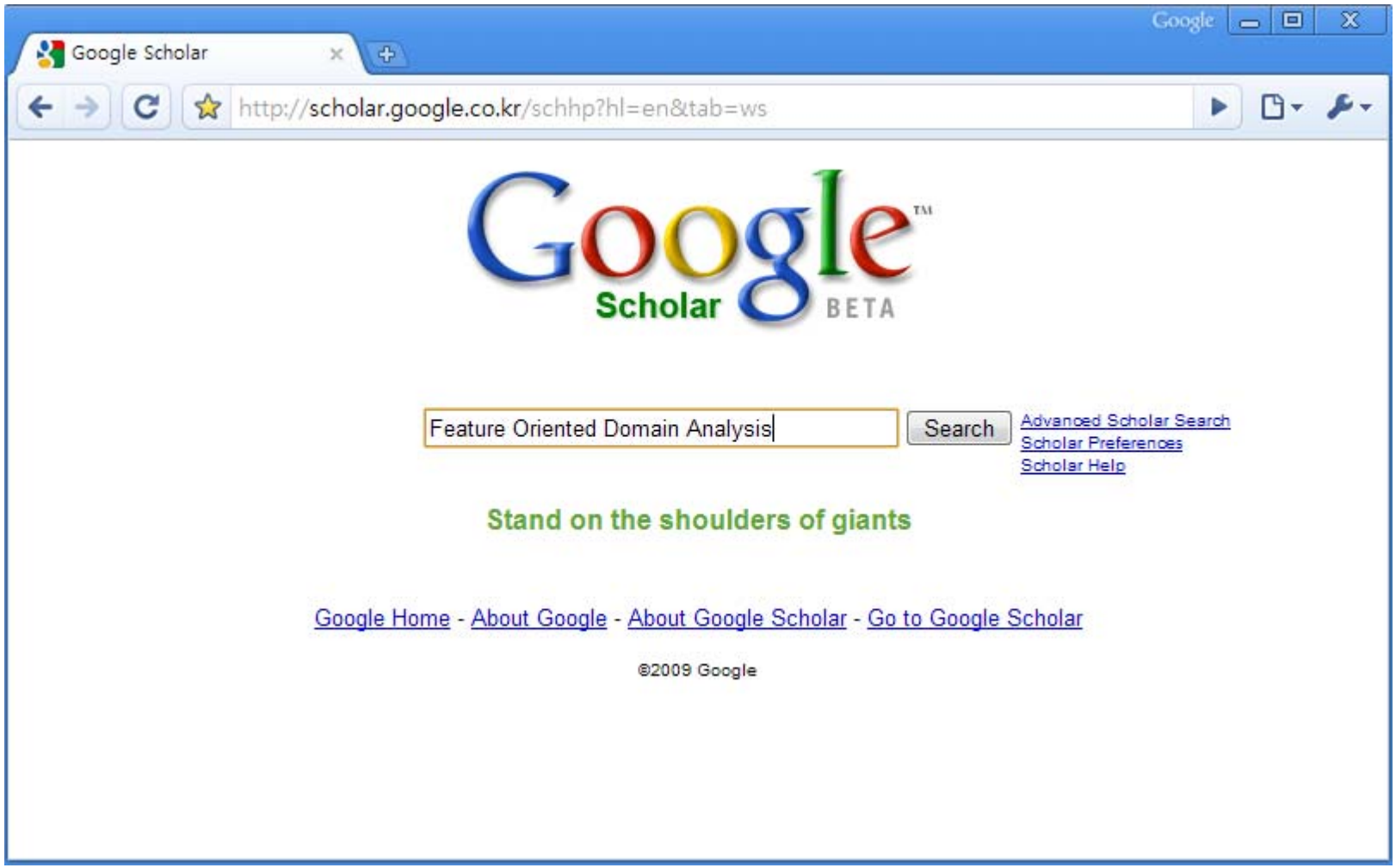

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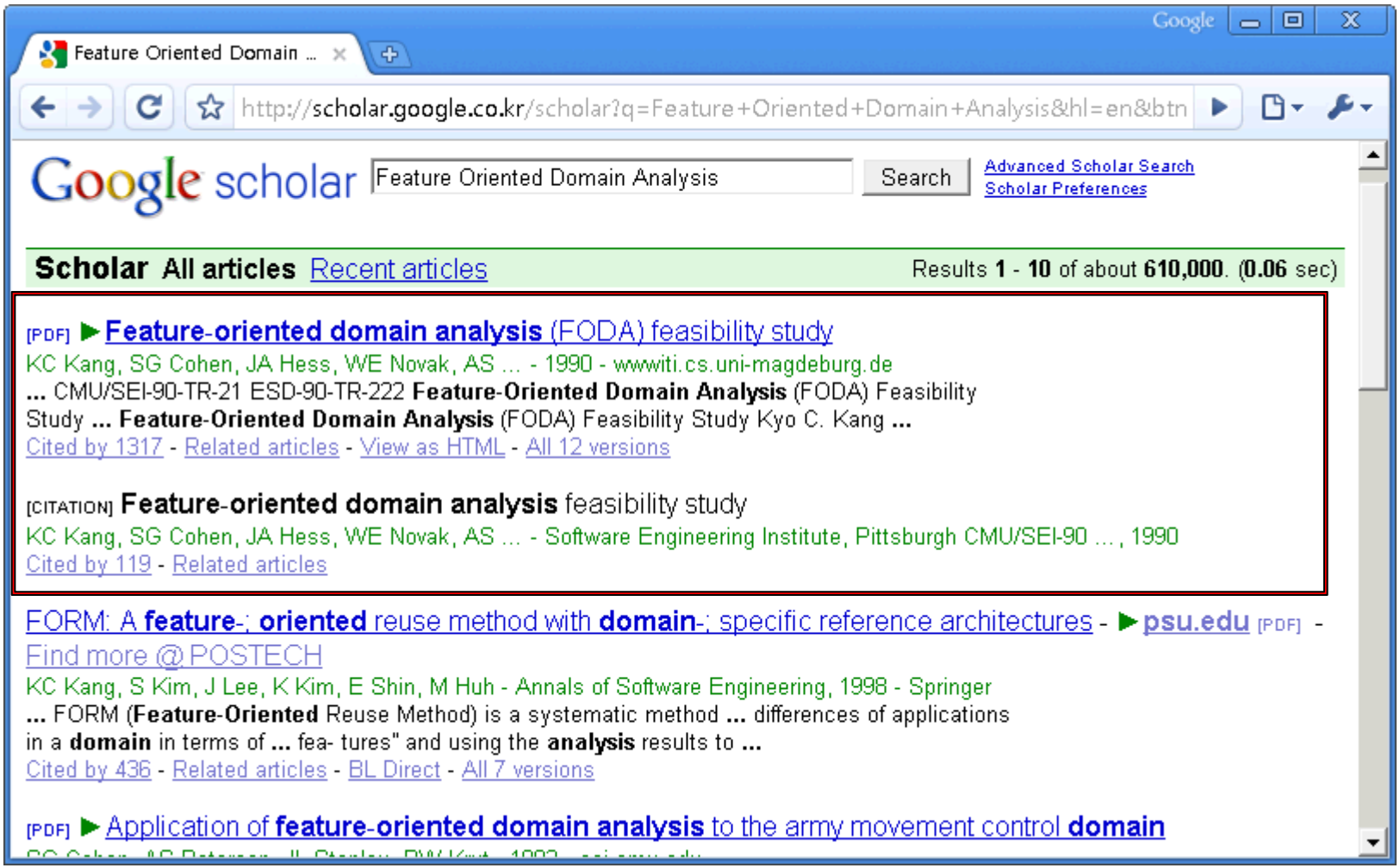

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We are talking about FODA

Technical Report
CMU/SEI-90-TR-21
ESD-90-TR-222
November 1990

Feature-Oriented Domain Analysis (FODA) Feasibility Study

Kyo C. Kang
Sholom G. Cohen
James A. Hess
William E. Novak
A. Spencer Peterson

Domain Analysis Project

Approved for public release.
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Pittsburgh, Pennsylvania 15213

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Agenda

- Introduction
- Looking Back
  - Number of Citations
  - Feature Model Genealogy
  - Why Popular?
  - Salient Features of FODA Report
- Looking Forward
  - Future Works
  - Other Issues
- Acknowledgement

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Feature-Oriented Domain Analysis (FODA) Feasibility Study

Kang, K.
Cohen, S.
Hess, J.
Novak, W.
Peterson, A.

Technical Report
CMU/SEI-90-TR-021

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Successful software reuse requires the systematic discovery and exploitation of commonality across related software systems. By examining related software systems and the underlying theory of the class of systems they represent, domain analysis can provide a generic description of the requirements of that class of systems and a set of approaches for their implementation. This report will establish methods for performing a domain analysis and describe the products of the domain analysis process. To illustrate the application of domain analysis to a representative class of software systems, this report will provide a domain analysis of window management system software.

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People

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KC Kang, SG Cohen, JA Hess, WE Novak, AS Peterson - 1990 - Carnegie Mellon University
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KC Kang, SG Cohen, JA Hess, WE Novak, AS Peterson - Software Engineering Institute, CMU, 1990
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S Cohen, K Kang, J Hess, W Nowak, S Peterson - Pittsburgh, Pennsylvania, USA, 1990
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Domain analysis: an introduction - ▶ jmu.edu [DOC] - Find more @ POSTECH
R Prieto-Diaz - ACM SIGSOFT Software Engineering Notes, 1990 - portal.acm.org
... abstraction from identi- fying common **features** is usually ... OO- Object-**oriented** software development is another area where **domain analysis** is often ...
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KC Kang, SH Cohen, JA Hess, WE Novak, AS Peterson - 1990 - Technical report CMU/SEI-90-TR-21, Software Engineering ...
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[CITATION] **Feature-Oriented Domain Analysis** (FODA) Feasibility Study. Software Engineering Institute Technical ...
K Kang, S Cohen, J Hess, W Novak, A Peterson - 1990 - SEI-90-TR-21, ADA 235785
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Key authors: K Kang - S Cohen - J Hess - W Novak - A Peterson

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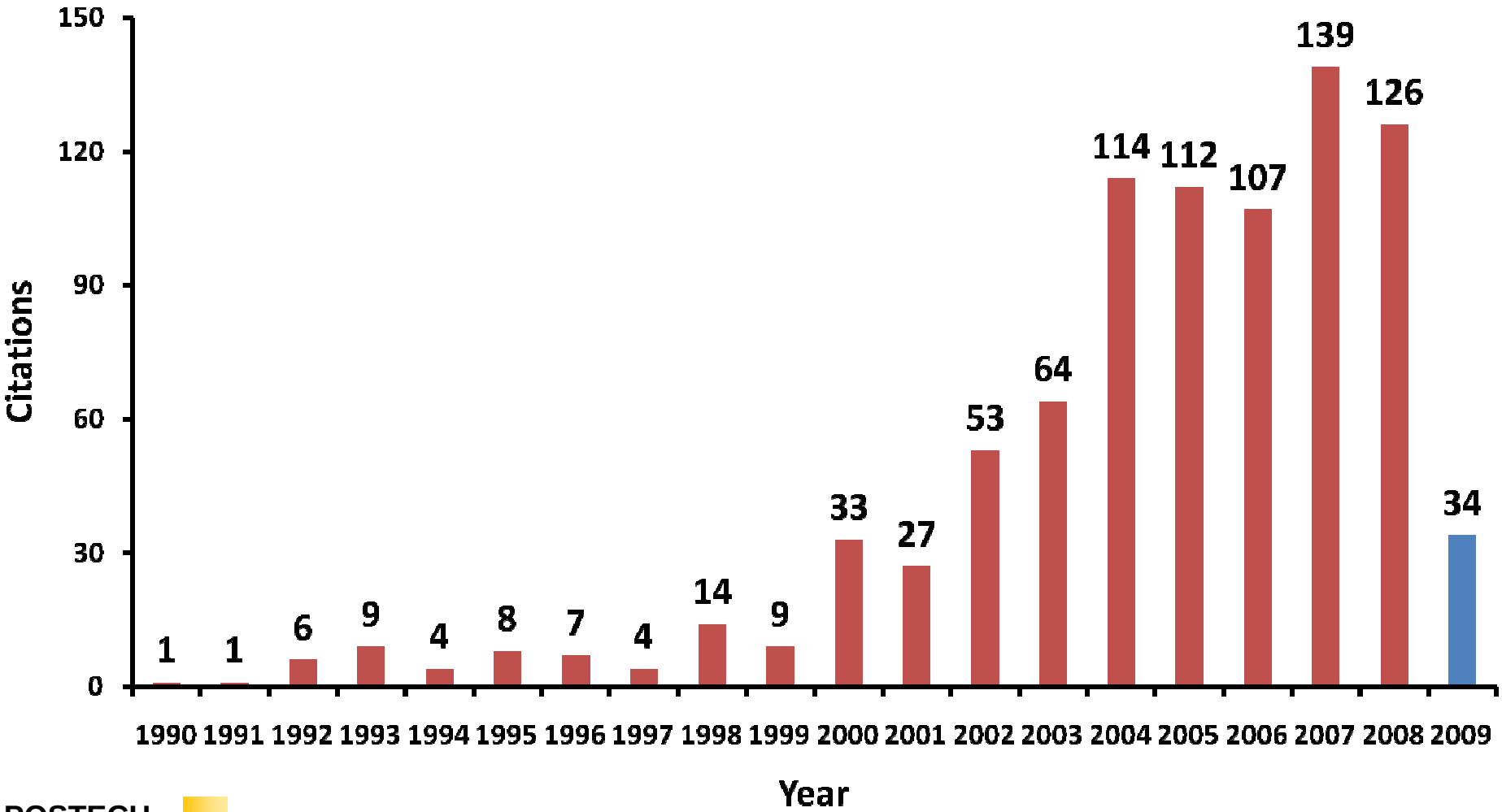

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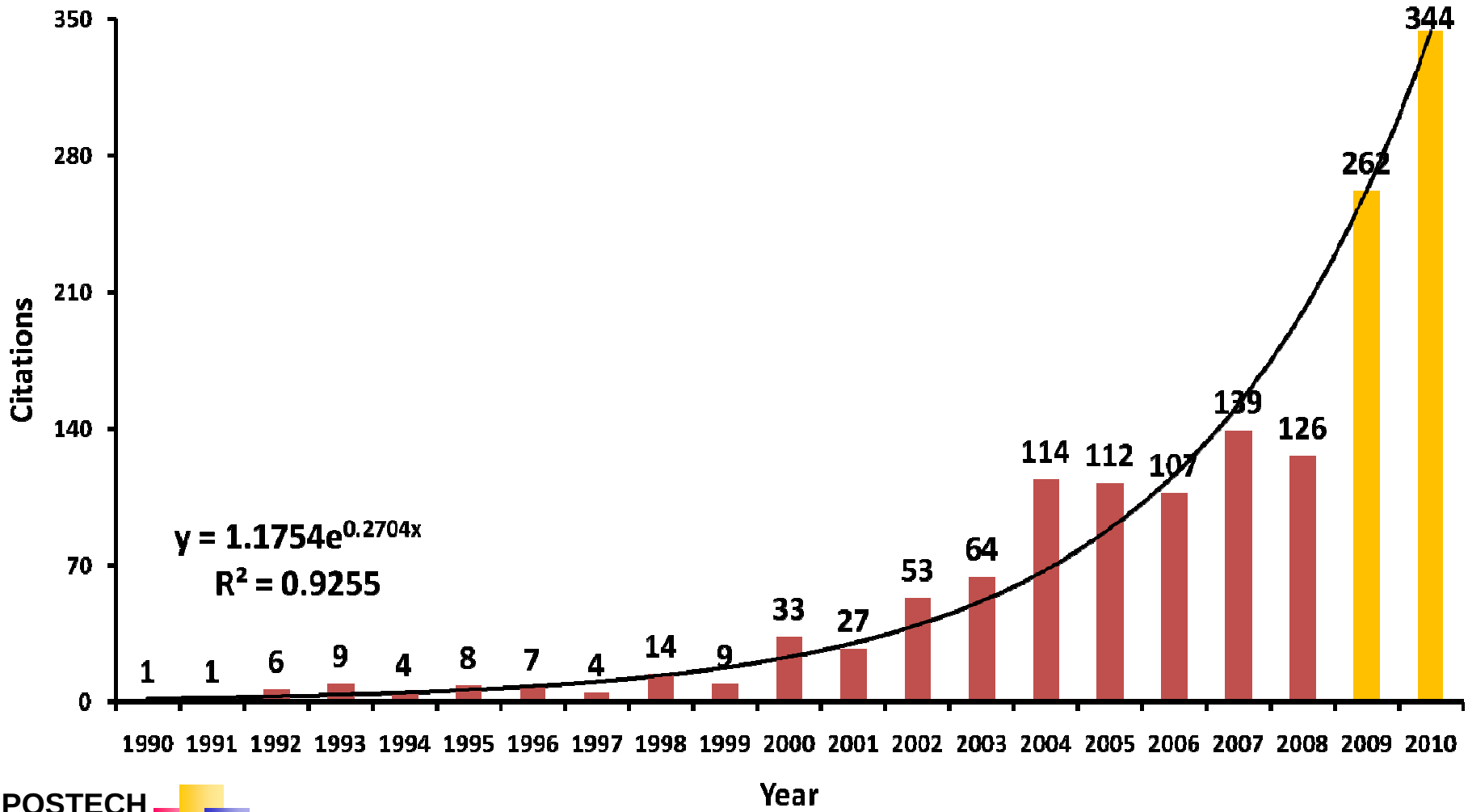

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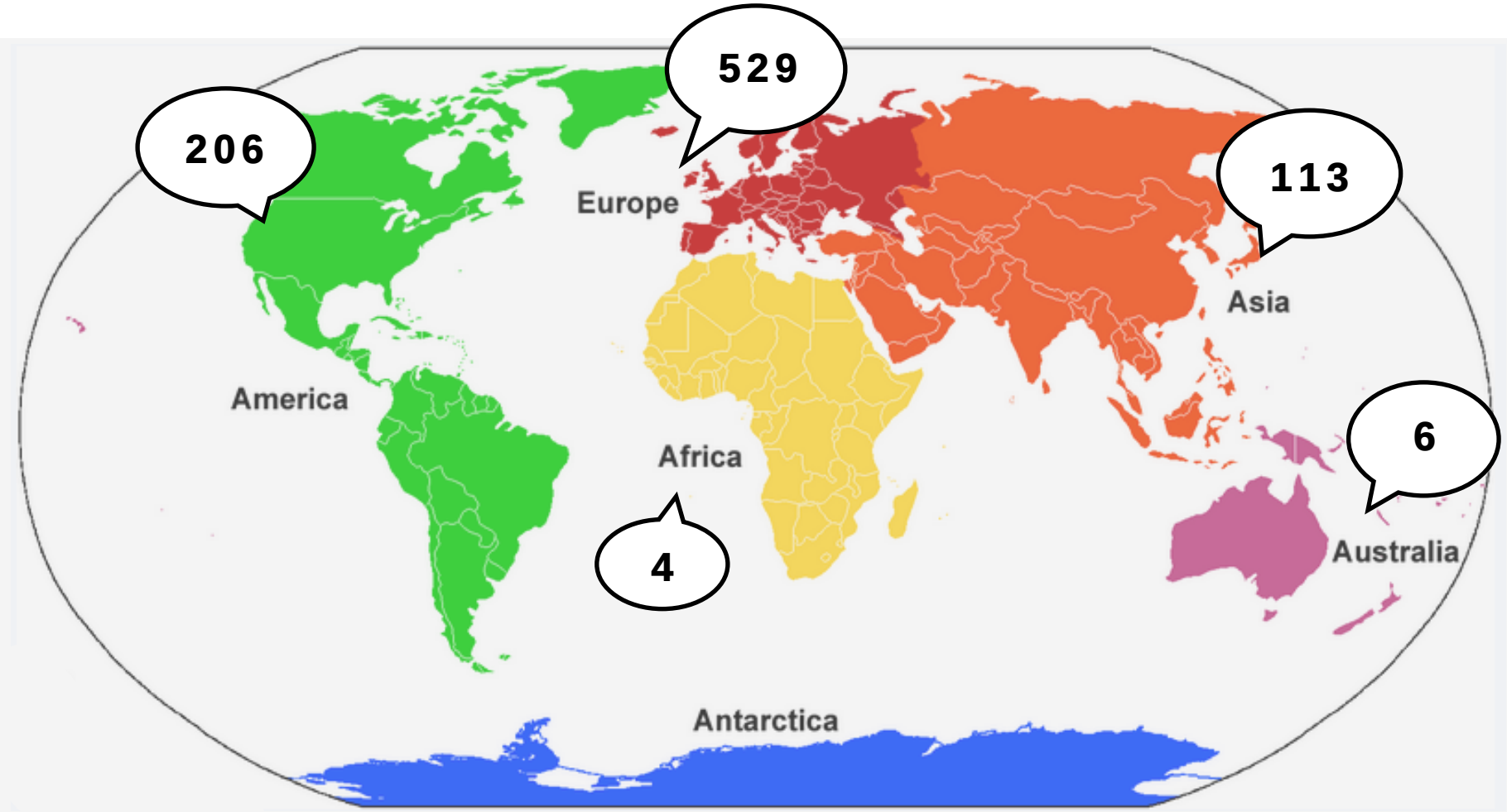

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Industry vs. Academia

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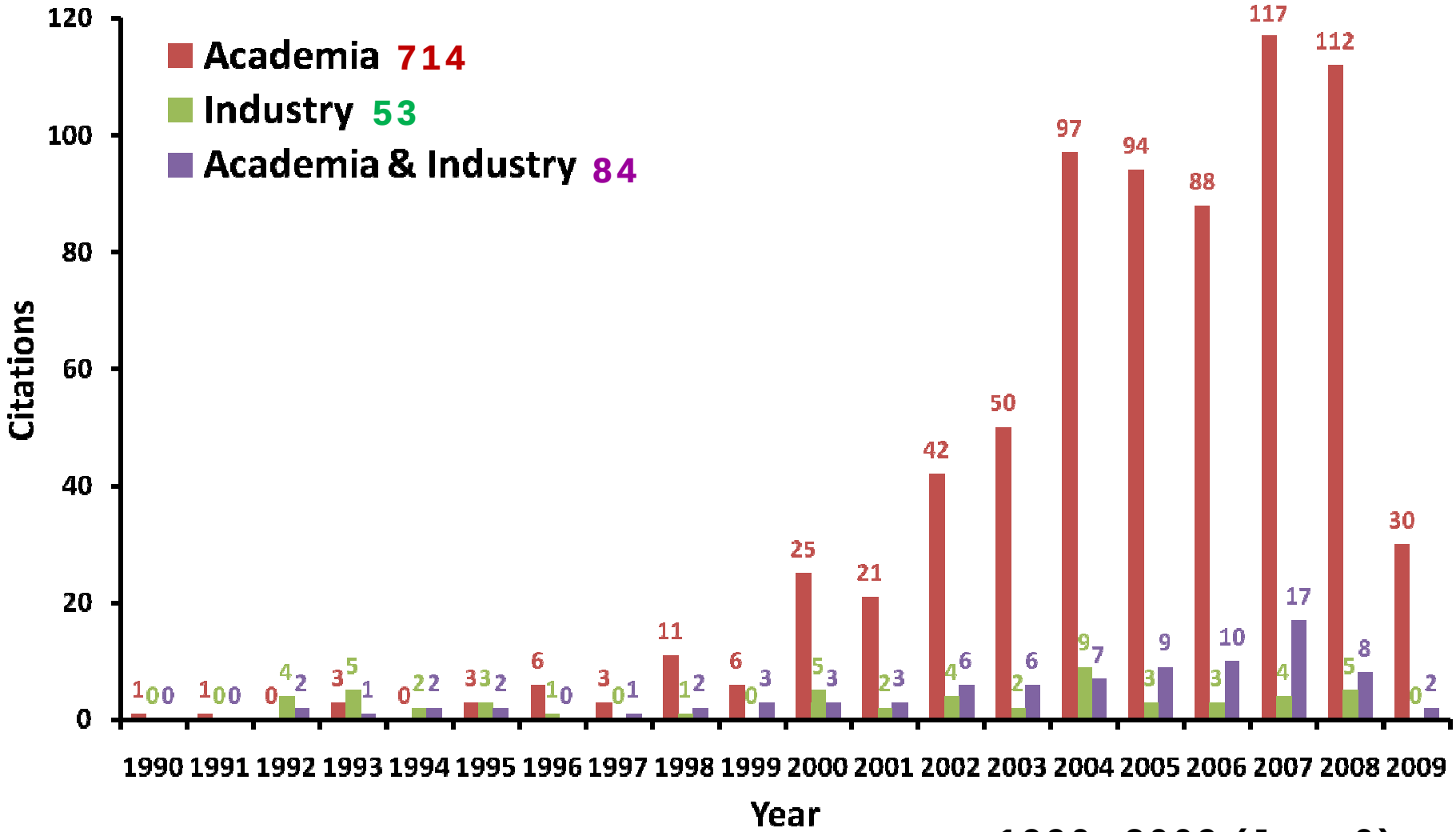

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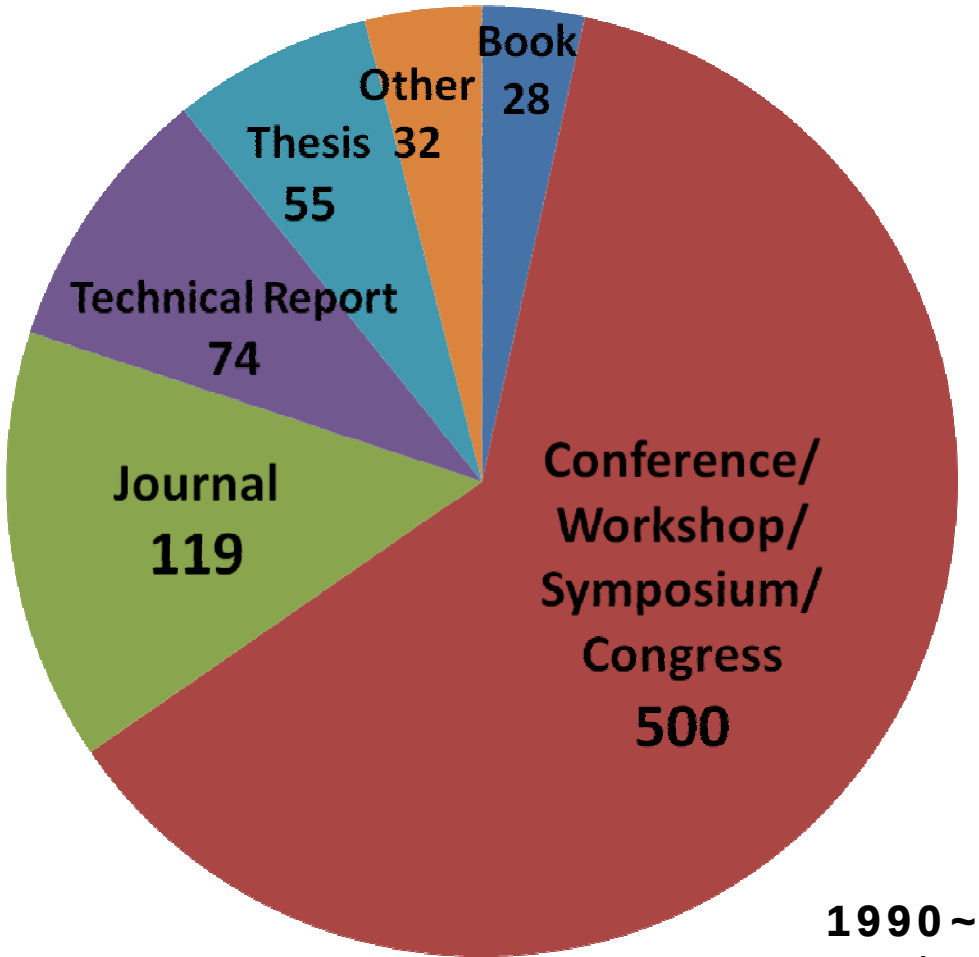

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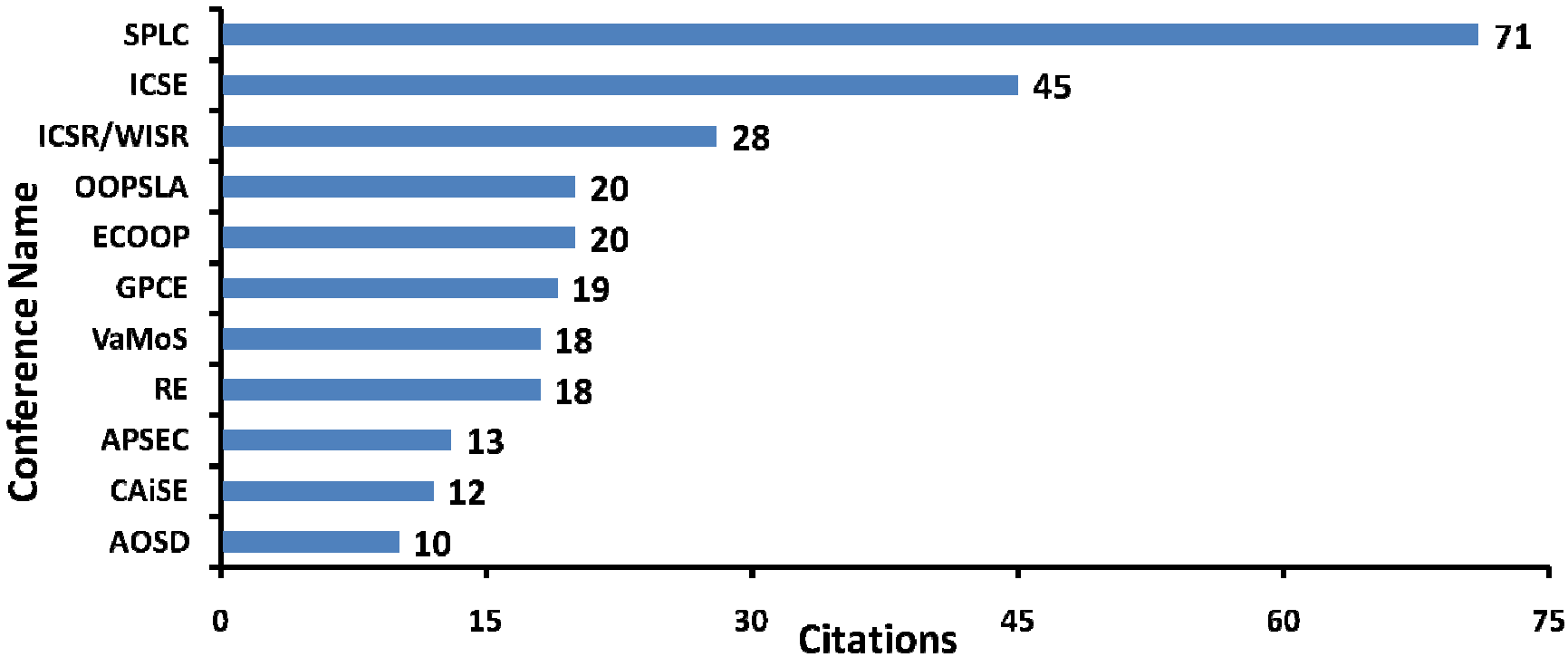

SPLC: International Software Product Line Conference
ICSE: International Conference on Software Engineering
ICSR/WISR: International Conference on Software Reuse/ Annual Workshops on Institutionalizing Software Reuse
OOPSLA: International Conference on Object Oriented Programming, Systems, Languages and Applications
ECOOP: European Conference on Object-Oriented Programming
GPCE: International Conference on Generative Programming and Component Engineering
VaMoS: International Workshop on Variability Modeling of Software-intensive Systems
RE: International Requirements Engineering Conference
APSEC: Asia-Pacific Software Engineering Conference
CAiSE: International Conference on Advanced Information Systems Engineering
AOSD: International Conference on Aspect-Oriented Software Development

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Conference Trend

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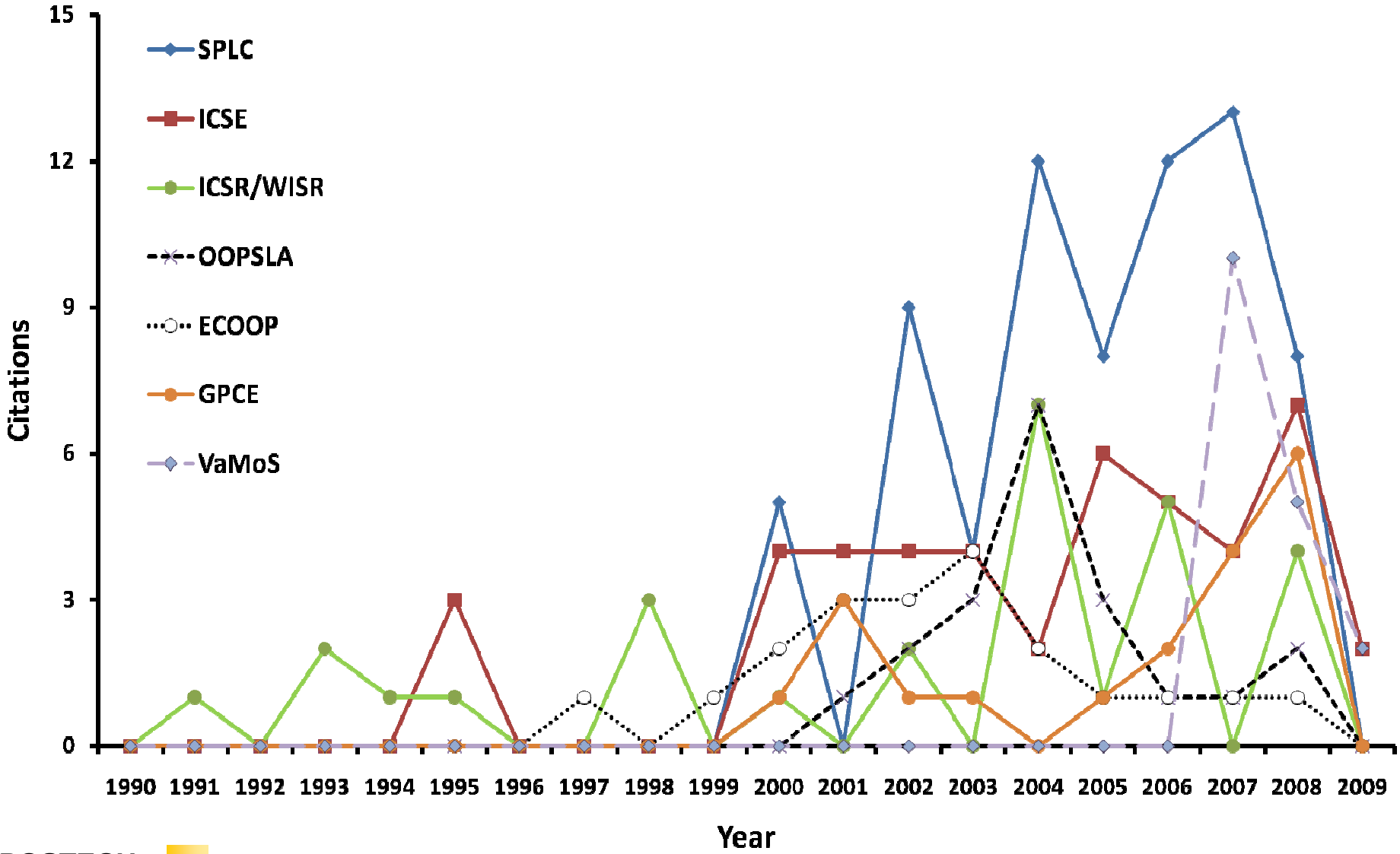

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Subject Differences

Number of Citations

Subject Categories

- Feature Modeling
- Feature Model Formalization
- Feature Model Extension

- Generative Programming
- Domain-Specific Language
- Feature-Oriented Design/Programming

- Product Configuration
- Variability Management

- Product Line Methodology /Product Line Adoption
- Doman Analysis /Requirements Analysis
- Domain-Specific Architecture
- Reusable Component Development
- Refactoring/Reengineering

- Tool Development

- Business Application
- Embedded Application
- SOA

- Other

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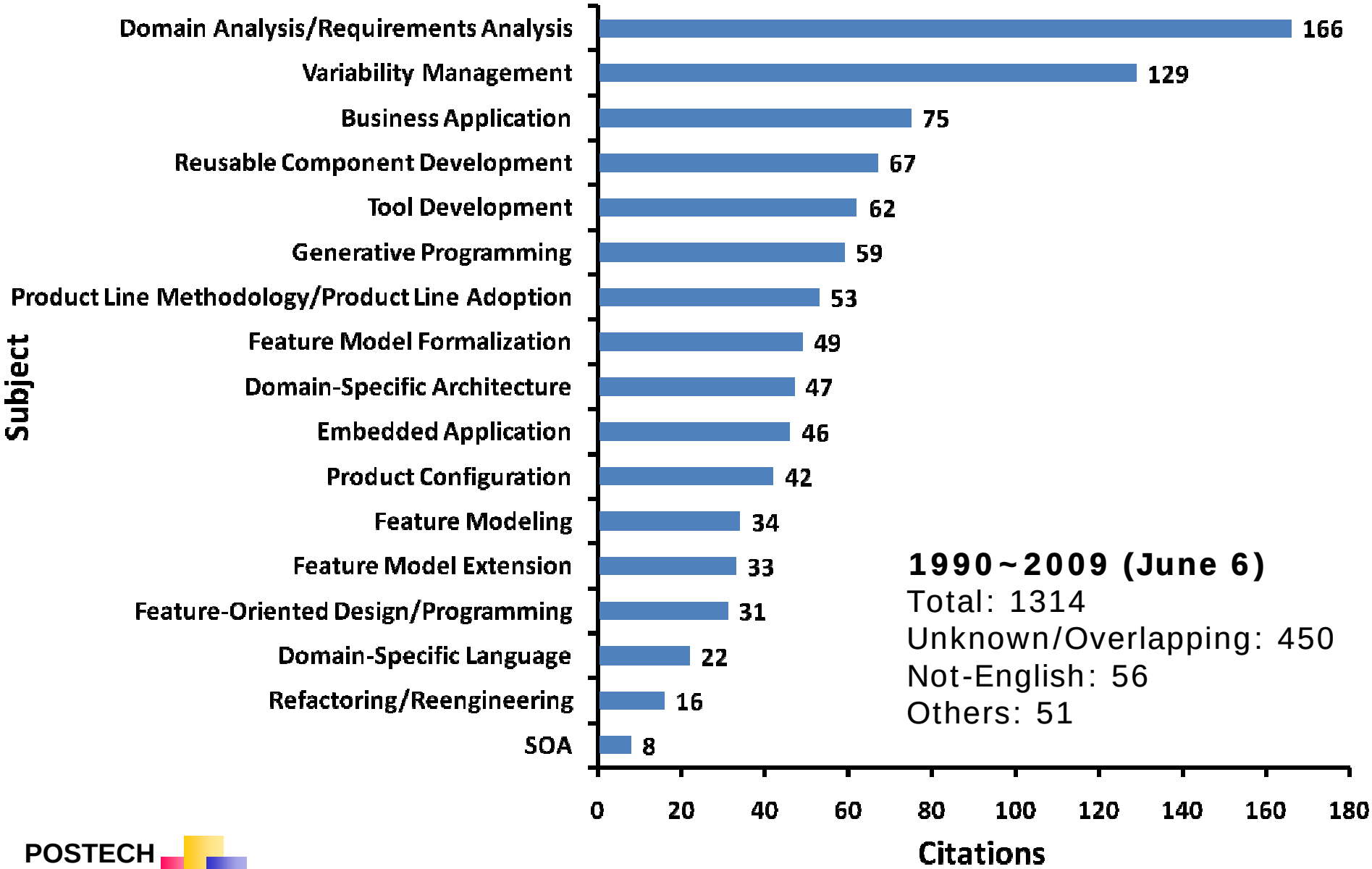

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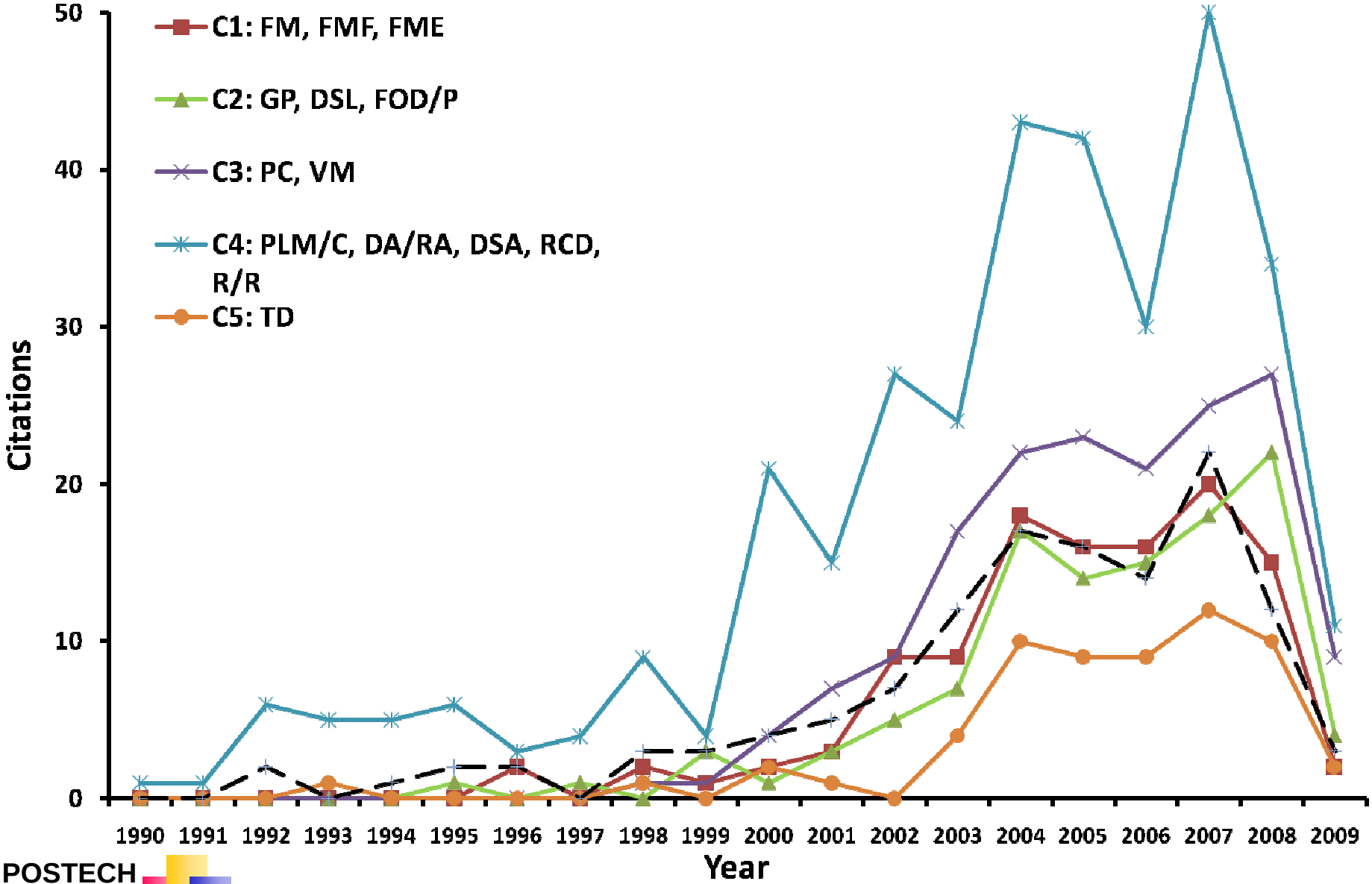

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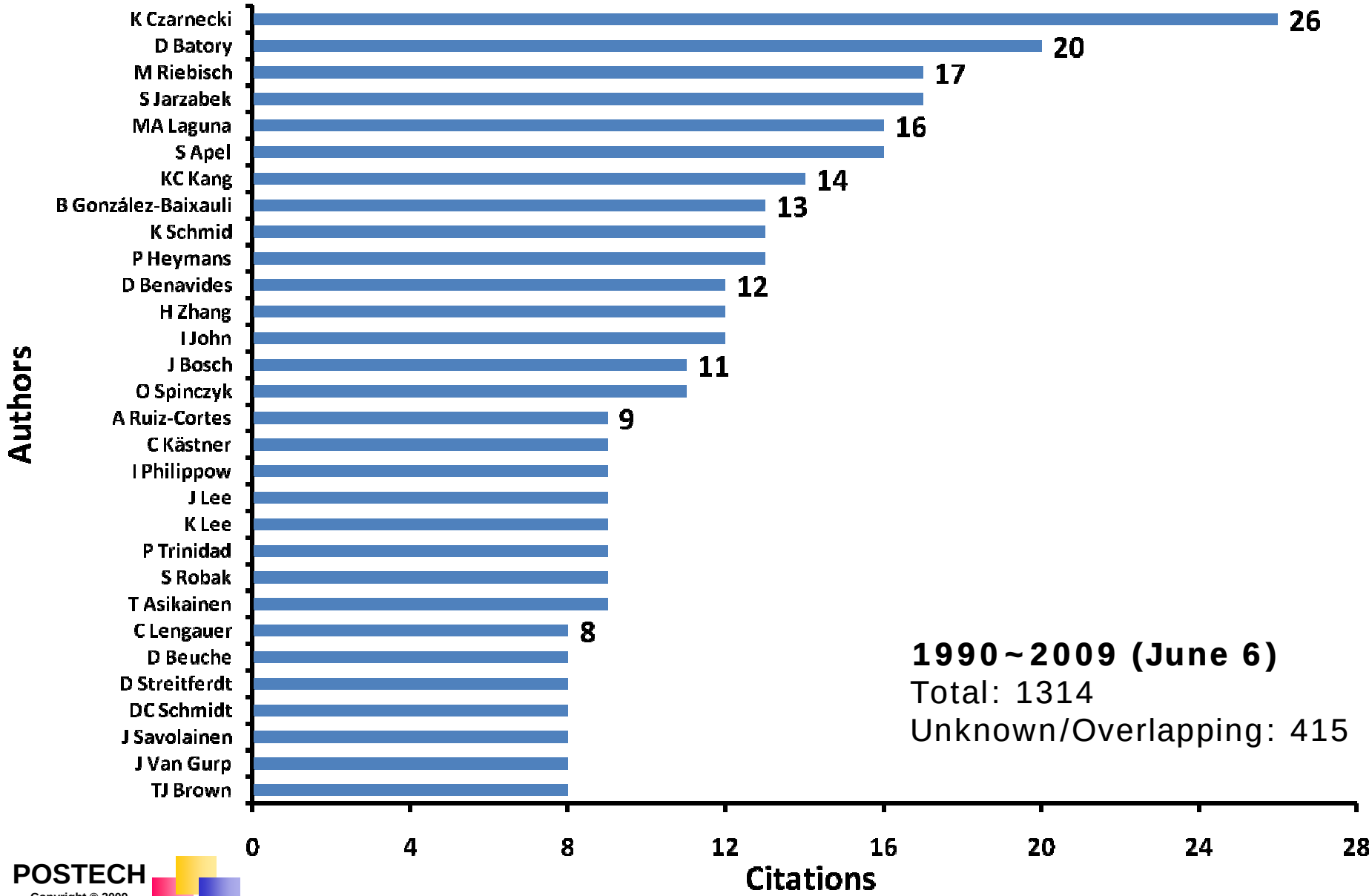
Top-30 People

Number of Citations



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Survey: Top-30 People

1. What are the contributions of FODA?

2. What are the remaining problems for FODA?

3. What is your own one-sentence definition/feeling about the feature model?

4. Anything else you would suggest for inclusion?

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The Contributions of FODA:

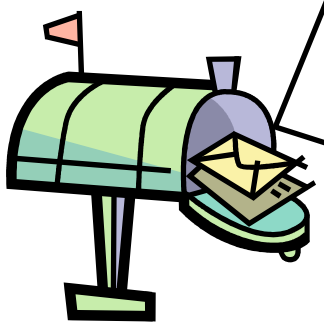
Systematic domain analysis method used in software product line engineering. (C Kastner, S Apel, C Lengauer)

Strongly influencing how software configuration is seen in software product line, and popularizing the domain analysis concept. (K Schmid)

Laying the groundwork for feature analysis and feature modeling. (J Van Gurp)

Feature modeling :

- Essential technique for defining the space of programs that define a software product line. (D Batory)
- Simple but comprehensive way to modeling commonalities and variabilities in a domain. (H Zhang, J Lee, S Jarzabek, T Asikainen)
- Easy to use and communicate between stakeholders. (C Kastner)
- Giving a name to a fundamental form of modularity in context of product lines. (D Batory)



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The Remaining Problems for FODA:

Addressing other parts of the life cycle (Especially application engineering). (K Schmid)

Clear mapping between features and software artifacts. (J Van Gurp, K Schmid)

Standardization of feature model extensions; Trade-off between expressiveness and simplicity. (C Kastner, S Apel, C Lengauer, T Asikainen, K Schmid)

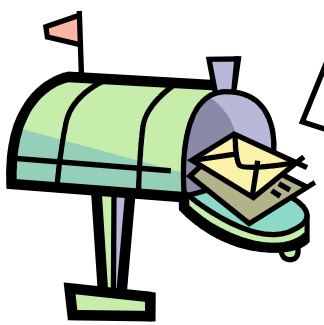
Scalability of feature model. (C Kastner, D Batory)

Managing Complexity in view of many inter-dependent features. (J Van Gurp, S Jarzabek)

Feature model evaluation. (J Lee)

Integration with UML Model. (S Jarzabek)

Good teaching materials. (D Batory)



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Own One-Sentence Definition / Feeling about the Feature Model:

A model that provides the foundations of software reuse. (J Lee)

A simple means to describe the commonalities and variabilities of a domain / product line. (S Apel, C Lengauer)

Good and easy to understand, practical and fundamental. (H Zhang)

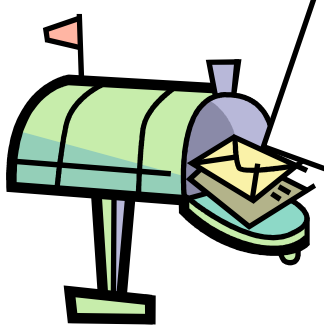
Easy to use (management-compatible) graphical model to describe variability. (C Kastner)

Great notation, accepted by all in the field. (S Jarzabek)

One of the useful ways to analyze requirements (required features) as well as a means to describe given software in terms of features (provided features). (J Van Gurp)

An idea well received by the community but still lacking content meeting the scientific standards. (T Asikainen)

Great approach to make one understand the core idea of product line engineering (But I'm not sure whether it is the right way of looking at variability for the actual development). (K Schmid)



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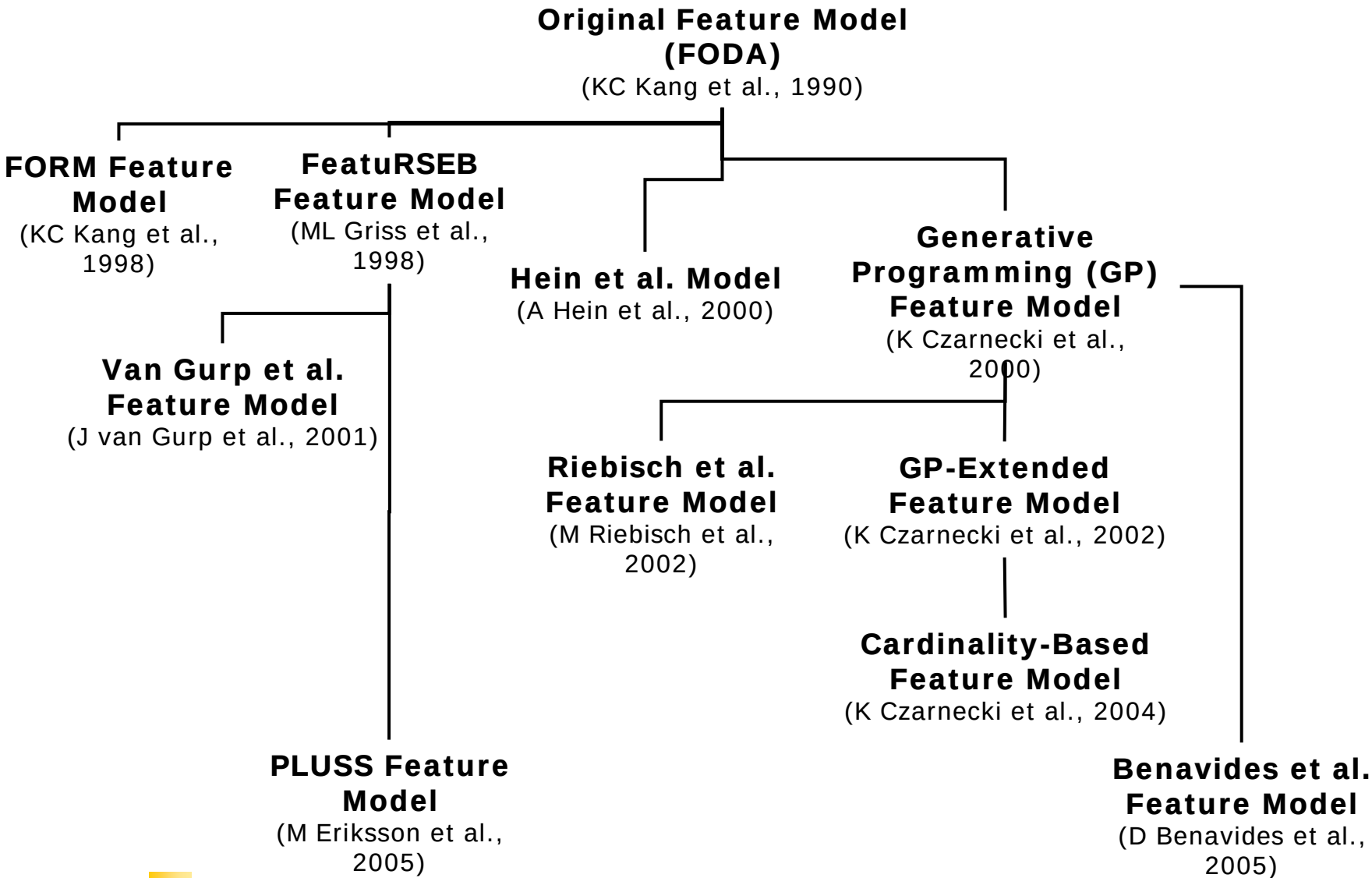
Feature Model Genealogy



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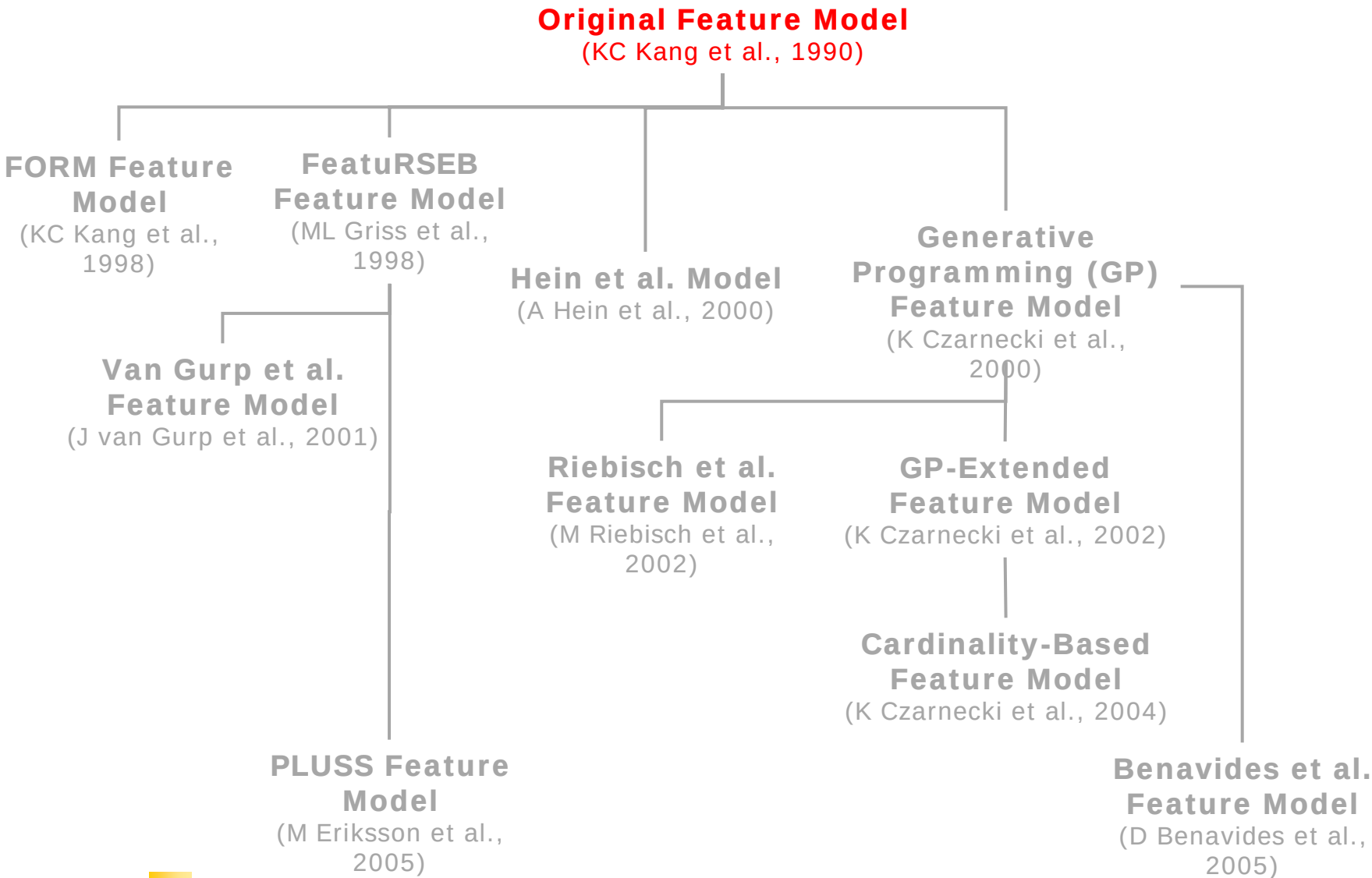

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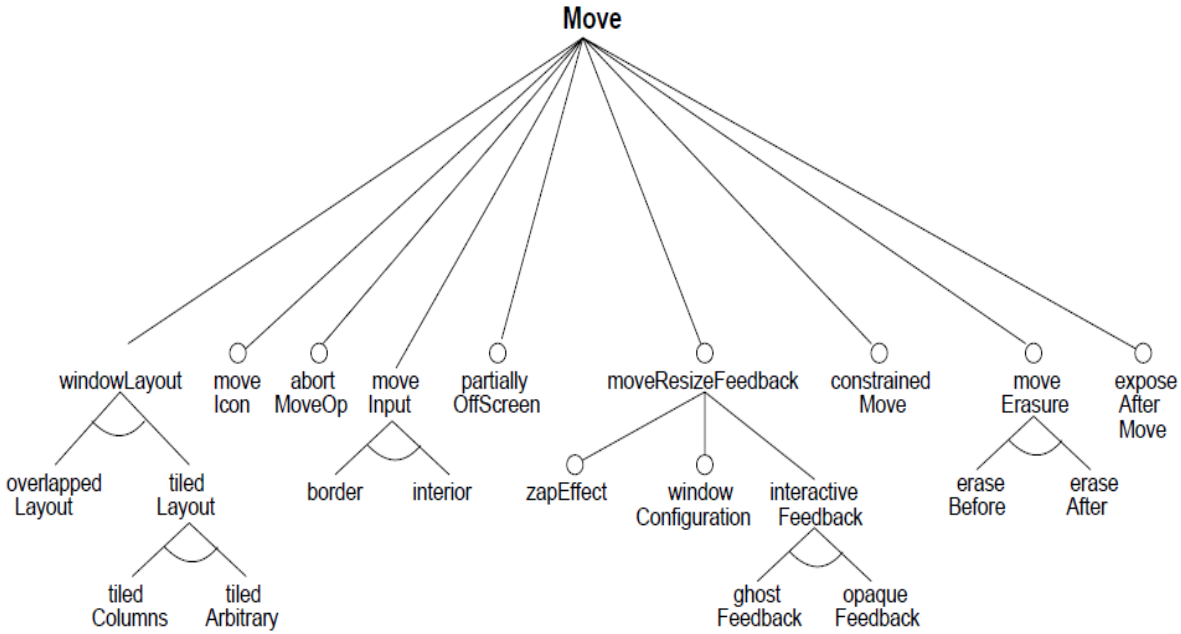
Feature Model Genealogy

Original Feature Model
(KC Kang et al., 1990)



- Feature diagram: A Graphical And/Or Hierarchy of Features
  - Mandatory / Optional / Alternative Feature
  - Composed-of Relationship
- Composition Rules: Mutual Dependency (Requires) and Mutual Exclusion (Mutex-with) Relationships
- Issues and Decisions: Record of Trade-offs, Rationales, and Justifications
- System Feature Catalogue: Record of Existing System Features

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Extensions from Original Feature Model

- Diagram Shape
- Layer
- Relationship Type
- Feature Type
- Feature Attribute
- Feature Cardinality
- Feature Group and Group Cardinality
- Constraint Notation
- Binding Time Notation

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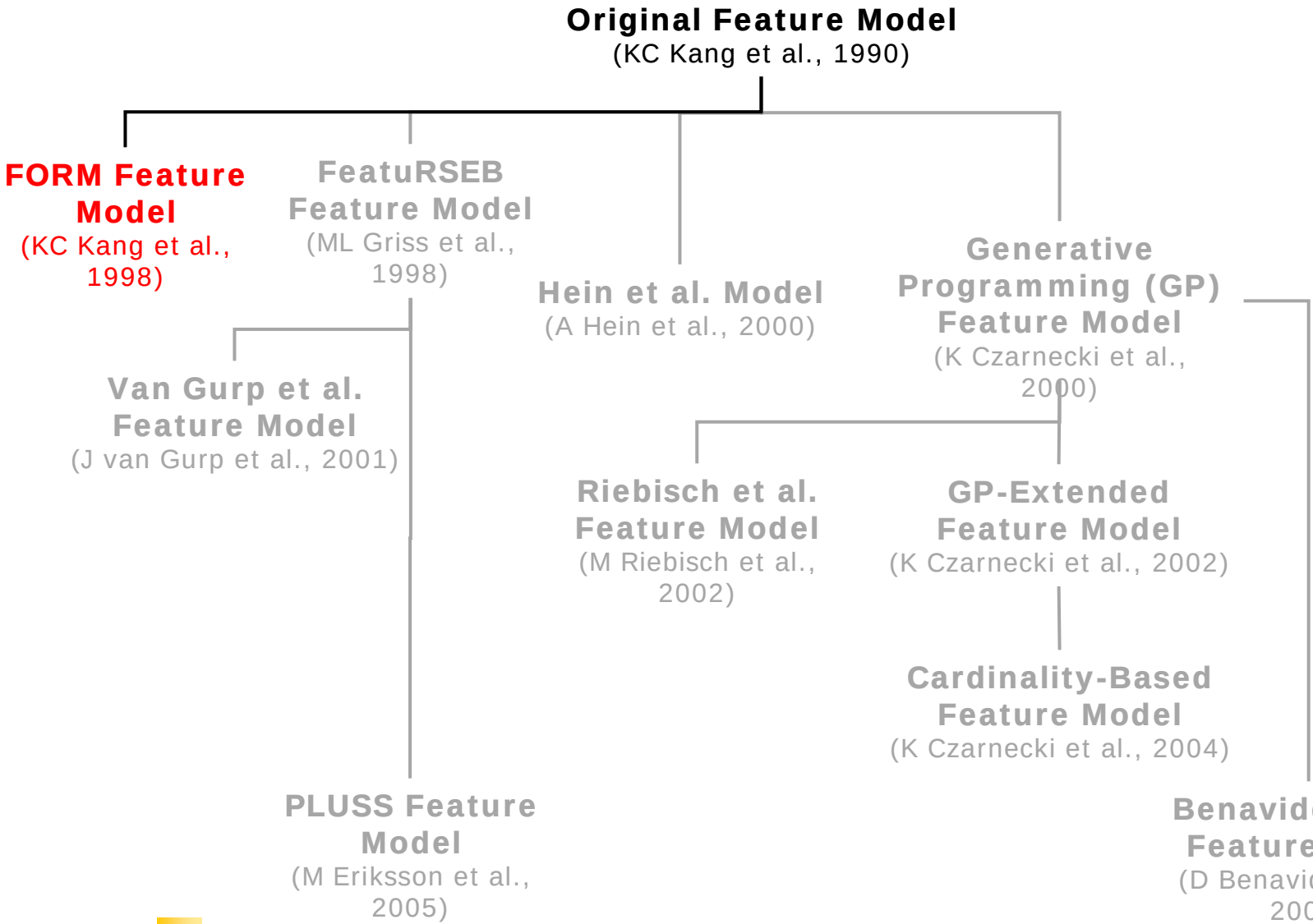
Feature Model Genealogy



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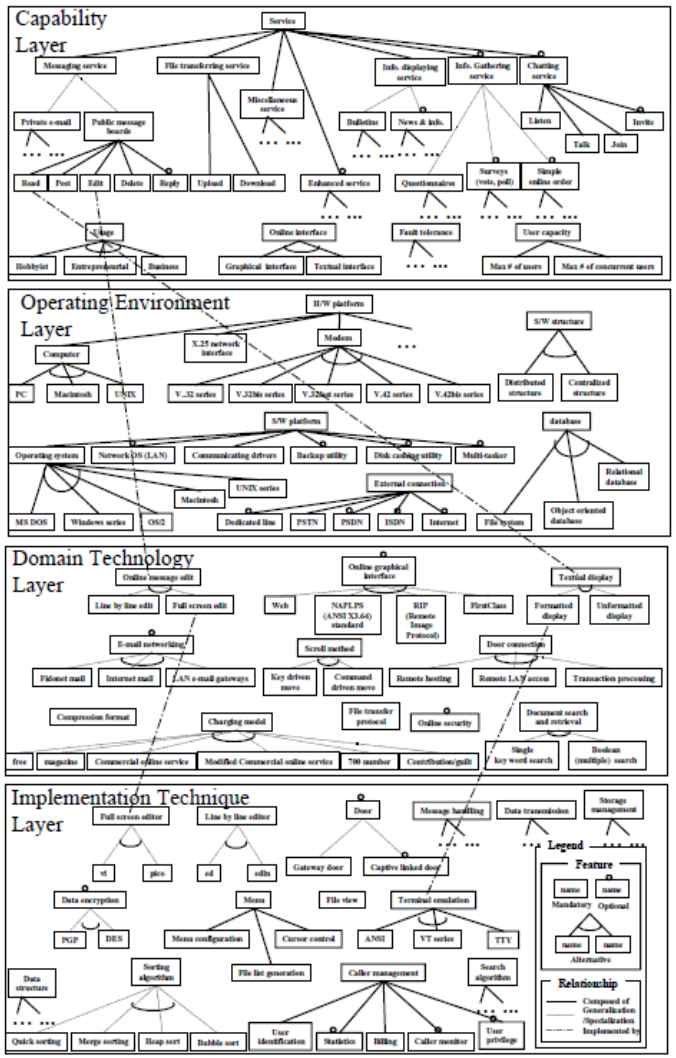
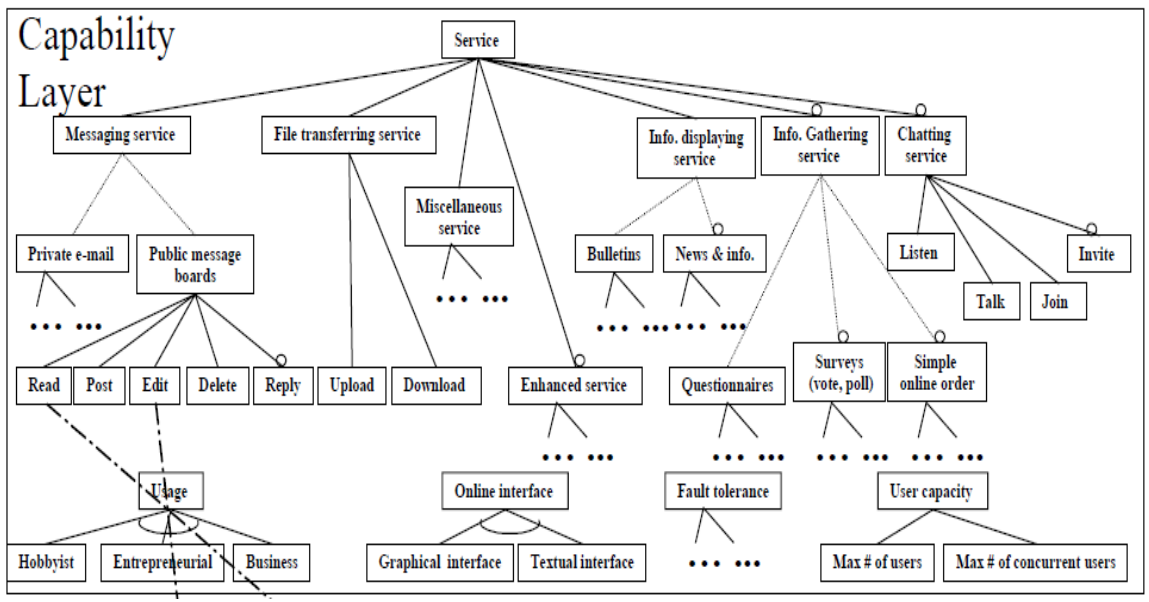
Feature Model Genealogy

FORM Feature Model (KC Kang et al., 1998)



- Layer
  - Capability
  - Operating Environment
  - Domain Technology
  - Implementation Technology
- Relationship Type:
  - Implemented-by



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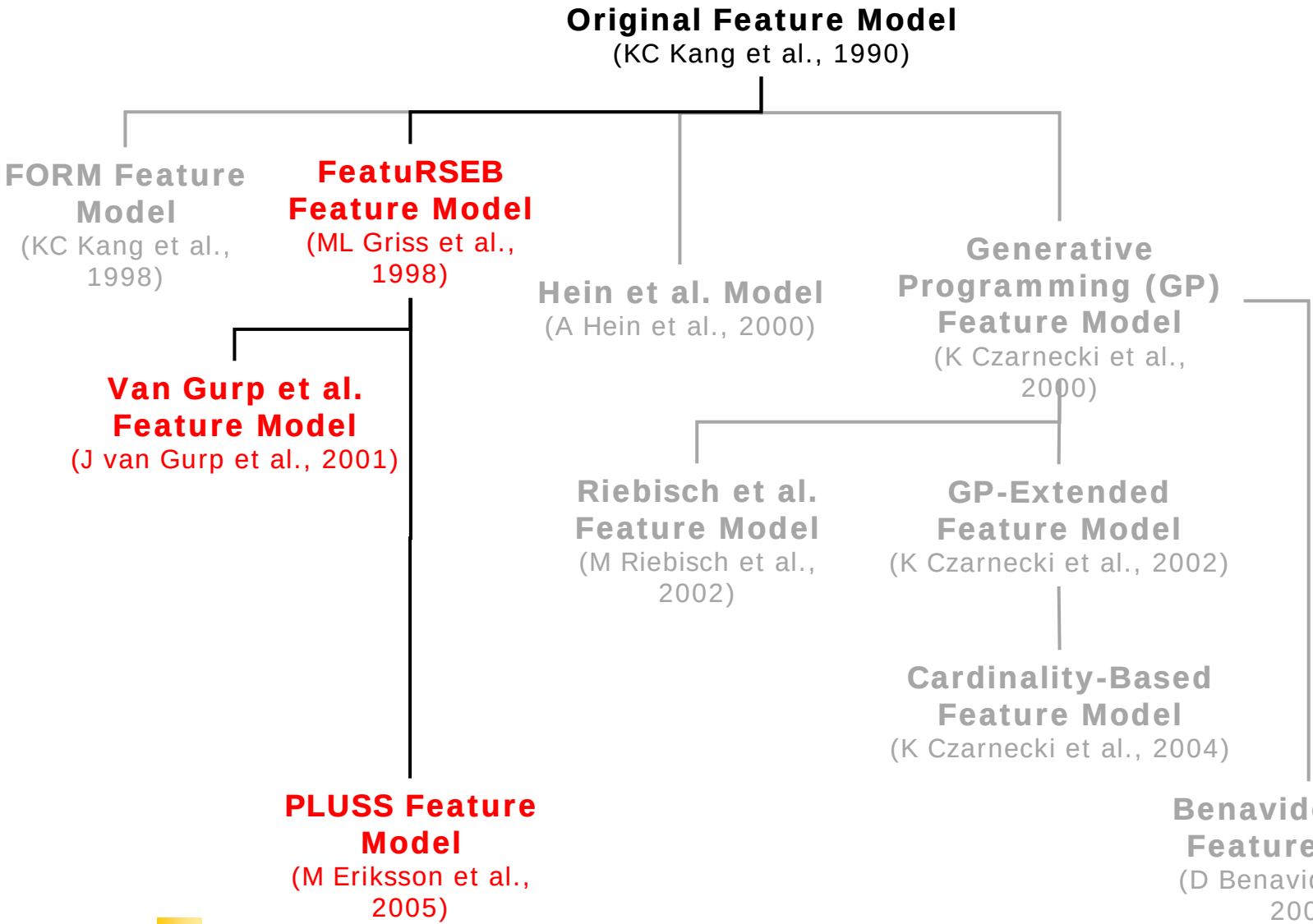

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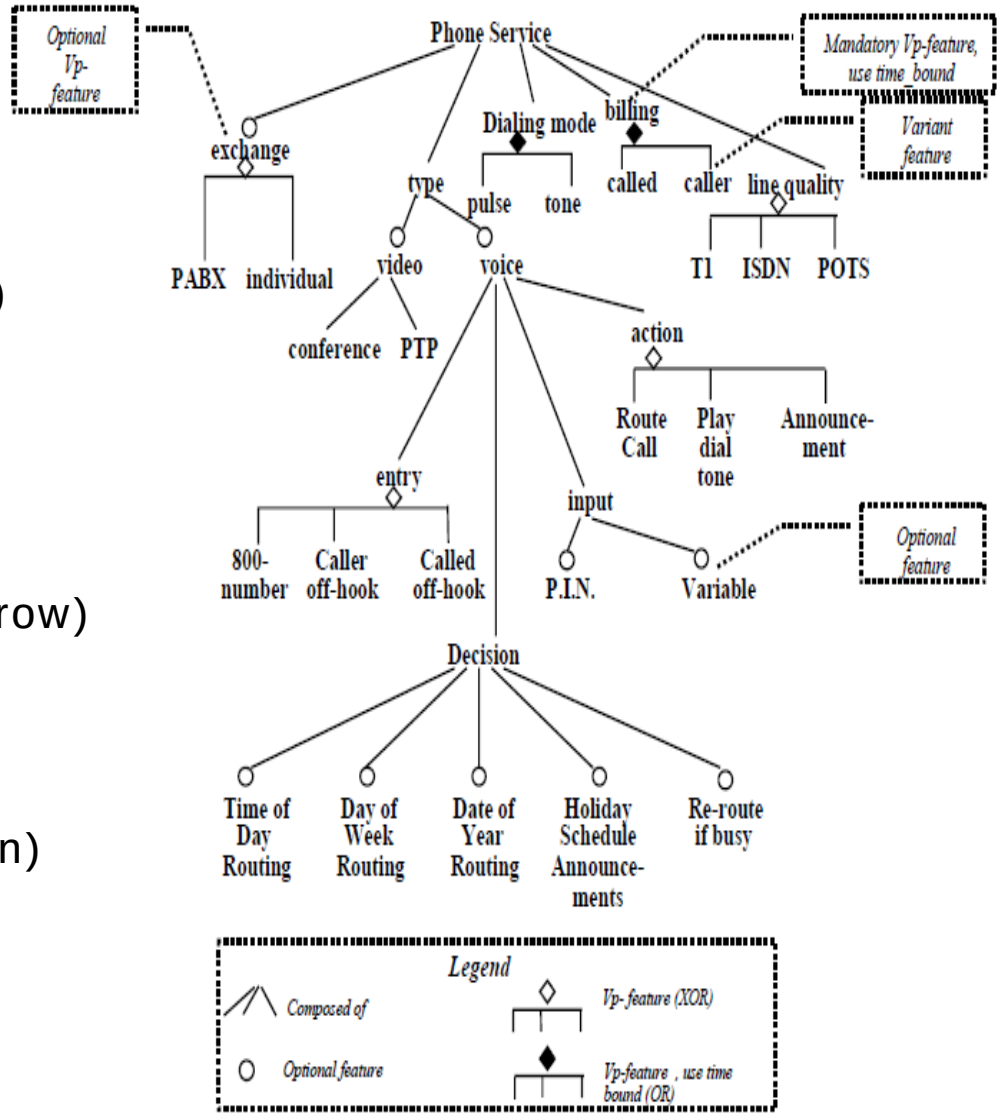
Feature Model Genealogy

FeatuRSEB Feature Model (ML Griss et al., 1998)

Combine FODA and the Reuse-Driven Software Engineering Business (RSEB)

- Feature Type
  - Alternative Feature
    - → Variation Point Feature / Variant Feature
- Constraint Notation (with Dashed Arrow)
- Bound Time Notation
  - Reuse Time Bound (XORed-disjunction)
  - Use Time Bound (ORed-disjunction)



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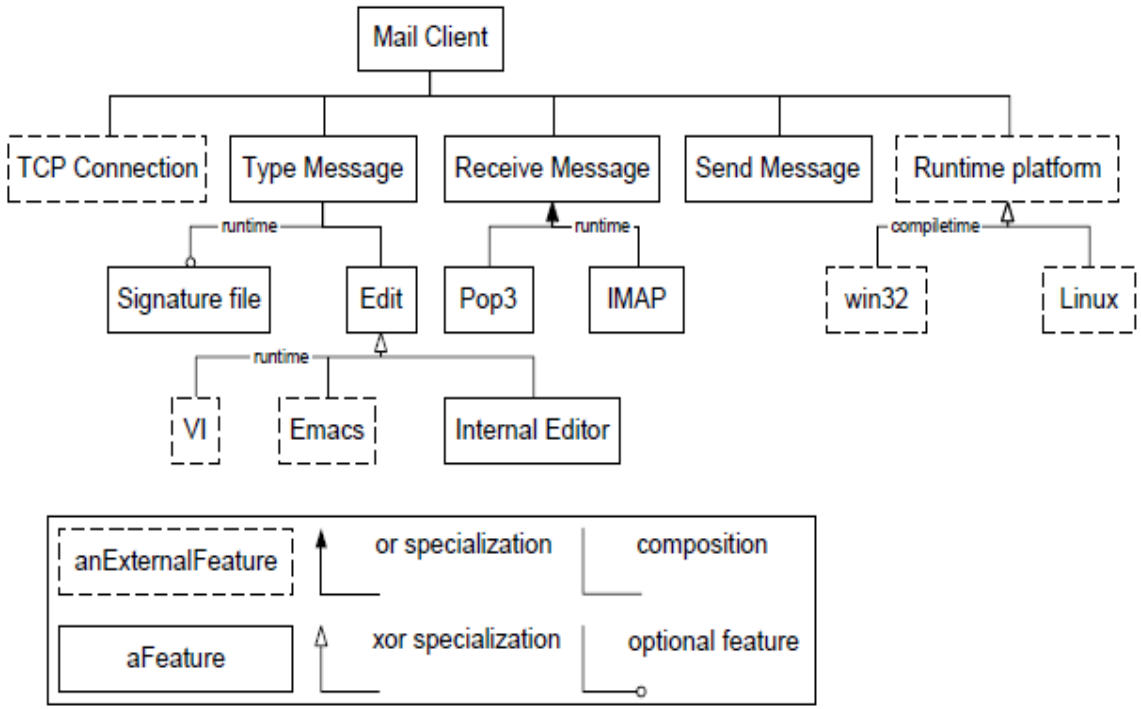
Feature Model Genealogy

Van Gurp et al. Feature Model (J van Gurp et al., 2001)

- Feature Type
  - External Feature
  - Alternative Feature
    → OR Specialization/ XOR Specialization
- Binding Time Notation



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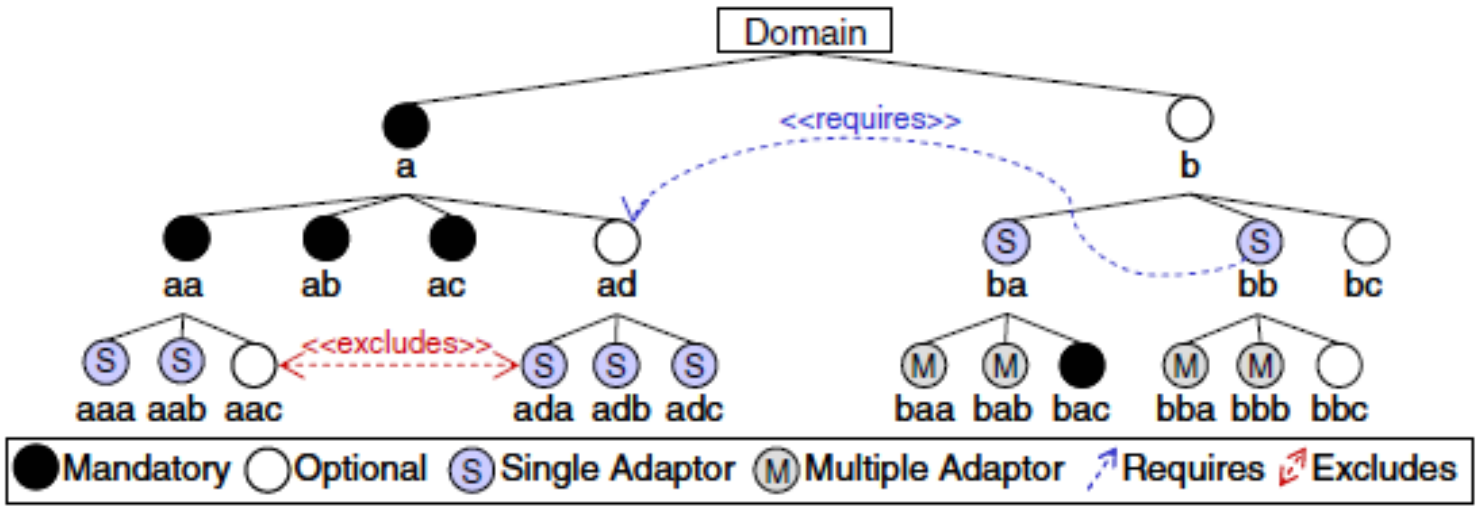
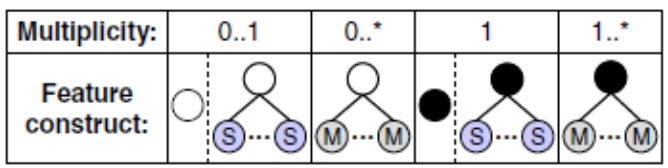
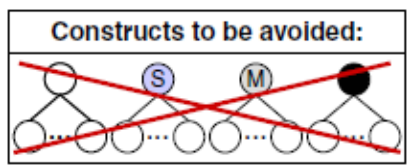
Feature Model Genealogy

PLUSS Feature Model
(M Eriksson et al., 2005)

- Diagram Shape
  - Feature as Circle (Black, White, 'S', 'M')
- Feature Type
  - Alternative Feature
    → Single Adapter / Multiple Adapter
- Constraint Notation







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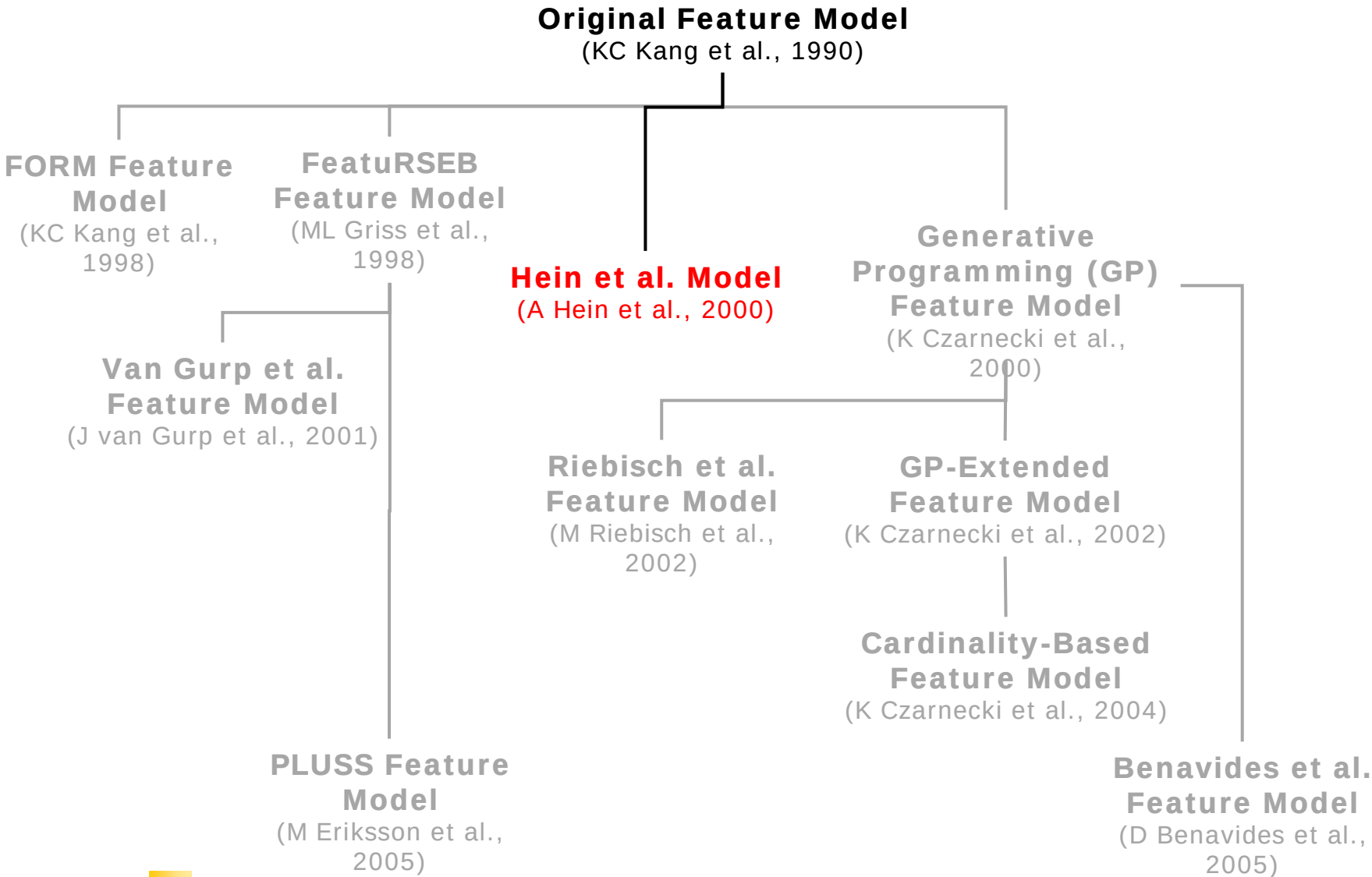
Feature Model Genealogy



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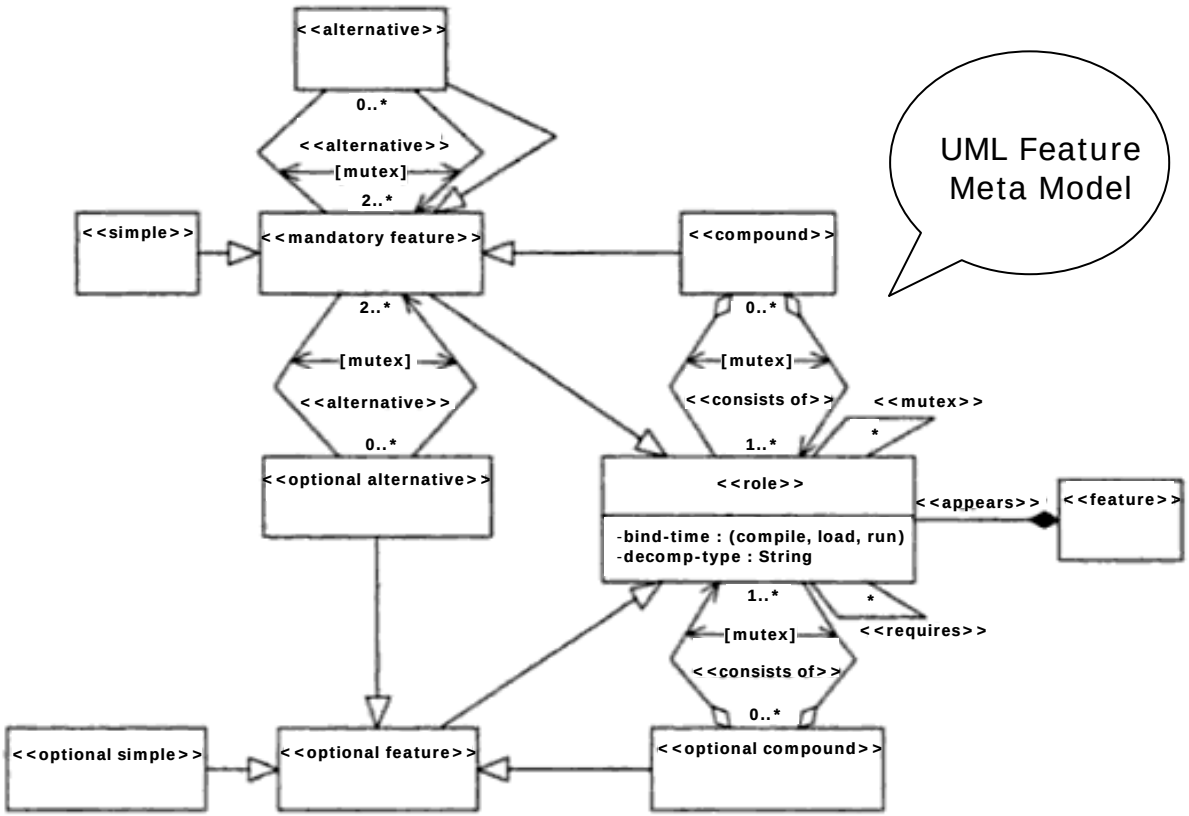
Feature Model Genealogy

Hein et al. Feature Model (A Hein et al., 2000)

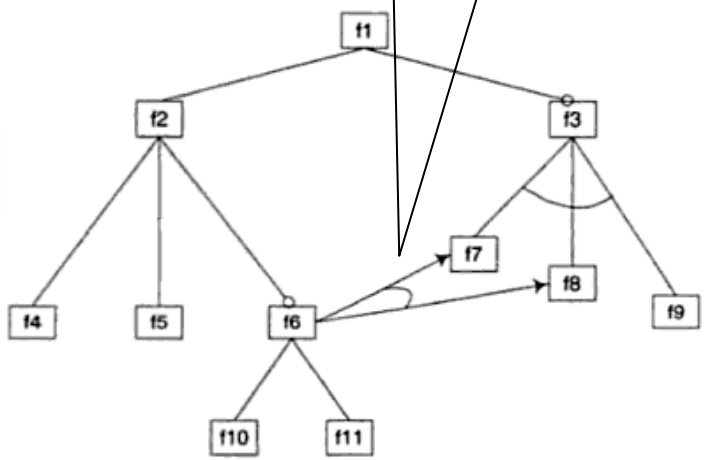
Use of UML

- Relationship Type
  - Arrow for Secondary Structure



UML Feature Meta Model

"f6" is "Optional Compound" in Primary Structure and "Alternative" in Secondary Structure



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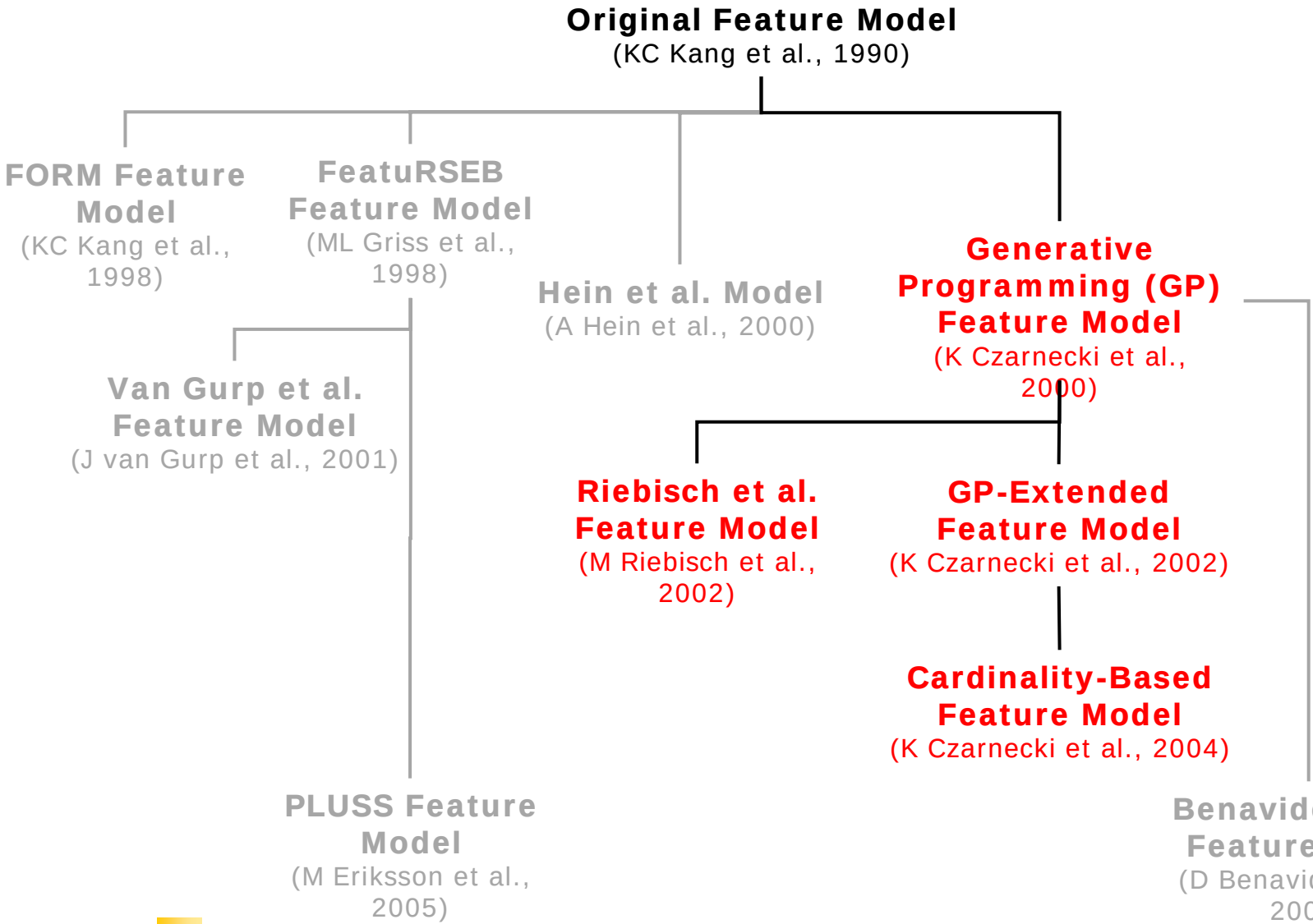
Feature Model Genealogy



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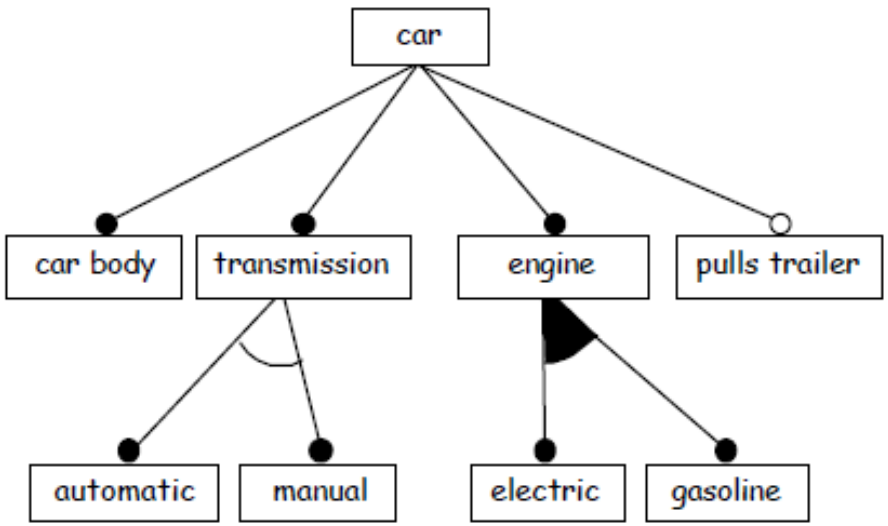
Generative Programming Feature Model (K Czarnecki et al., 2000)



- Diagram Shape
  - Feature Name in a Box
  - Box with Circle
    - : Black = Mandatory
    - : White = Optional
- Feature Type
  - OR Feature (Black Triangle)

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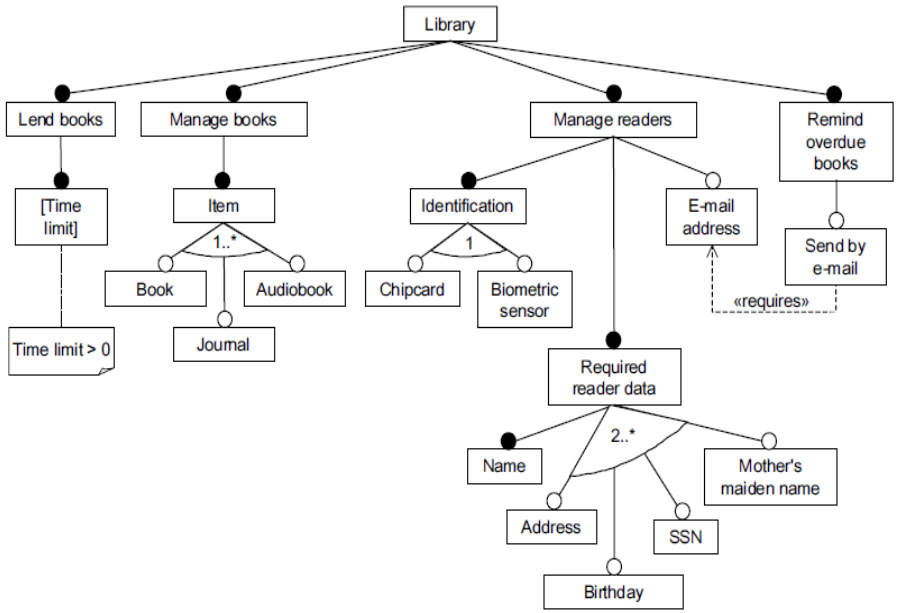
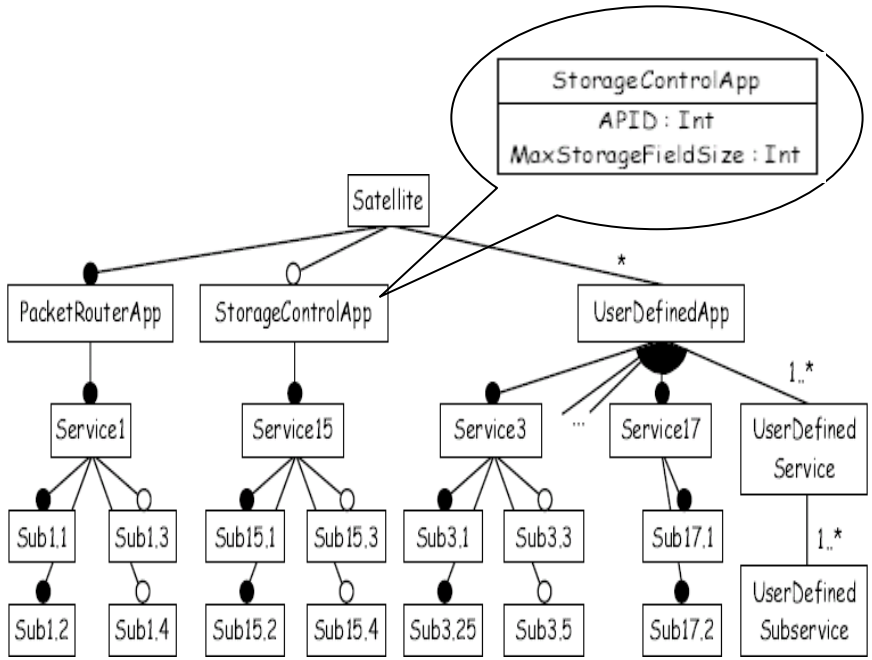
Feature Model Genealogy

Riebisch et al. Feature Model (M Riebisch et al., 2002)



- Diagram Shape / Feature Type
  - Inherit GP Feature Model
- Feature Group and Group Cardinality
- Constraint Notation

GP Extended Feature Model (K Czarnecki et al., 2002)



- Diagram Shape / Feature Type
  - Inherit GP Feature Model
- Feature Attributes
- Feature Cardinality

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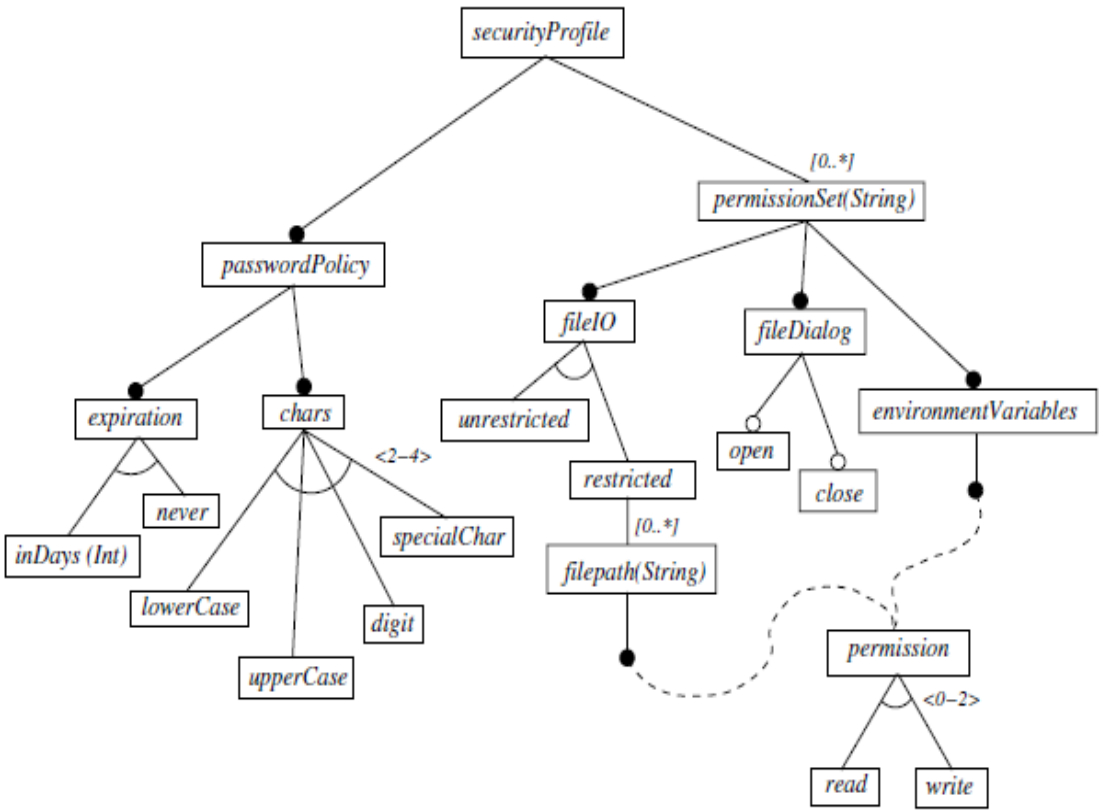
Cardinality-Based Feature Model
(K Czarnecki et al., 2004)



- Diagram Shape / Feature Type
  - Inherit GP Feature Model
- Relationship Type
  - Feature Diagram Reference (Dashed Line)
- Feature Cardinality
- Feature Group and Group Cardinality

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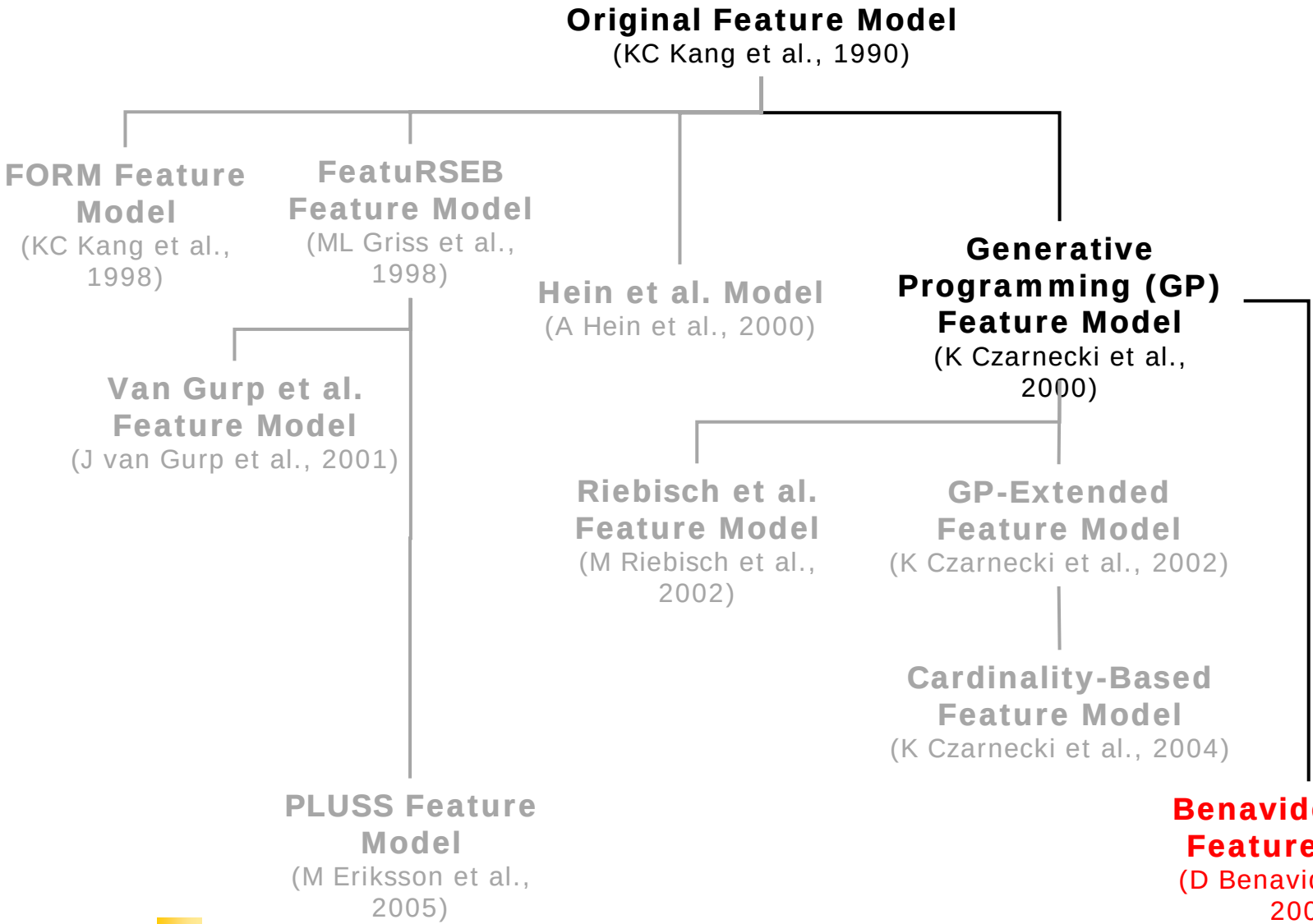
Feature Model Genealogy



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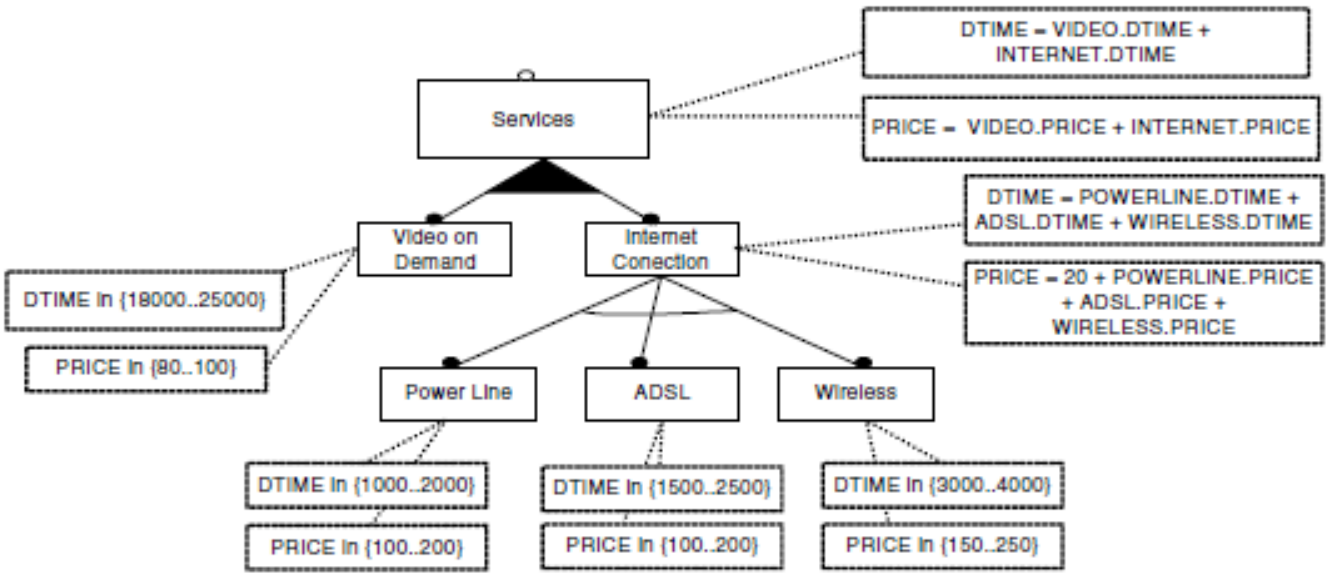
Benavides et al. Feature Model
(D Benavides et al., 2005)



- Diagram Shape / Feature Type
  - Inherit GP Feature Model
- Relationship Type
  - Attribute Relationship (with Dashed Line)
- Feature Attribute

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Why Popular?

- Codification of the Most Critical Information for Reuse
  - Commonality and Variability
  - Medium for Identifying Variation Points and Variants
- Simplicity
- Understandability
  - Intuitive
- Practicality
- Applicability

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Salient Features of FODA Report

- " For example, features from the window manager domain such as *constrainedMove* and *zapEffect* could have been specified more precisely using a formal specification technique."

  → Formalization

- " If the domain is well-defined and is expected to remain stable, a preprocessor or an application generator development technique might be appropriate to process the compile-time features."

  → Generative Programming

- " The description should also indicate whether it is a compile-time, an activation-time, or a runtime feature."

  → Binding time, Dynamic Product Line

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Salient Features of FODA Report

- " The classification of the features can be used in the components construction for modularization and for selection of appropriate development techniques."

  → Component Development

- " A record of the issues and decisions that arise in the course of the feature analysis must be incorporated into the feature model to provide the rationale for choosing options and selecting among several alternatives."

  → Configuration Decision Support

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Agenda

- Introduction
- Looking Back
  - Number of Citations
  - Feature Model Genealogy
  - Why Popular?
  - Salient Features of FODA Report
- Looking Forward
  - Future Works
  - Other Issues
- Acknowledgement

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Future Works

Feature analysis for different aspects at different phases of the life-cycle

PL Contexts	Requirements	Design	Implementation
Legal / Social Constraint User Profile Market / Business Usage Operating Environment Computing Resource / Platform Standards	Domain model Capability Use Case	Architecture Component Variation Point / Variants	Modules / Algorithms
	Configuration View Structural View Dependency View Binding View	FM-VP Decision Dependency Analysis (Consistency) QA Conformance Analysis View Consistency Analysis	Platform Conformance Analysis Variation Support Analysis Binding Time Support Connector Support

Decision Modeling (Rationales), Variability/Integrity Management

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Domain analysis

- Different domains may require different approaches
  - Service analysis may be good for business applications domains
  - How about goal analysis?
  - “Goal -> Service->feature” as a unified method?
- Modeling mechanisms
  - Feature model is popular but many extensions
    - Should it be standardized?
  - Formalization
- Deciding the right level of abstraction; how to structure
- Feature explosion problem
  - How to model, analyze, and manage
  - High level of complex dependencies among them
- Feature interaction problem

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Other Issues

- Goal-oriented (value-based) configuration of features
  - Knowledge-based configuration
  - Quality attributes or user-goals
- Going from domain analysis to architecture and component design
  - Designing architectures and components based on the analysis results (commonality and variability information)
    - SOA vs. agent-based vs. other architecture models
  - Building variability into architectures and components
  - Selecting appropriate mechanisms for the problem
  - Dealing with complex dependencies between features

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- Specification of models
  - Reuse contexts and assumptions
- Verification of quality attributes of integrated systems
  - Safety, reliability, etc.
  - Detecting feature interaction problems
- Configuration management
  - Version control of components and architectures with multi-product nature
  - Evolution of the product line itself

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- PL for systems in the newly emerging computing environments
  - Service Oriented Architecture
  - Ubiquitous computing environment/cloud computing
    - Dynamic binding of features
    - Run-time verification
  - From compile-time engineering to run-time engineering
    - Embedment of SE knowledge in running systems
- Tools!

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How to change to PL-based organization

- How to evolve: staged process model for reuse adoption
- Key process areas
  - Best practices
- Metrics
  - Key indicators: cost of production, time-to-market, project completion time, etc.
  - Relationship between reuse, quality, and productivity
  - Relationship between reuse and ROI for sustainability of a reuse program

Process models

- Proactive vs. reactive vs. extractive models
  - Best practices
- PL process vs. agile methods

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- Asset management (How to make PL-based development happen in an organization)-"Institutionalize" PL
  - Who should develop assets (with variation points)
  - Who should maintain assets (variability management)
  - Who will be responsible for quality assurance
  - Who should enforce the use of assets (policies)
  - Models (best practices)
    - Centralized vs. distributed
- Product line engineering in the context of a business strategy
  - "High option potentials"
  - ROI analysis
    - Estimating ROI from a reuse program
    - Estimating benefits from strategic market position
- Product line engineering in the global development environment
  - Component development outsourcing
    - Variability specification
    - Variability management

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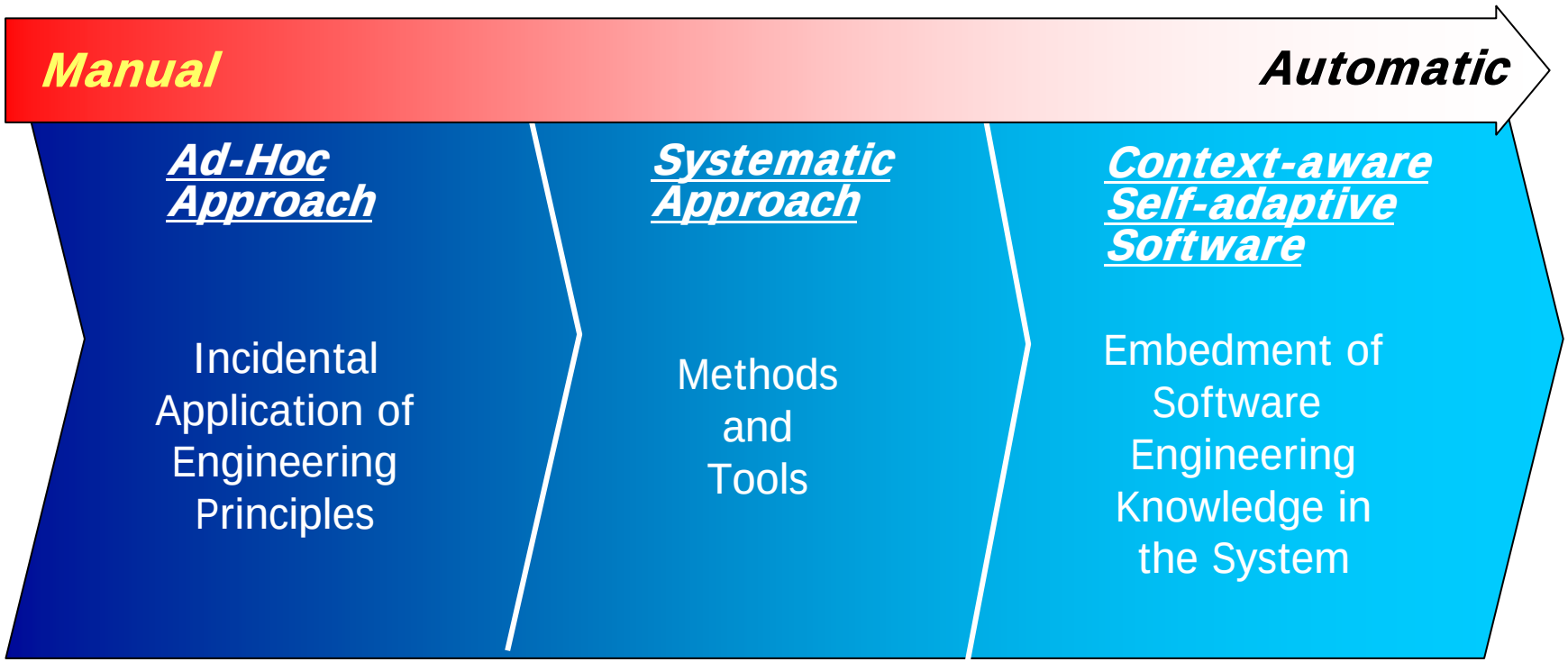
Embedment of SE Knowledge

Technical Trends



- Modulization
- Information hiding
- Encapsulation
- ...

- Commonality and variability analysis
- Parameterization
- Template framework
- ...

- Monitor and dynamic reconfigurator
- Dynamic binding
- Architecture reconfiguration
- Run-time verification
- ...

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