From Understanding Great Design in Architecture Toward Achieving Great Design in Information Systems

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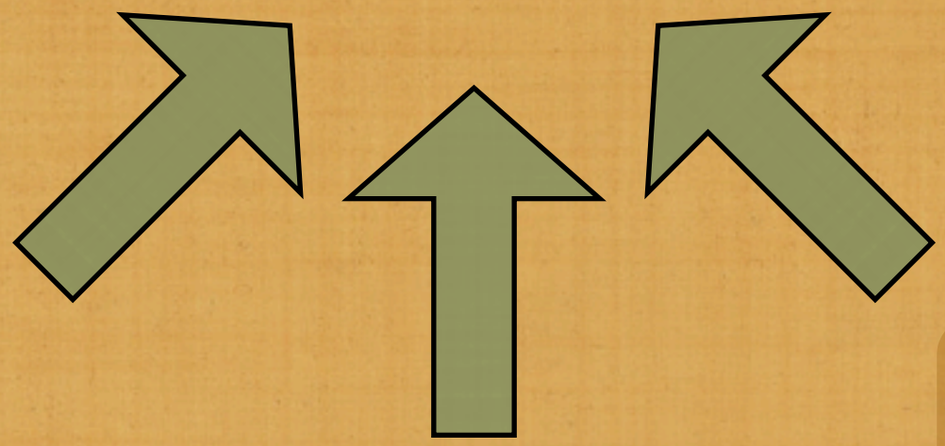
CIS/IPM Seminar 4/7/2008

Overview

- Is there science to guide great design? There are myriad “rules of thumb” and “patterns” born of experience that proffer assurance of successful design in this situation or that one. However, to aspire to great design we need to reach for a comprehensive perspective on design that guides our design choices.
- This presentation focuses on the qualities that define good, even great design as characterized by a leading theorist of physical architecture and the patriarch of pattern languages and design patterns, Christopher Alexander. I will map his concepts to design principles for models of information systems.
- This mapping coupled with George Lakoff's theory of the role of metaphor in human perception, cognition and understanding; and Fred Brooks' theory of essential and accidental elements of systems forms the heart of an ongoing search for a fundamental system of design principles to achieve *thriving information systems*.

A Search For A Fundamental System Of Design Principles To Achieve Thriving Information Systems



Fred Brooks' Essence and Accidents of Building Information Systems

Christopher Alexander's Theory of Life in Architecture

George Lakoff's Theories of Metaphor in Cognition

Fred Brooks Essence and Accidents of Building Information Systems

"Whereas the difference between poor conceptual designs and good ones may lie in the soundness of design-method, the difference between good designs and great ones surely does not. Great designs come from great designers. Software construction is a creative process. Sound methodology can empower and liberate the creative mind; it cannot inflame or inspire the drudge."

"The differences are not minor – they are rather like the differences between Salieri and Mozart. Study after study shows that the very best designers produce structures that are faster, smaller, simpler, cleaner, and produced with less effort. [...] The differences between the great and the average approach an order of magnitude."

"I believe the hard part of building software to be the specification, design, and testing of this conceptual construct, not the labor of representing it and testing the fidelity of the representation."

Brooks, Frederick P., "No Silver Bullet: Essence and Accidents of Software Engineering," *Computer*, Vol. 20, No. 4 (April 1987) pp. 10-19.

Christopher Alexander's Theory of Life in Architecture

Humans perceive order "as elements that systematically conform as constituent components of a whole achieving an arrangement of 'WHOLENESS'."

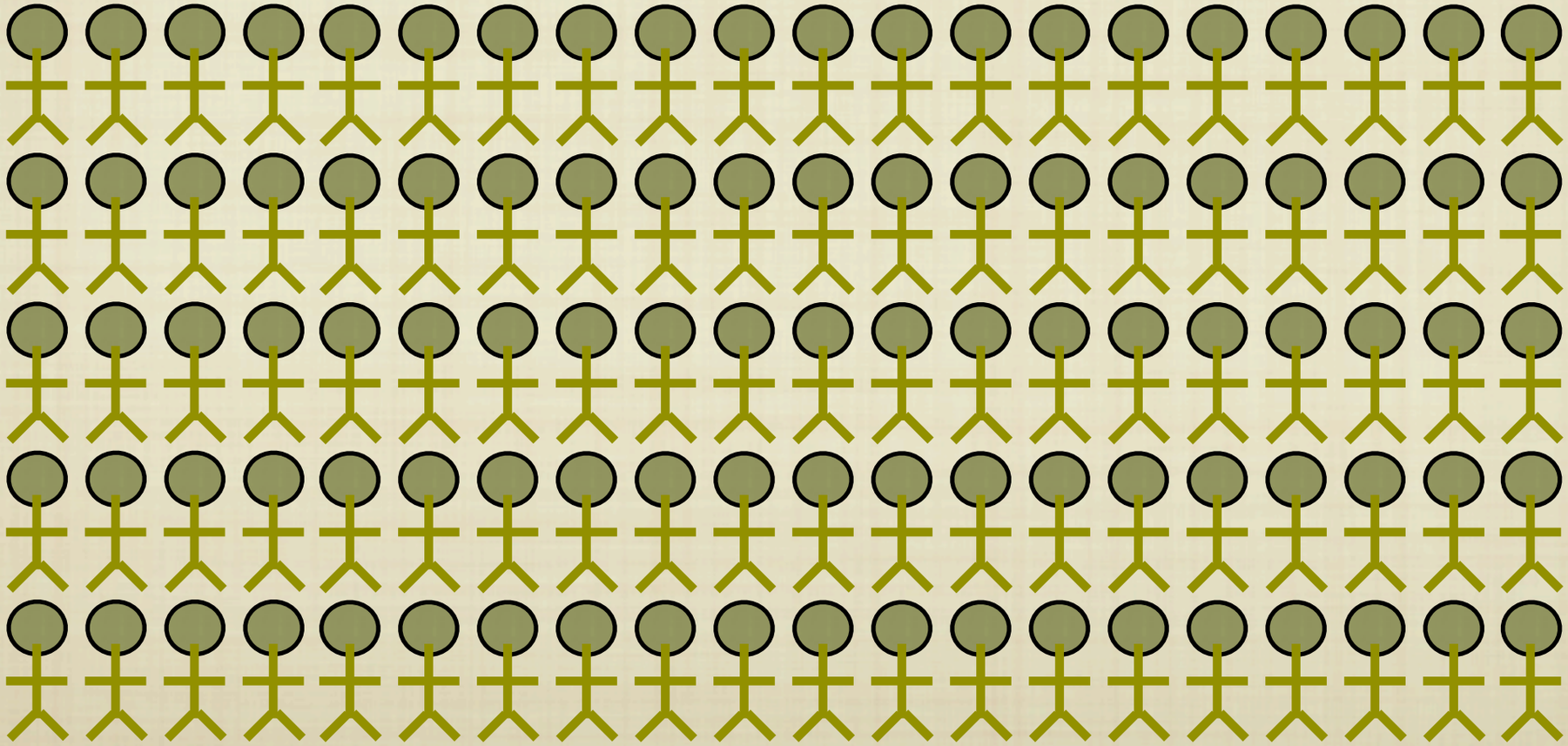
Presented any two systems as visual images, in excess of 80% of observers consistently agree upon which exhibits the greater degree of "life."

Order is dynamic rather than static. It derives not from multiplicity but from the transparency of unfolding structure.

"The concept extends to any space where objects & relationships are observed."

Alexander, Christopher, The Nature of Order An Essay on the Art of Building and the Nature of the Universe: Book I - The Phenomenon of Life, Berkeley, California: The Center for Environmental Structure, 2002.

>80% Consistently Agree on which system of visual images exhibit "Life"



George Lakoff's Theories of Metaphor in Cognition

- As physical beings our awareness is based upon a sensorimotor experience of the world around us that allows us to distinguish between event experiences.
- Through countless repetitions of sensorimotor experience we develop categories that give rise to prototypical concepts called primary metaphors.
- Most of these categorizations become so ingrained as to be operable at a subconscious level such that human subjects can "sense" an understanding or recognition of concepts without the immediate capacity to explain it.
- The physiology of the human brain is "hard-wired" to store, retrieve and correlate memory aided by categorization with new events categorized to a particular primary metaphor whose attributes are automatically ascribed to the new event (through immediate conceptual mapping via neural connections).
- Integrated in a spatial-motor sense of our surroundings (reaching for, moving toward or away from, being over, under, inside or outside of, surrounded by) the sensorimotor system of our experience is a continuous source of physical patterns that frame our consciousness and our subjectivity.

Lakoff, G. and M. Johnson, Metaphors We Live By, University of Chicago Press, Chicago, IL, 1980.
Lakoff, G. and M. Johnson, Philosophy in the Flesh, Basic Books, New York, NY, 1999.
Lakoff, G. and R. Núñez, Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being, Basic Books, New York, NY, 2000.

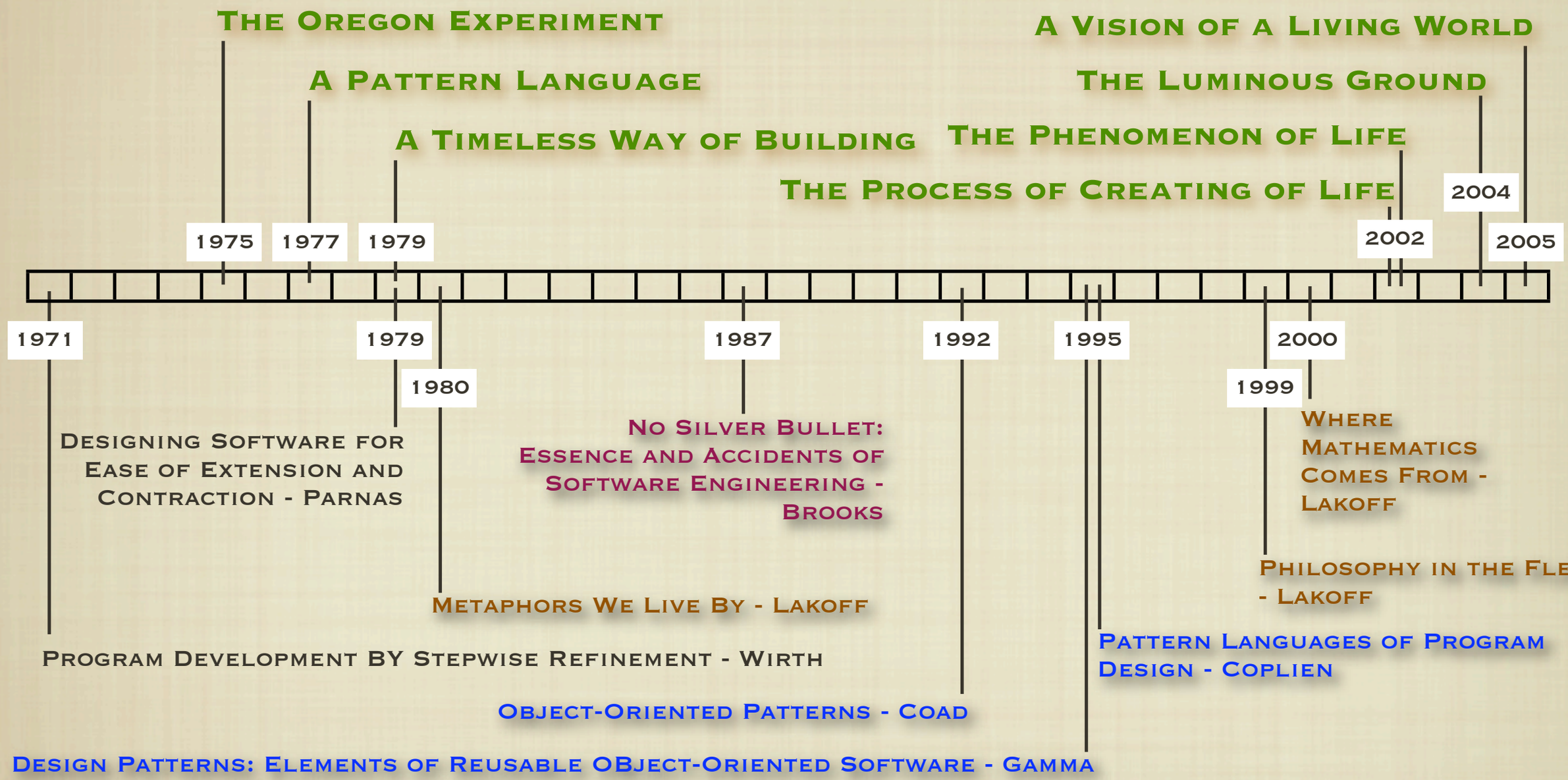
What Makes Great Architecture?

OOPSLA 1996 Keynote Speech Introduction by Jim Coplien

- "Once in a great while, a great idea makes it across the boundary of one discipline to take root in another. The adoption of **Christopher Alexander**'s patterns by the software community is one such event."

- "Alexander both commands respect and inspires controversy in his own discipline; he is the author of several books with long-running publication records,
  - the first recipient of the AIA Gold Medal for Research,
  - a member of the Swedish Royal Academy since 1980,
  - a member of the American Academy of Arts and Sciences,
  - recipient of dozens of awards and honors including:
    - the Best Building in Japan award in 1985,
    - the American Association of Collegiate Schools of Architecture Distinguished Professor Award."

Alexander's Journey in Design



The Nature of Order

- "The arrangement of things is based upon their arrival at relative positions influenced by forces that guide their movement or evolution. Continuously guided by these forces order emerges and is preserved over time, space or change as elements systematically conform as constituent components of a whole achieving an arrangement of 'wholeness'." (Alexander)

- Wholeness is stable, disorder is not!

Wholeness & Centers

- Center - "a distinct set of points in space, which, because of its organization, because of its internal coherence, and because of its relation to its context, exhibits centeredness, forms a local zone of relative centeredness with respect to other parts of space."

- "In any given region of space, some sub-regions have higher intensity as centers; others have less...or none. The overall configurations of their nested centers, together with their relative intensities, comprise a single structure – 'the' Wholeness of that region."

Center Properties

- Alexander identifies fifteen properties of centers that contribute to the degree of life experienced by an observer.
- "Quantum mechanics asserts, via the mathematics, that particles are physically affected in their behavior by the wholeness of the space in which they move. ... [Wholeness] is not restricted to buildings or works of art, but is valid and essential even in those parts of the world that we have historically believed to be mechanical in nature." (Alexander)

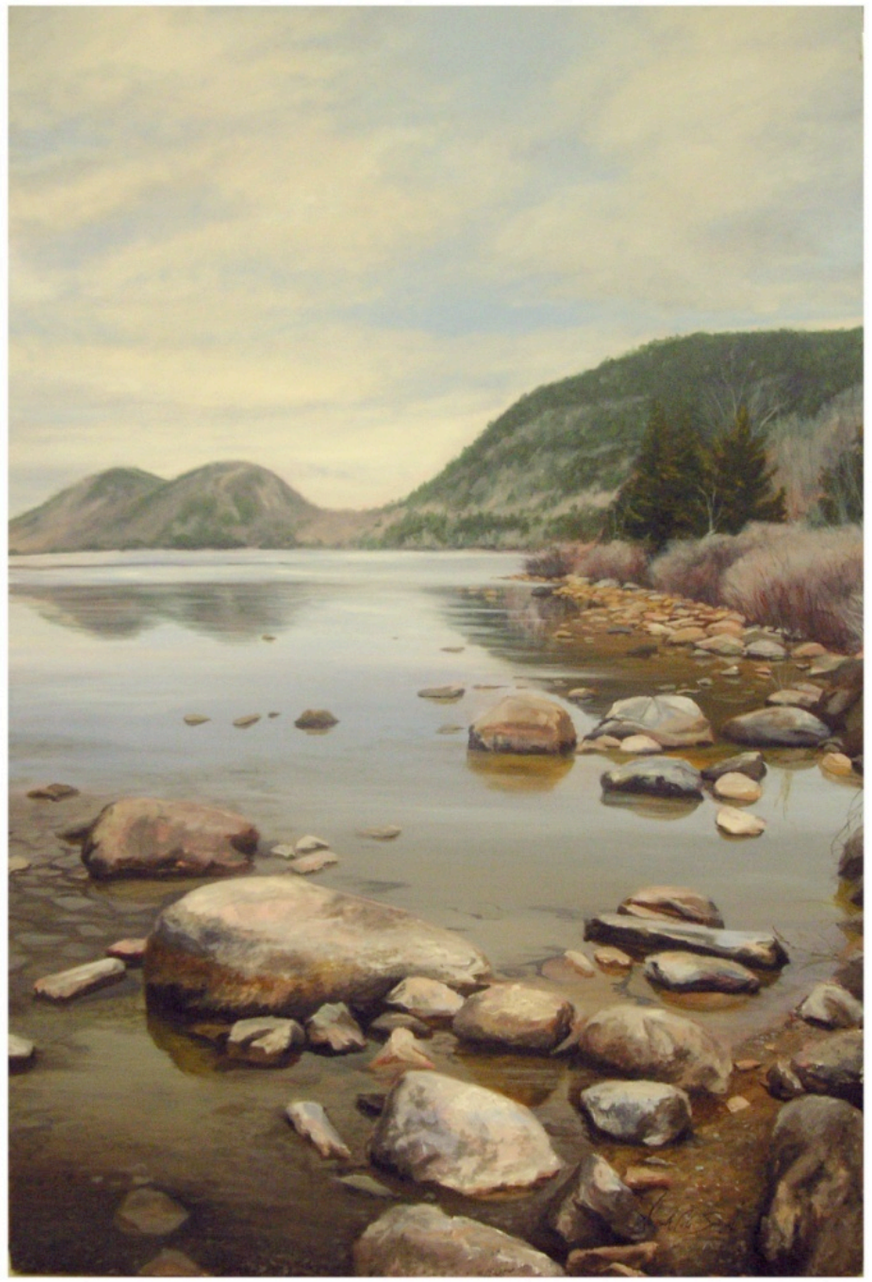
A Contemplative Tour of Alexander's 15 Properties of Centers

Levels of Scale

A strong center is made stronger partly by smaller strong centers contained in it, and partly by its larger strong centers which contain it.

A balanced range of sizes is pleasing and beautiful.

JORDAN POND WITH A VIEW OF THE BUBBLES



HANNAH COLE SCHIANO

Strong Centers

A strong center requires a field-like effect created by other centers.

Good design offers areas of focus or weight.

HAGIA SOPHIA

ISIDOROS AND ANTHEMIOS

Boundaries

The field-like effect is strengthened by the creation of a ring-like center.

Outlines focus attention on the center.

Alternating Repetition

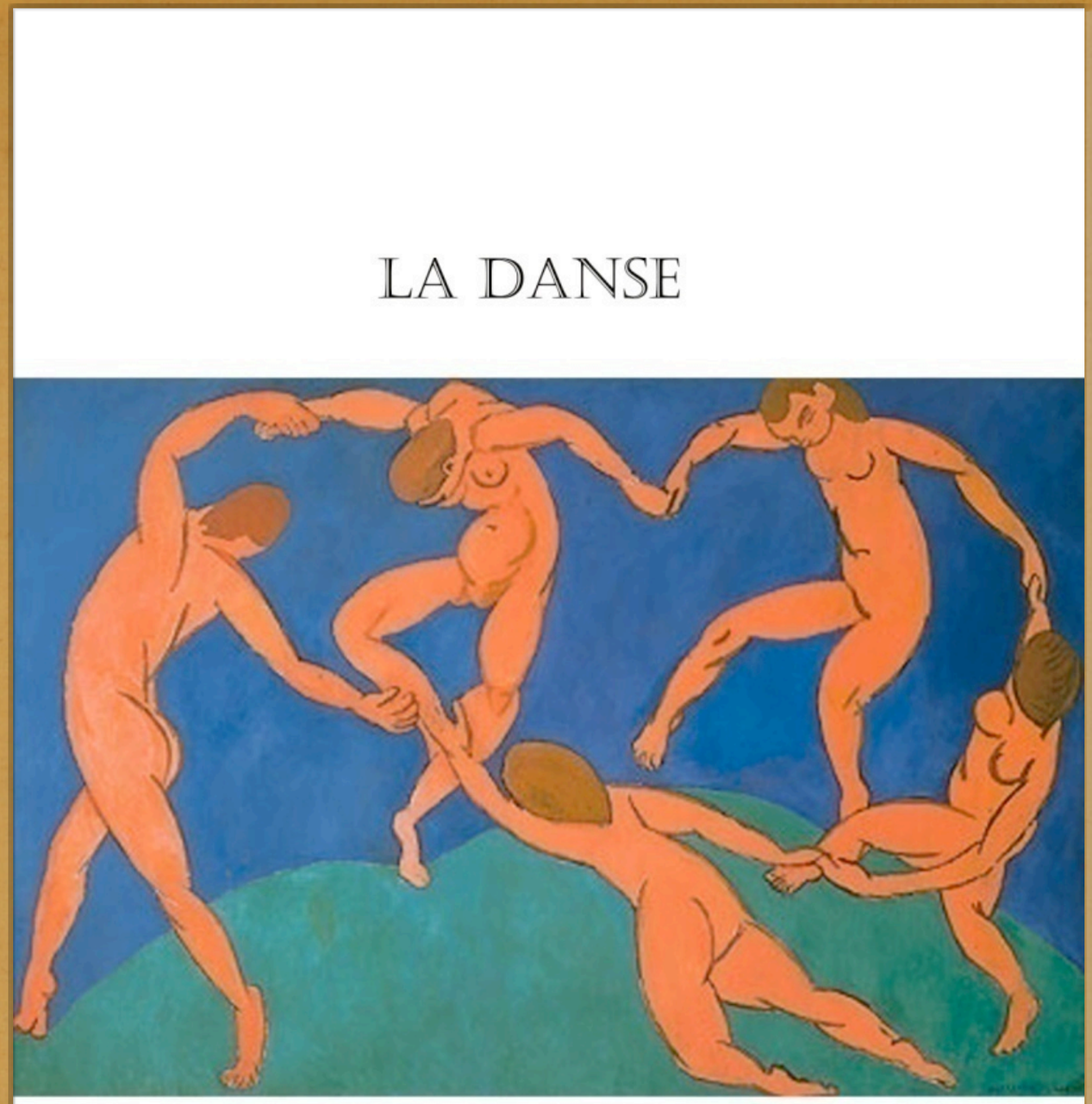
Centers are strengthened when they repeat, by the insertion of other centers between them.

Repeating various elements creates a sense of order and harmony.

Positive Space

A center should draw strength from the centers immediately adjacent.

Background should reinforce rather than detract from the center.

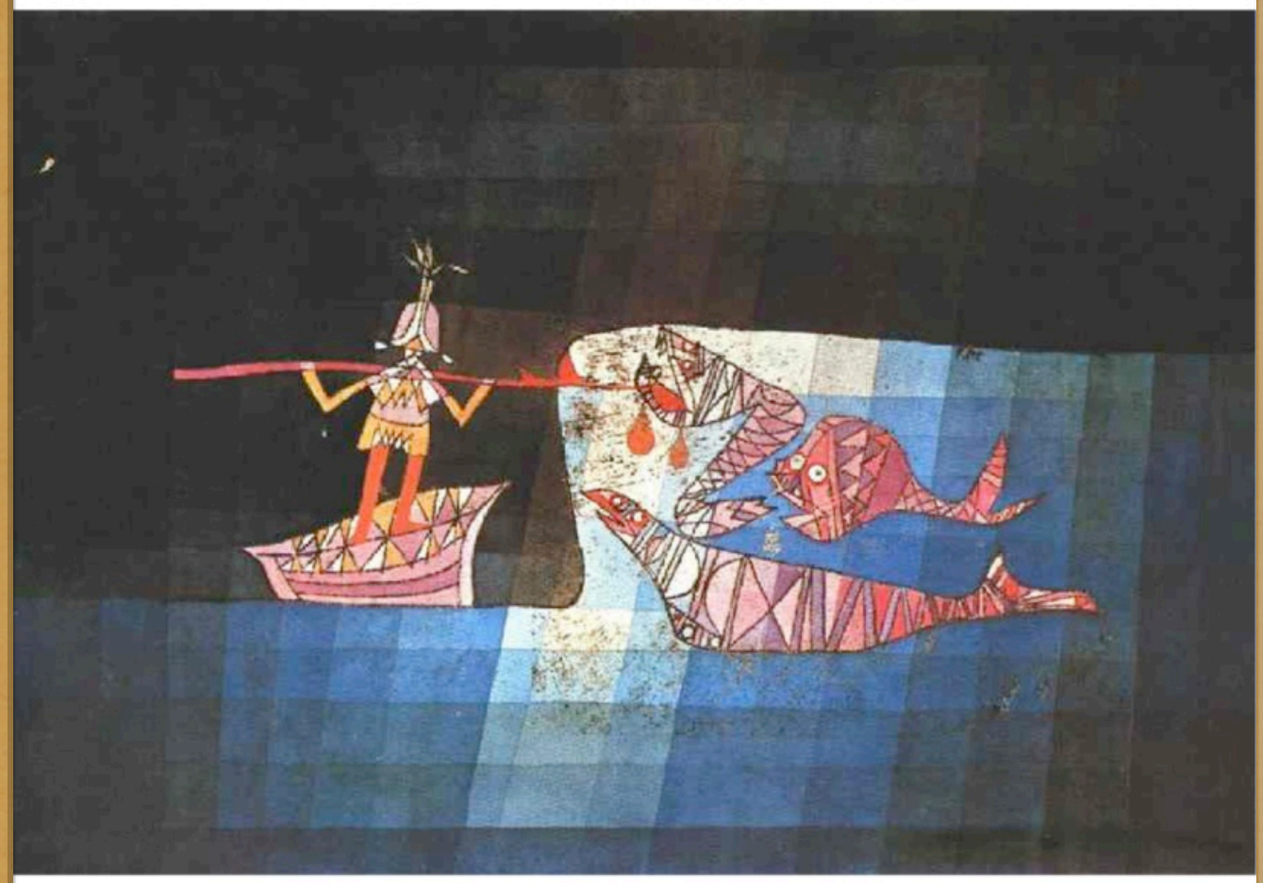


Good Shape

The strength of a given center depends on its actual shape. And the shape, its boundaries and the space around it must be made up of strong centers.

Simple forms create an intense, powerful center.

BATTLE SCENE



PAUL KLEE

Local Symmetries

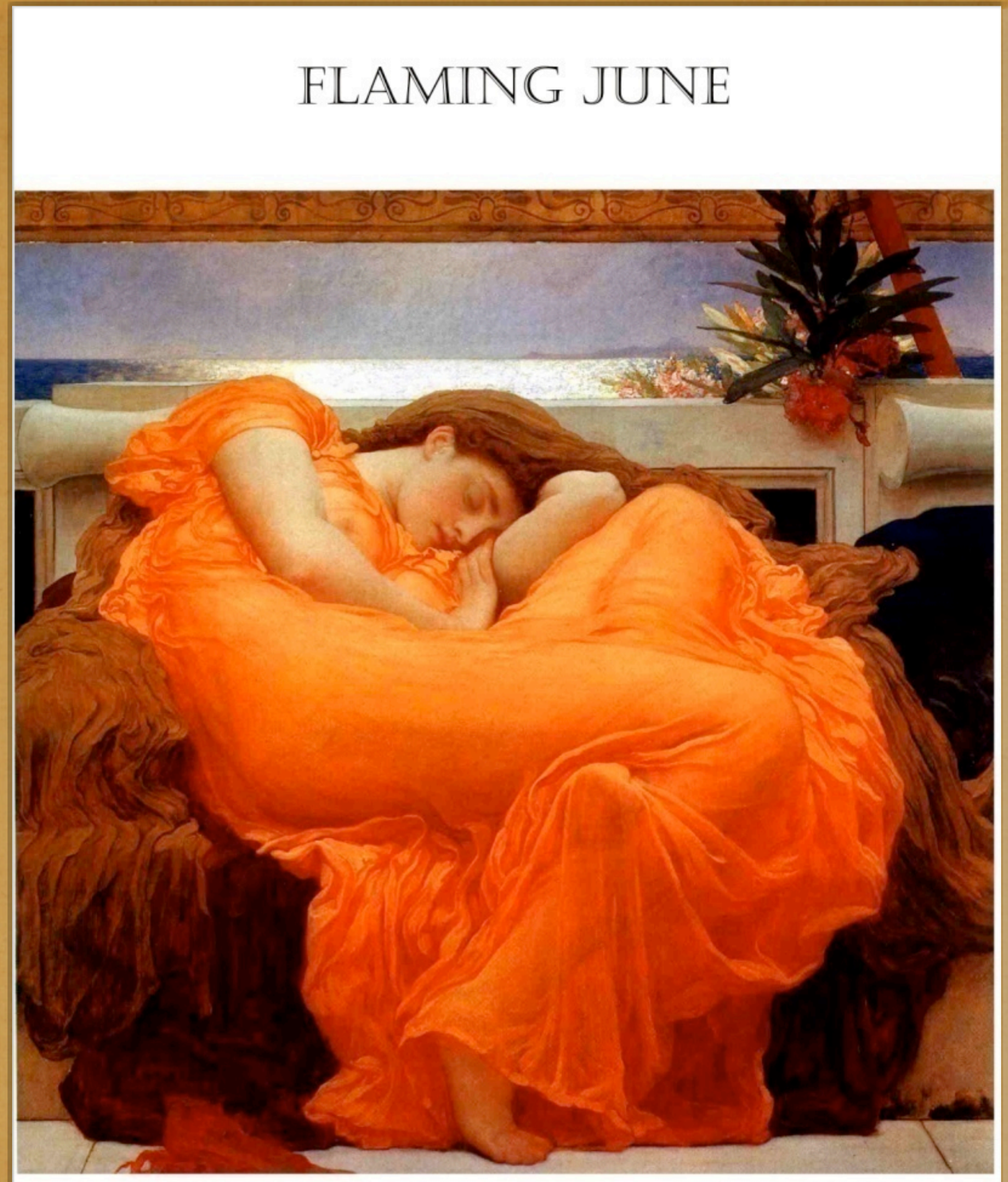
The intensity of a center is increased by the extent to which other smaller centers are themselves arranged in locally symmetrical groups.

Organic, small-scale symmetry works better than precise, overall symmetry.

Deep Interlock and Ambiguity

The intensity of a center can be increased when it is attached to nearby strong centers through a third set of strong centers that ambiguously belong to both.

Looping, interconnected elements promote unity and grace.



Contrast

A center is strengthened by the sharpness of distinction between itself and the surrounding centers.

Unity is achieved with visible opposites.

Gradients

A center is strengthened by a graded series of different sized centers which then point to a new center.

The proportional use of space and pattern creates harmony.

ALVAR AALTO, ELISSA AALTO
AND
HARALD DEILMANN

Roughness

The way a center draws its strength from irregularities in sizes, shapes and arrangements.

Texture and imperfections convey uniqueness and life.

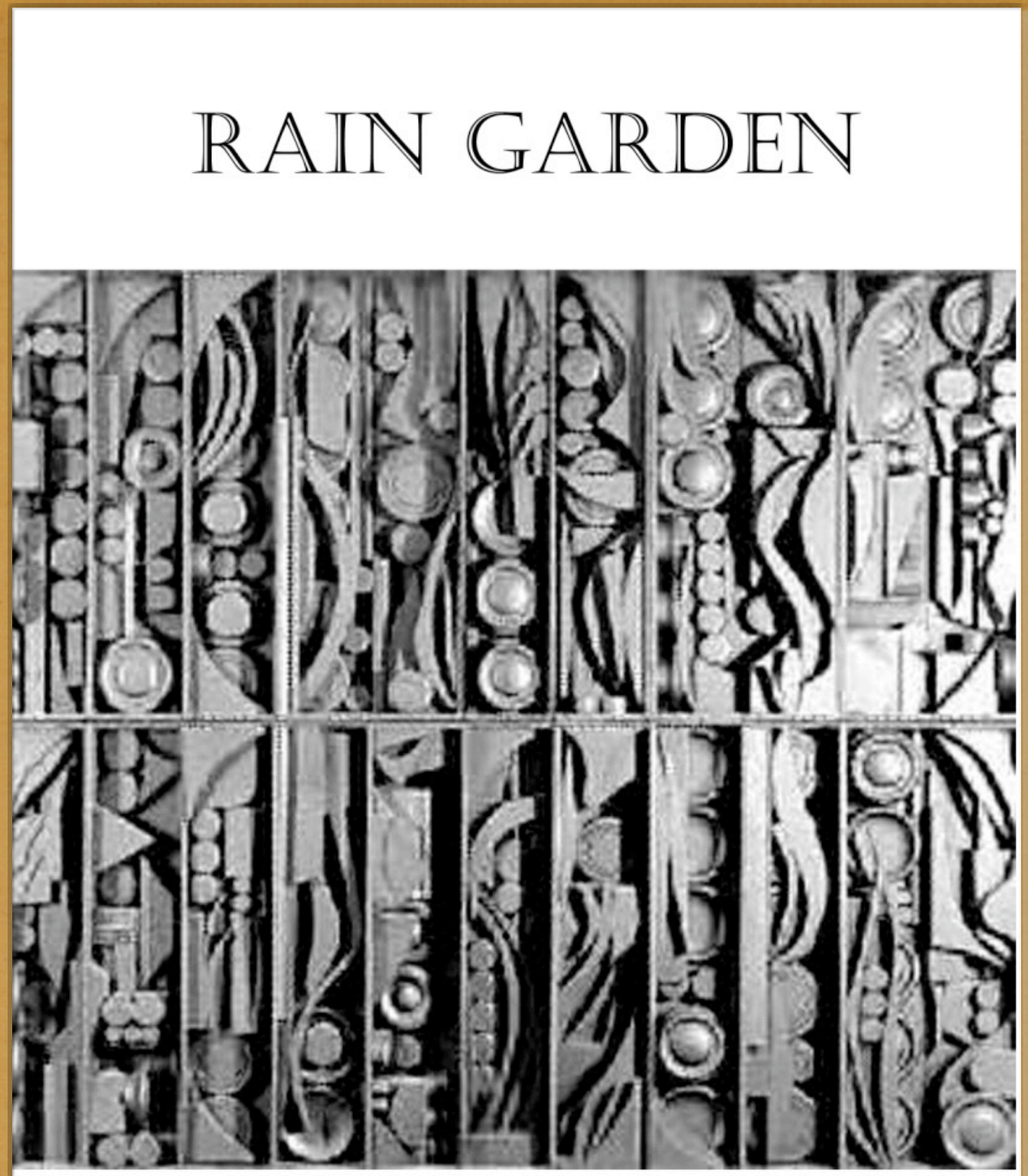
STORY PAINTER

JACOB LAWRENCE

Echoes

The strength of a given center depends on similarities of angle and orientation.

Similarities should repeat themselves throughout a design.



The Void

The intensity of every center depends on the existence of a still place – an empty center.

Empty spaces offer calm and contrast.

TIDAL BROOK WITH GRASS

SALLY LADD COLE

Simplicity and Inner Calm

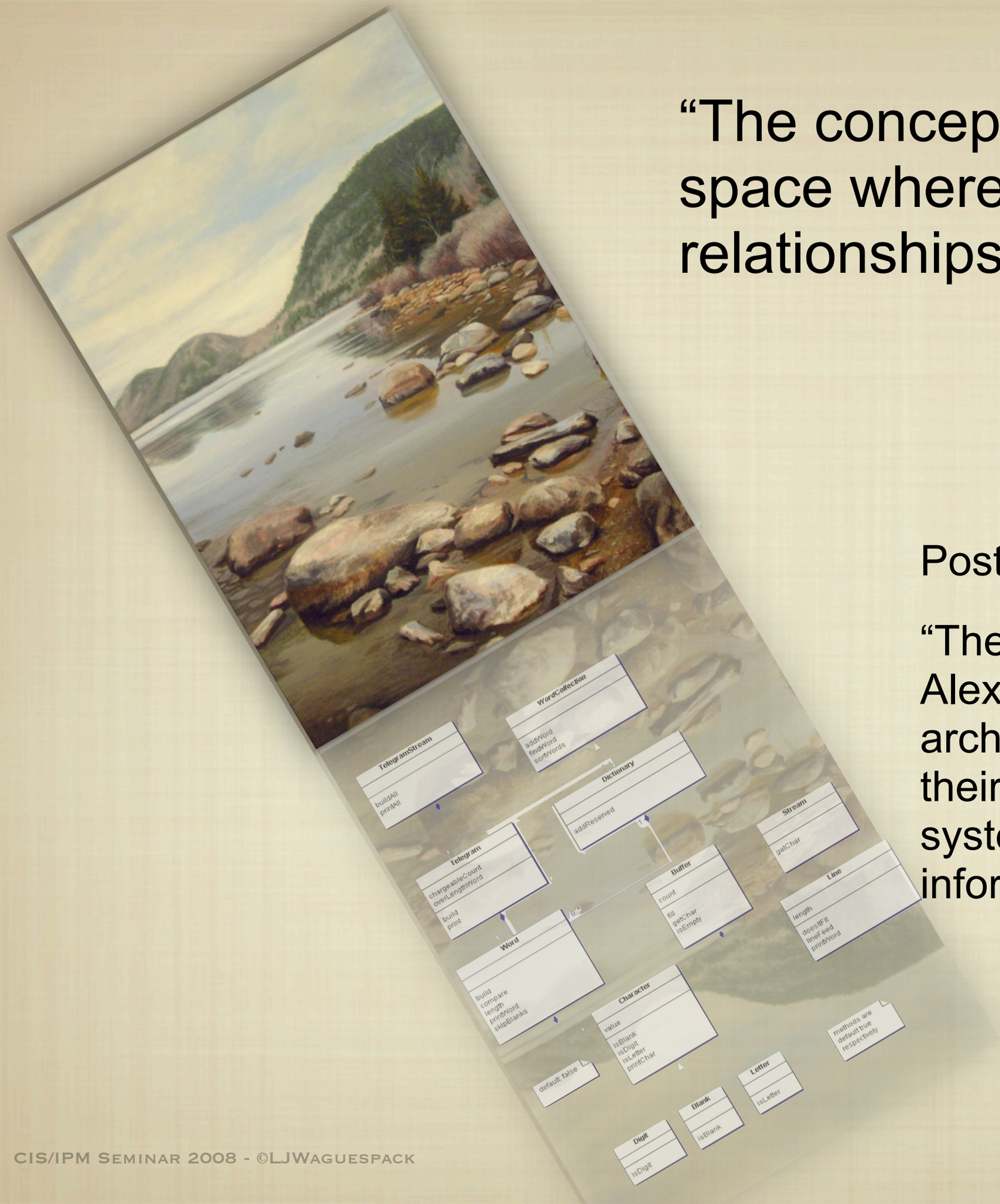
The strength of a center depends on its simplicity.

Use only essentials and avoid extraneous elements.

Not Separateness

The strength of a center depends on the extent to which that center is merged smoothly with surrounding centers.

Designs should be connected and complementary, not egocentric and isolated.



"The concept extends to any space where objects & relationships are observed."

Alexander

Postulation:

"The elements of order that Alexander describes for physical architecture may be perceived in their counterparts present in any system architecture – specifically information systems."

Waguespack

Centers in the conceptual World

- To apply Alexander's concepts of physical structure to information systems they must first be translated from a language of physical space to a language of cognitive space.
- physical position and distance translate to concepts of consonance in "fields" populated by abstractions rather than shapes.
- In this cognitive space we use the term choice as the counterpart of Alexander's term center.
- Center ==> Choice

Center Properties

Alexander's 15 Properties of Strong Centers
Levels of Scale
Strong Centers
Boundaries
Alternating Repetition
Positive Space
Good Shape
Local Symmetries
Deep Interlock and Ambiguity
Contrast
Gradients
Roughness
Echoes
The Void
Simplicity and Inner Calm
Not Separateness

Mapped to Choices

Alexander's 15 Properties of Strong Centers
Levels of Scale
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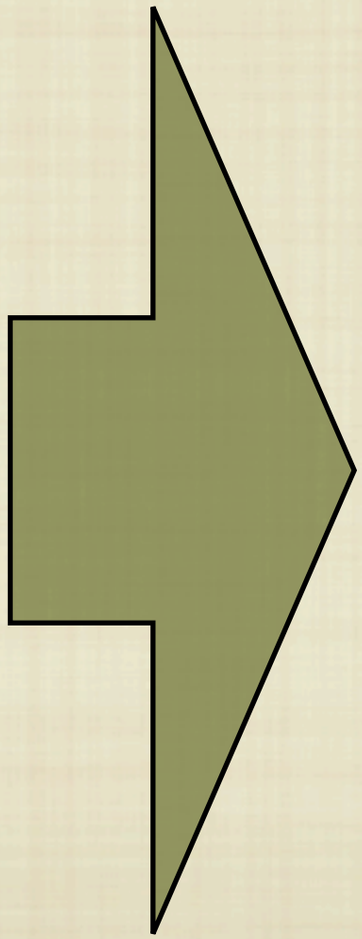


System Design Principles
Stepwise Refinement
Cohesion
Encapsulation
Extensibility
Modularization
Correctness
Transparency
Composition of Function
Identity
Scale
User Friendliness
Patterns
Programmability
Reliability
Elegance

Contrast ==> Identity

- Contrast: The way that a center is strengthened by the sharpness of the distinction between its character and the character of surrounding centers

- Identity: identity is whatever makes an entity definable and recognizable, ontologically or in terms of possessing a set of qualities or characteristics that distinguish it.

(e.g. In Data Modeling this is the foundation for the discriminating function of the primary key.)

Boundaries ==> Encapsulation

- Boundaries: The way that a field-like effect of a center is strengthened by the creation of a ring-like center, made of smaller centers that surround and intensify the first. The boundary also unites the center with the centers beyond it, thus strengthening it further.

Alexander Calder

- Encapsulation: In a collection of choices the distinctiveness and modularity of an individual choice combine like the bounding function of a cellular membrane holding the module's choice separate, distinct and locally complete exposed only through its interface.

Center Properties

	Alexander's Property Support Intersection Row item supported by column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Levels of Scale															
2	Strong Centers															
3	Boundaries															
4	Alternating Repetition															
5	Positive Space															
6	Good Shape															
7	Local Symmetries															
8	Deep Interlock and Ambiguity															
9	Contrast															
10	Gradients															
11	Roughness															
12	Echoes															
13	The Void															
14	Simplicity and Inner Calm															
15	Not Separateness															

Center Properties

	Alexander's Property Support Intersection Row item supported by column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Levels of Scale		●	●			●			●						
2	Strong Centers				●			●		●	●			●		●
3	Boundaries		●		●			●	●	●	●					
4	Alternating Repetition		●			●	●		●	●						●
5	Positive Space	●	●	●			●	●		●		●		●		
6	Good Shape	●	●			●			●		●		●		●	
7	Local Symmetries	●				●				●				●		
8	Deep Interlock and Ambiguity				●	●				●		●	●			●
9	Contrast			●		●			●		●			●		●
10	Gradients	●	●					●		●		●	●			●
11	Roughness		●			●	●				●				●	●
12	Echoes	●					●	●			●	●				●
13	The Void	●		●		●		●		●					●	
14	Simplicity and Inner Calm						●	●					●	●		●
15	Not Separateness			●		●			●		●	●		●	●	

Center Properties

	Alexander's Property Support Intersection Row item supported by column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Levels of Scale		●	●			●			●						
2	Strong Centers				●			●		●	●			●		●
3	Boundaries		●		●			●	●	●	●					
4	Alternating Repetition		●			●	●		●	●						●
5	Positive Space	●	●	●			●	●		●		●		●		
6	Good Shape	●	●			●			●		●		●		●	
7	Local Symmetries	●				●				●				●		
8	Deep Interlock and Ambiguity				●	●				●		●	●			●
9	Contrast			●		●			●		●			●		●
10	Gradients	●	●					●		●		●	●			●
11	Roughness		●			●	●				●				●	●
12	Echoes	●					●	●			●	●				●
13	The Void	●		●		●		●		●					●	
14	Simplicity and Inner Calm						●	●					●	●		●
15	Not Separateness			●		●			●		●	●		●	●	

Inter-Property Support Analysis

Alexander's Property Support Row item supported by column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Modeling principle
1 Levels of Scale	4															Stepwise Refinement
2 Strong Centers	1	6														Cohesion
3 Boundaries	2	4	6													Encapsulation
4 Alternating Repetition	3	2	3	6												Extensibility
5 Positive Space	4	3	3	3	8											Modularization
6 Good Shape	2	1	3	4	3	8										Correctness
7 Local Symmetries	1	2	1	2	3	2	4									Transparency
8 Deep Interlock and Ambiguity	1	2	2	2	2	1	3	4								Composition of Functi
9 Contrast	1	3	2	3	2	3	3	2	6							Identity
10 Gradients	2	3	3	3	4	3	2	1	1	7						Scale
11 Roughness	2	2	2	4	3	5	1	1	2	3	7					User Friendliness
12 Echoes	1	2	2	2	4	3	1	0	1	4	4	6				Patterns
13 The Void	2	2	2	2	4	3	3	2	2	2	1	2	6			Programmability
14 Simplicity and Inner Calm	0	3	2	2	2	1	1	1	2	3	1	2	1	5		Reliability
15 Not Separateness	1	2	2	2	3	4	2	2	5	1	4	2	3	2	7	Elegance

- I paired every combination of properties and counted the number of supporting properties that they shared in common. The resulting matrix is shown below.
- I propose that the intersection number indicates how "closely" one property is aligned with another based on the supporting properties they share. This involves a significant assumption: the contribution of any property is equivalent to the contribution of any other one, Given that assumption I hypothesize that "strength" of the "proximity" of one property to another may be used to indicate their "clustering" as in serve similar or related purposes in design quality.

Property Coherence Analysis

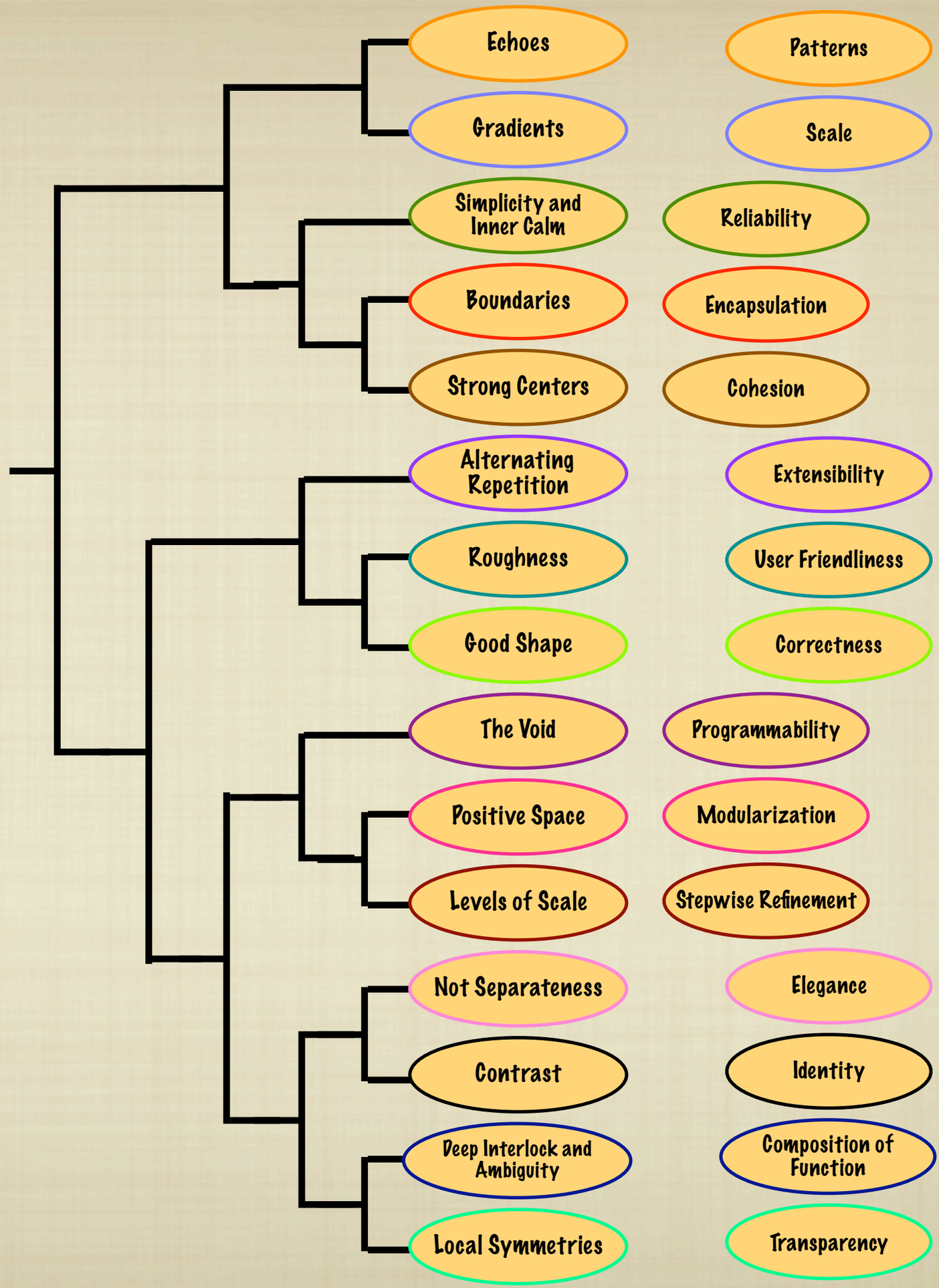
	Alexander's Property Support Coherence Row item supported by column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Modeling principle
1	Levels of Scale	0.00															Stepwise Refinement
2	Strong Centers	1.58	0.00														Cohesion
3	Boundaries	1.17	0.67	0.00													Encapsulation
4	Alternating Repetition	0.75	1.33	1.00	0.00												Extensibility
5	Positive Space	0.50	1.13	1.13	1.13	0.00											Modularization
6	Good Shape	1.25	1.71	1.13	0.83	1.25	0.00										Correctness
7	Local Symmetries	1.50	1.17	1.58	1.17	0.88	1.25	0.00									Transparency
8	Deep Interlock and Ambiguity	1.50	1.17	1.17	1.17	1.25	1.63	0.50	0.00								Composition of Function
9	Contrast	1.58	1.00	1.33	1.00	1.42	1.13	0.75	1.17	0.00							Identity
10	Gradients	1.21	1.07	1.07	1.07	0.93	1.20	1.21	1.61	1.69	0.00						Scale
11	Roughness	1.21	1.38	1.38	0.76	1.20	0.66	1.61	1.61	1.38	1.14	0.00					User Friendliness
12	Echoes	1.58	1.33	1.33	1.33	0.83	1.13	1.58	2.00	1.67	0.76	0.76	0.00				Patterns
13	The Void	1.17	1.33	1.33	1.33	0.83	1.13	0.75	1.17	1.33	1.38	1.69	1.33	0.00			Programmability
14	Simplicity and Inner Calm	2.00	0.90	1.27	1.27	1.35	1.68	1.55	1.55	1.27	0.97	1.66	1.27	1.63	0.00		Reliability
15	Not Separateness	1.61	1.38	1.38	1.38	1.20	0.93	1.21	1.21	0.45	1.71	0.86	1.38	1.07	1.31	0.00	Elegance

- To estimate "proximity" I devised the following definition of "coherence" or the degree to which two properties relate or contribute similarly to overall design quality. I calculated the degree of overlap between the supporting properties of every pair of properties in the set. For example: if all the supporting properties of Levels of Scale were found to support The Void then Levels of Scale's coherence with The Void would be 1.0 on a scale from 0-1. If only half were found then the coherence would be 0.5. Then coherence in the opposite direction is measured. That is, if all the supporting properties of The Void were found in the to support Levels of Scale then The Void's coherence with Levels of Scale would be 1.0, and so on. Therefore the minimum coherence between any two properties would be 0.0 while the maximum would be 2.0. Again using the assumption that "coherence" may be an additive characteristic.

	Center Property											Design Principle	
	Property being supported by:									#'s	#	Property being supported by:	Cluster#
10	Gradients	1	2	7	9	11	12	15		7	10	Scale	1
12	Echoes	1	6	7	10	11	15			6	12	Patterns	1
2	Strong Centers	4	7	9	10	13	15			6	2	Cohesion	2
3	Boundaries	2	4	7	8	9	10			6	3	Encapsulation	2
14	Simplicity and Inner Calm	7	8	12	13	15				5	14	Reliability	2
4	Alternating Repetition	2	5	6	8	9	15			6	4	Extensibility	3
6	Good Shape	1	2	5	6	8	10	12	14	8	6	Correctness	3
11	Roughness	2	5	6	10	11	14	15		7	11	User Friendliness	3
1	Levels of Scale	2	3	6	9					4	1	Stepwise Refinement	4
5	Positive Space	1	2	3	6	7	9	11	13	8	5	Modularization	4
13	The Void	1	3	5	7	9	14			6	13	Programmability	4
7	Local Symmetries	1	5	9	13					4	7	Transparency	5
8	Deep Interlock and Ambiguity	4	5	9	13					4	8	Composition of Function	5
9	Contrast	3	5	8	10	13	15			6	9	Identity	5
15	Not Separateness	3	5	8	10	11	13	14		7	15	Elegance	5

	Center Property	Properties that support all members of the cluster	#	Design Principle	Principles that support all members of the cluster
Cluster 1					
	Gradients	Levels of Scale	1	Scale	Stepwise Refinement
	Echoes	Local Symmetries	7	Patterns	Transparency
		Roughness	11		User Friendliness
		Not Separateness	15		Elegance
Cluster 2					
	Strong Centers	Local Symmetries	7	Cohesion	Transparency
	Boundaries	Not Separateness	15	Encapsulation	Elegance
	Simplicity and Inner Calm			Reliability	
Cluster 3					
	Alternating Repetition	Strong Centers	2	Extensibility	Cohesion
	Good Shape	Positive Space	5	Correctness	Modularization
	Roughness	Good Shape	6	User Friendliness	Correctness
Cluster 4					
	Levels of Scale	Boundaries	3	Stepwise Refinement	Encapsulation
	Positive Space	Contrast	9	Modularization	Identity
	The Void			Programmability	
Cluster 5					
	Local Symmetries	Positive Space	5	Transparency	Modularization
	Deep Interlock and Ambigu	The Void	13	Composition of Functic	Programmability
	Contrast			Identity	
	Not Separateness			Elegance	

- Using Alexander's supporting property list we clustered the properties based on the degree of overlapping supporting properties.
- The hierarchical clustering depicts the coherence or affinity between properties based upon the support they share
- The "reasonableness" of the mapping of property clusters to design principle clusters is another indication of the accuracy / efficacy of the mapping from properties to design principles.



Thriving System

Design Principle

Design Principle Cluster

Supporting Principles Shared by every principle in the cluster

Confident Assurance

- Reliability
- Transparency
- Elegance
- Encapsulation
- Cohesion
- Identity

Predictable Unfolding

- Stepwise Refinement
- Transparency
- User Friendliness
- Elegance
- Patterns
- Scale
- Transparency

Sustainable Vitality

- Modularization
- Elegance
- Programmability
- Composition of Function

Faithful Service

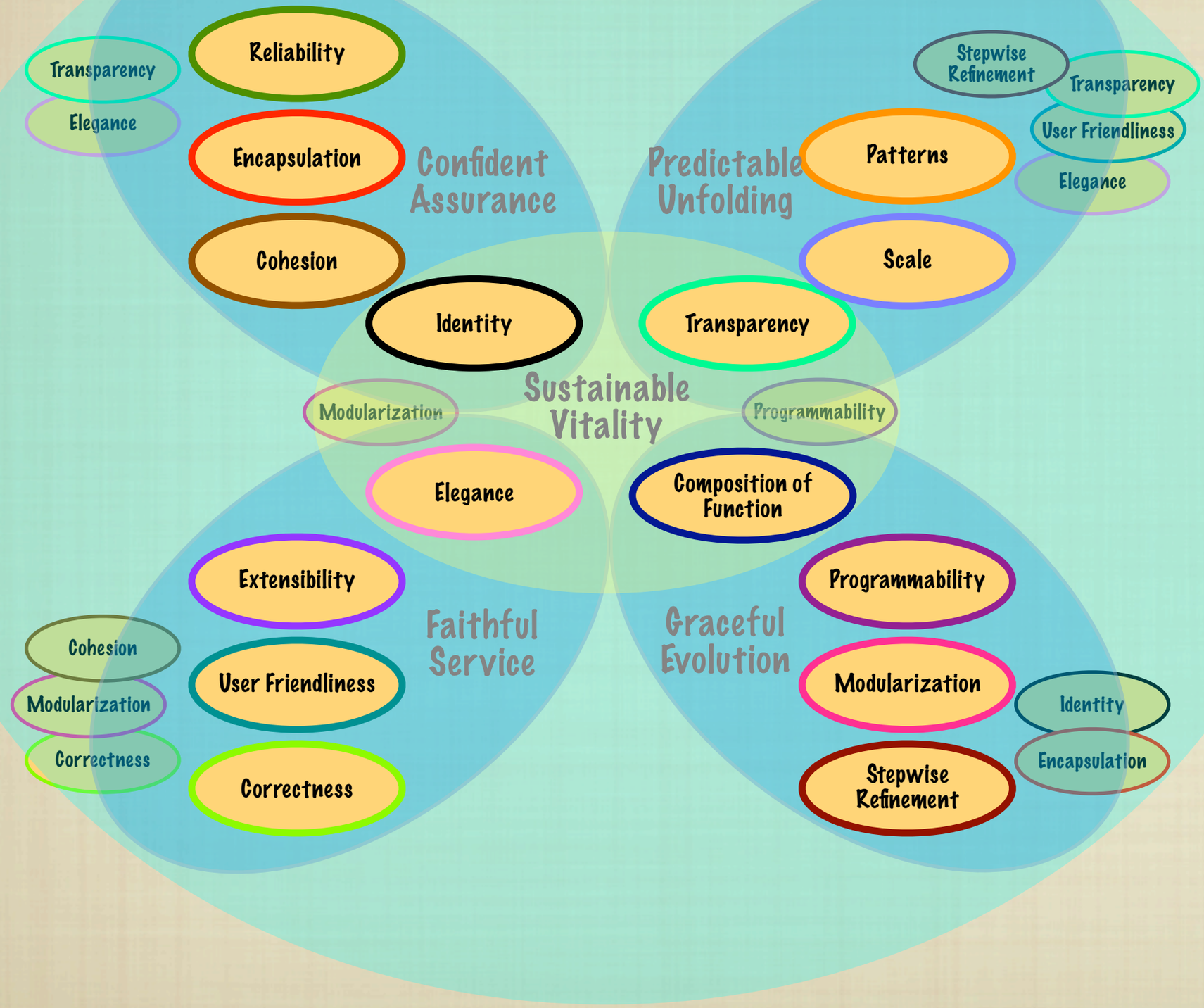
- Extensibility
- Cohesion
- Modularization
- User Friendliness
- Correctness
- Correctness

Graceful Evolution

- Programmability
- Modularization
- Identity
- Encapsulation
- Stepwise Refinement

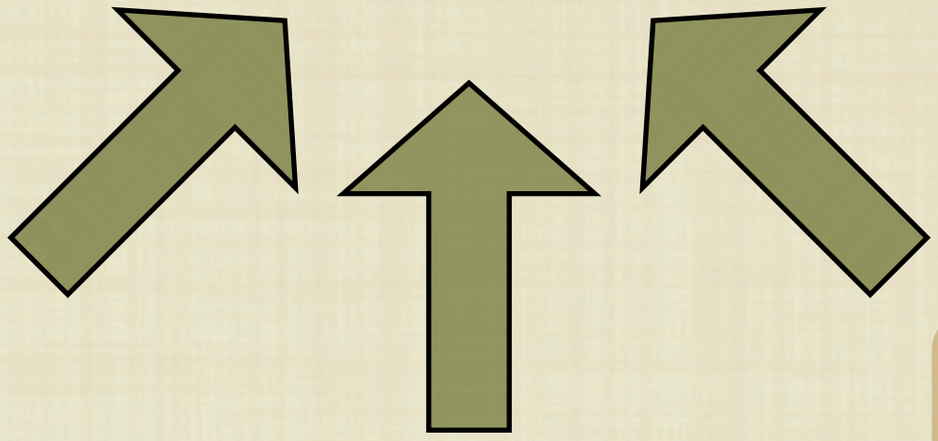
- Echoes
- Patterns
- Gradients
- Scale
- Simplicity and Inner Calm
- Reliability
- Boundaries
- Encapsulation
- Strong Centers
- Cohesion
- Alternating Repetition
- Extensibility
- Roughness
- User Friendliness
- Good Shape
- Correctness
- The Void
- Programmability
- Positive Space
- Modularization
- Levels of Scale
- Stepwise Refinement
- Not Separateness
- Elegance
- Contrast
- Identity
- Deep Interlock and Ambiguity
- Composition of Function
- Local Symmetries
- Transparency

Thriving System



- Echoes
- Patterns
- Gradients
- Scale
- Simplicity and Inner Calm
- Reliability
- Boundaries
- Encapsulation
- Strong Centers
- Cohesion
- Alternating Repetition
- Extensibility
- Roughness
- User Friendliness
- Good Shape
- Correctness
- The Void
- Programmability
- Positive Space
- Modularization
- Levels of Scale
- Stepwise Refinement
- Not Separateness
- Elegance
- Contrast
- Identity
- Deep Interlock and Ambiguity
- Composition of Function
- Local Symmetries
- Transparency

A Search For A Fundamental System Of Design Principles To Achieve Thriving Information Systems



Fred Brooks' Essence and Accidents of Building Information Systems

Christopher Alexander's Theory of Life in Architecture

George Lakoff's Theories of Metaphor in Cognition