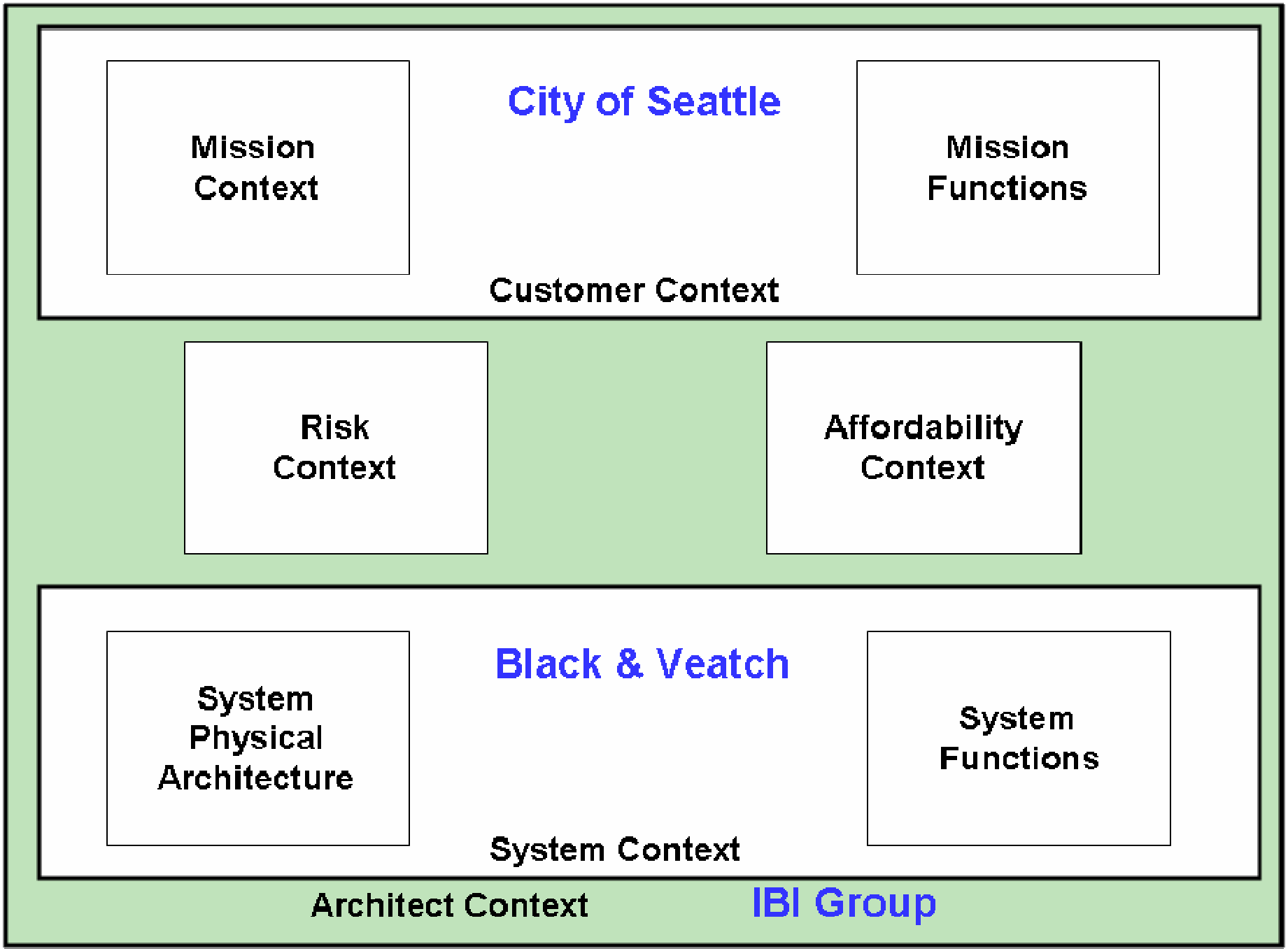
Evolutionary Computation Applied to System Architecture Development

Joseph Simpson
Dr. Cihan H. Dagli
April 5, 2008

Introduction

- Overview and Motivation
- Binary Matrix Representation
- Warfield - Interpretive Structural Modeling
- Formal Concept Analysis (FCS)
- Abstract Relation Types (ART)
- City of Seattle Example
- Summary



Customer Values List

A-07	Community Stewardship	G-09	Education
B-12	Environmental Quality	H-03	Progress
C-02	Freedom	I-05	Fiscal Responsibility
D-06	Economic Security	J-08	Opportunities
E-11	Environmental Stewardship	K-10	Diversity
F-01	Health and Safety	L-04	Social Equity

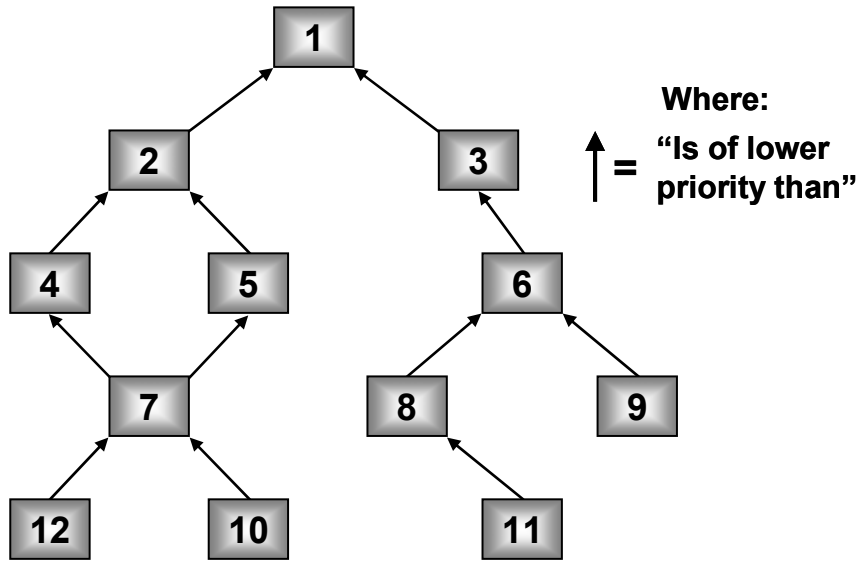
Matrix 1 - Unstructured

	A	B	C	D	E	F	G	H	I	J	K	L
A	1	0	0	0	0	1	0	0	1	0	0	1
B	1	1	0	0	0	1	0	0	0	0	0	0
C	0	0	1	0	0	1	0	0	0	0	0	0
D	0	0	0	1	0	1	0	1	0	0	0	0
E	1	0	0	0	1	1	0	0	0	0	0	0
F	0	0	0	0	0	1	0	0	0	0	0	0
G	0	0	0	1	0	1	1	0	0	0	0	0
H	0	0	0	0	0	1	0	1	0	0	0	0
I	0	0	1	0	0	1	0	0	1	0	0	0
J	0	0	0	1	0	1	0	0	0	1	0	0
K	1	0	0	0	0	1	0	0	0	0	1	0
L	0	0	1	0	0	1	0	0	0	0	0	1

Matrix 2 - Structured

	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0	0	0	0	0	0	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	0	0	0
3	1	0	1	0	0	0	0	0	0	0	0	0
4	1	1	0	1	0	0	0	0	0	0	0	0
5	1	1	0	0	1	0	0	0	0	0	0	0
6	1	0	1	0	0	1	0	0	0	0	0	0
7	1	0	0	1	1	0	1	0	0	0	0	0
8	1	0	0	0	0	1	0	1	0	0	0	0
9	1	0	0	0	0	1	0	0	1	0	0	0
10	1	0	0	0	0	0	1	0	0	1	0	0
11	1	0	0	0	0	0	0	1	0	0	1	0
12	1	0	0	0	0	0	1	0	0	0	0	1

Structured Graph



City of Seattle Mission Profile (example formal context)

Systems	Attributes						
	A	B	C	D	E	F	G
National	X		X			X	
State	X		X			X	
County	X	X	X	X			X
Regional	X	X	X	X			X
City of Seattle	X	X	X	X	X		X
Urban Core		X			X		X
Urban Village		X			X		X
Suburban		X			X		X

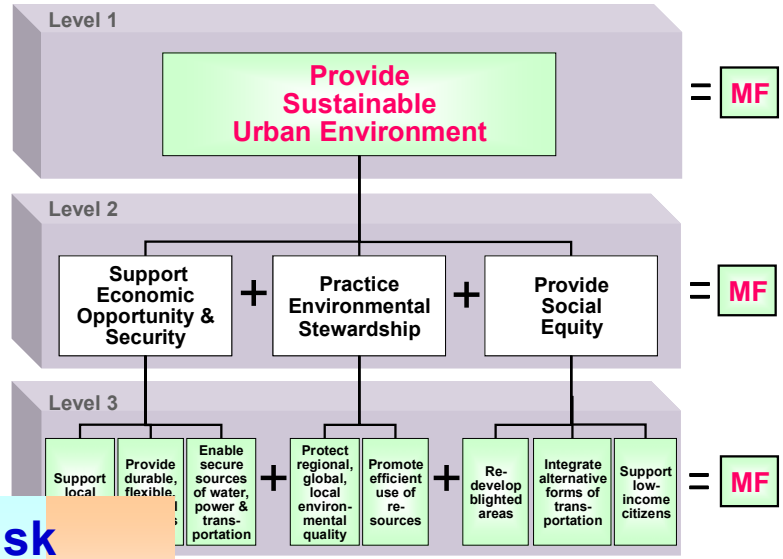
Where

A = Land Use
B = Utilities
C = Transportation
D = Economic Development
E = Economic / Environmental Security
F = Environmental Impact
G = Growth Mgt Restrictions

Architecture Example

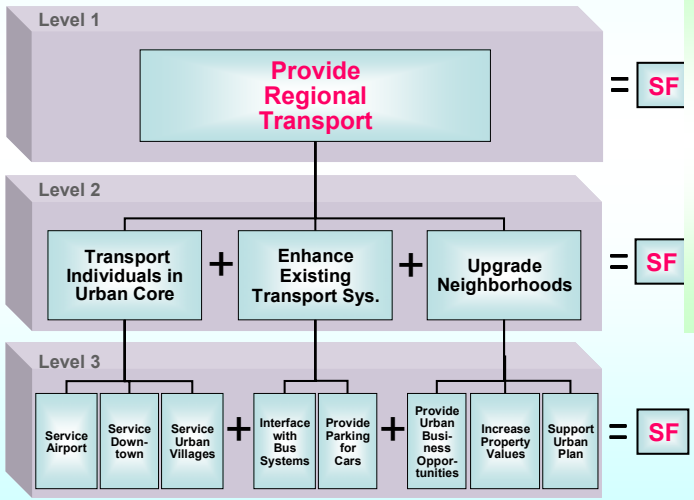
- Evaluate System and System of Systems Measures of Effectiveness Production Using Evolutionary Algorithms
- Three areas of the current development:
  - Using weighting factors for the roles
  - Exploring solution aggregation methods
  - Exploring different types of fuzzy inference methods.

City of Seattle Mission Function



A property of the system function that determines how well the mission function is performed

Operational Effectiveness



Regional Transport System Function

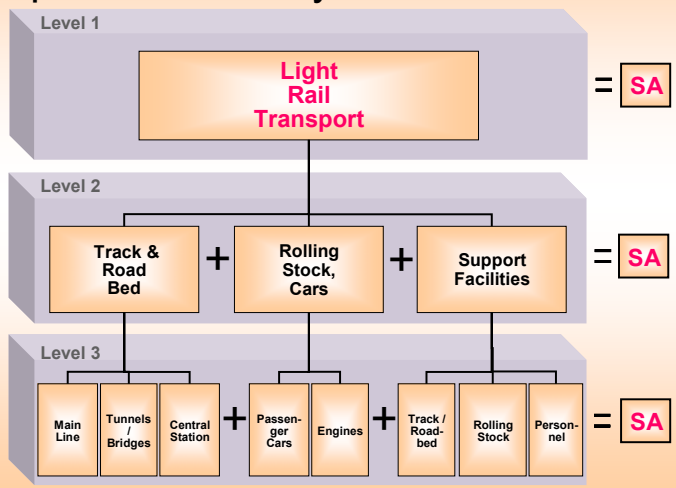
Risk

A property of the mission function, the system function and the system architecture

Operational Suitability

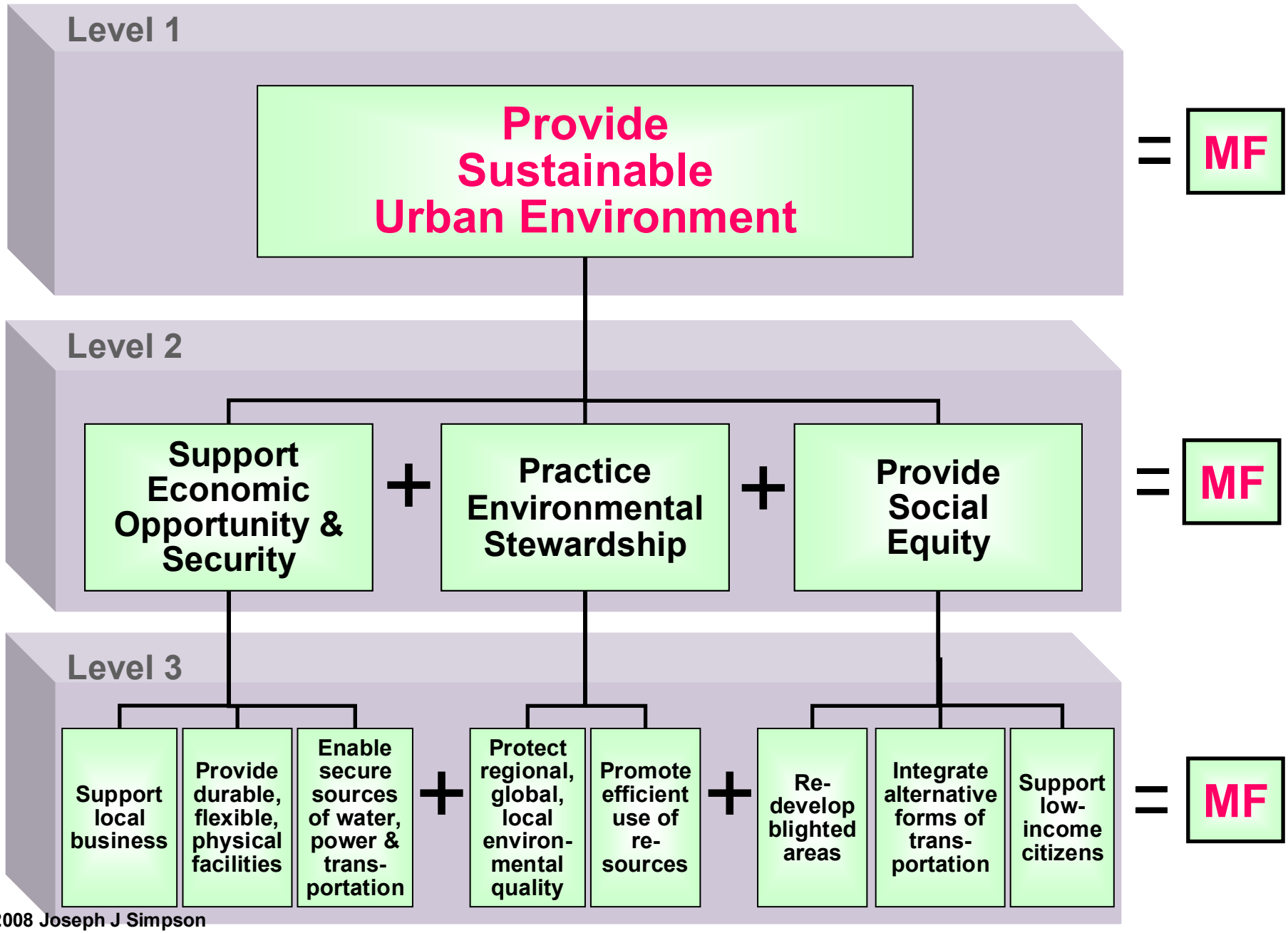
Life Cycle Cost

Properties of the system architecture

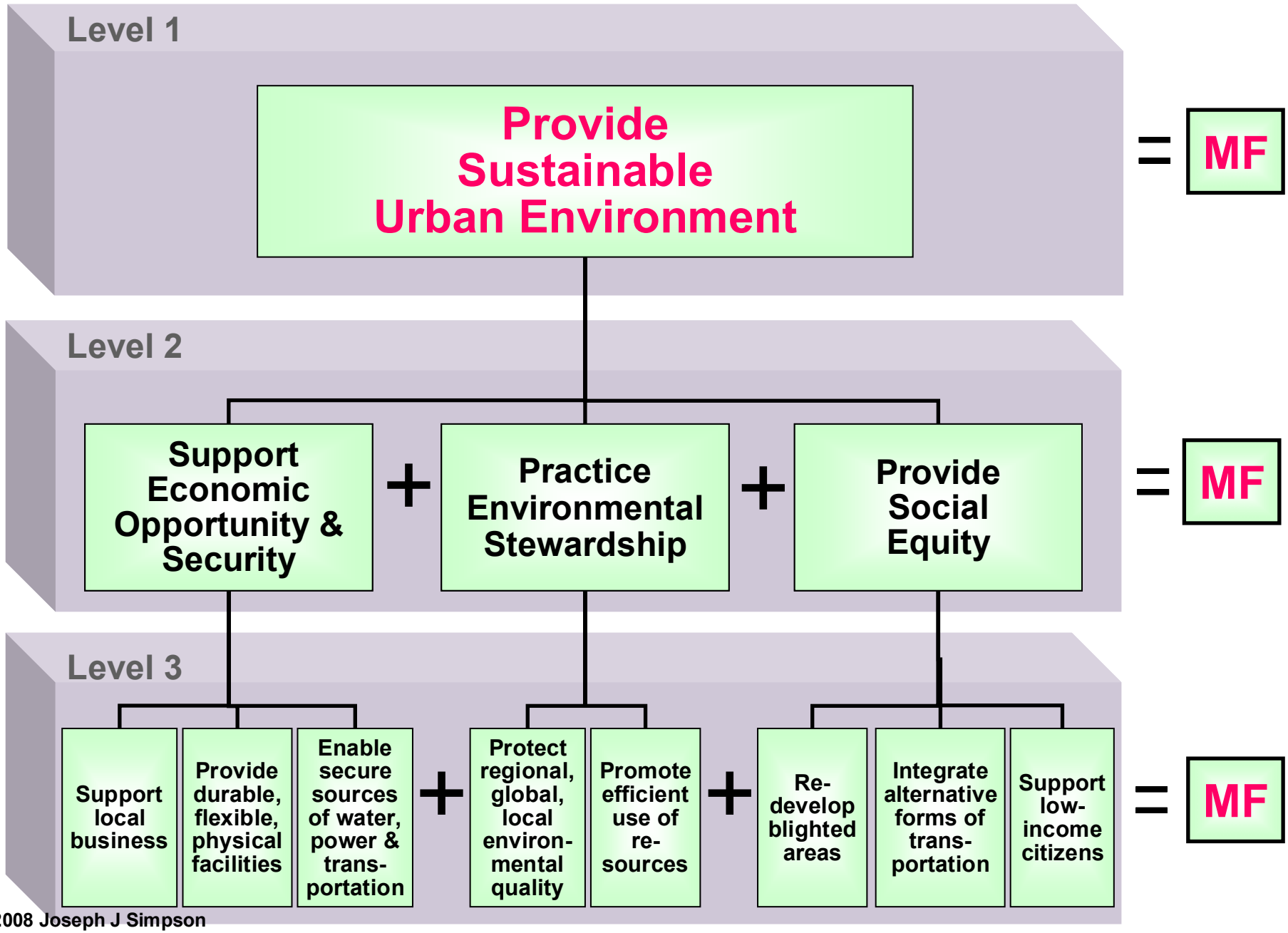


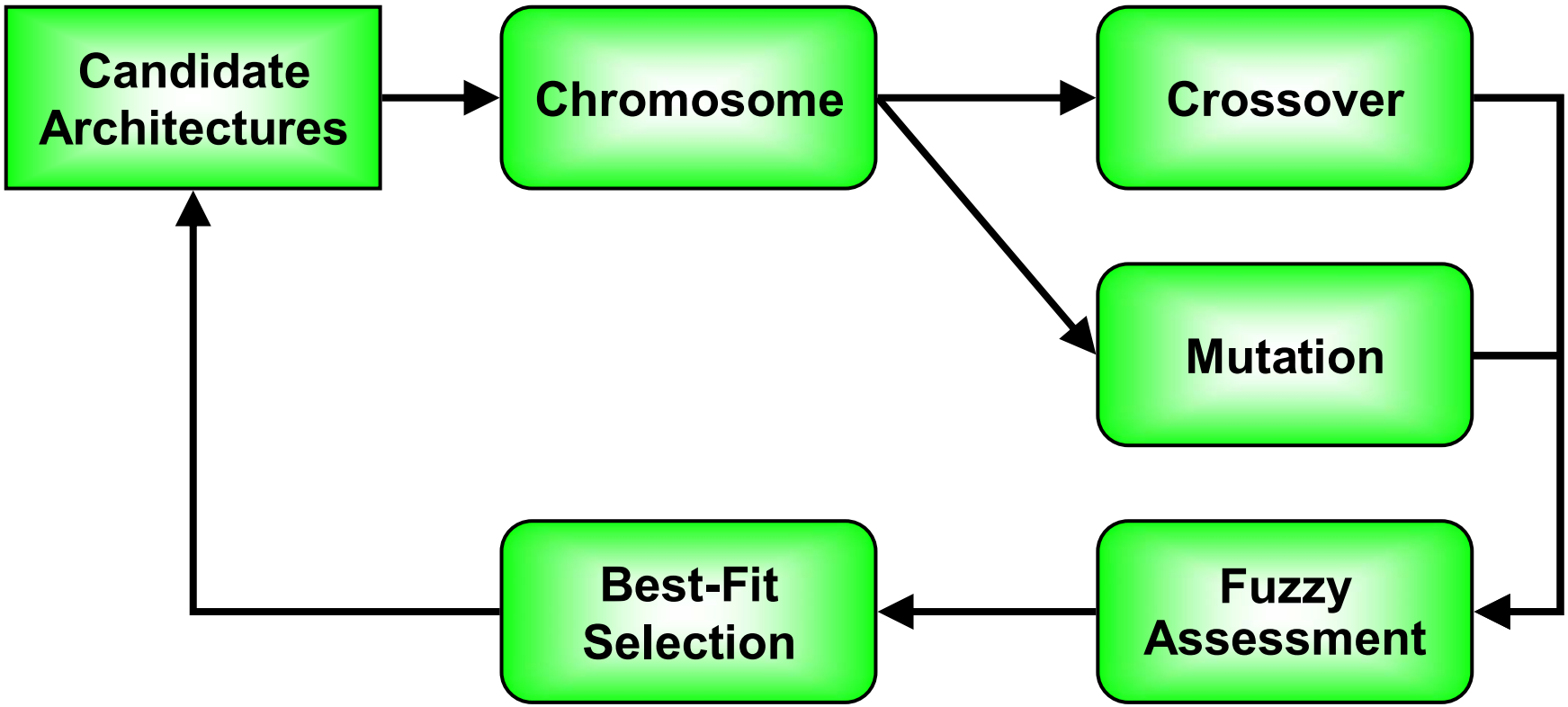
Light Rail Transport System Architecture

City of Seattle Mission Functions

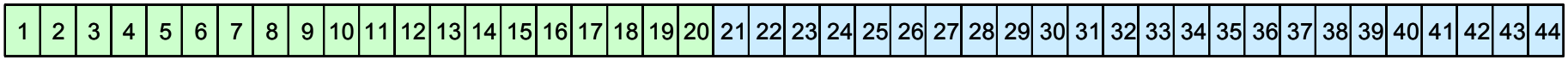


City of Seattle Mission Functions



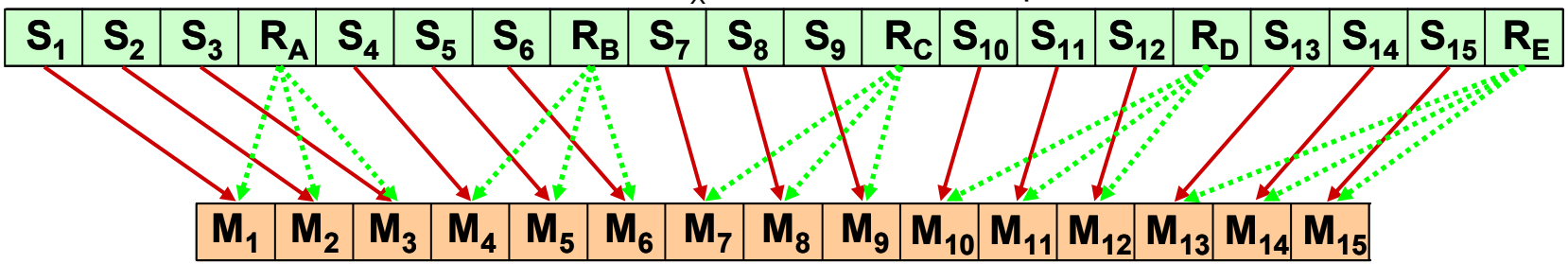


Genotype – Chromosome Structure



Genotype

Where $S_n \equiv n^{th}$ engineered system component
And $R_X \equiv x^{th}$ redundant component

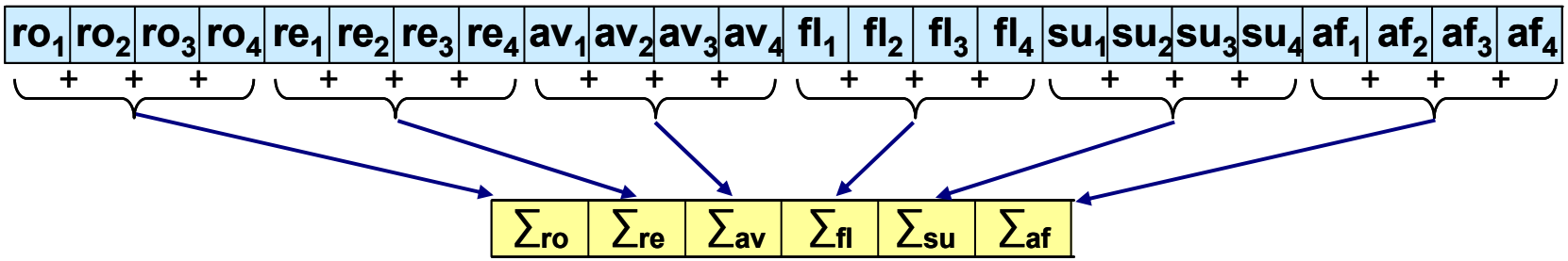


Operational Effectiveness

Where $M_n \equiv n^{th}$ City of Seattle Mission Function

Genotype

ro ≡ robustness
re ≡ reliability
av ≡ availability
fl ≡ flexibility
su ≡ survivability
af ≡ affordability



Operational Suitability, Risk, Affordability

Where $\sum_{yy}$ ≡ sum of the respective system attributes

Phenotype – Candidate Architecture

Summary

- Opportunity to apply effective technology
- Existing systems architecting representation
- Standard techniques – SE, SA and CI
- Low ‘cost of entry’ for CI and EA model
- Rapidly developing technology area

Questions?