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Article

# Patterns of Growth: Operationalizing Alexander's "Web Way of Thinking"

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**Abstract**

Christopher Alexander was often characterized—and sometimes seemed to characterize himself—as "sui generis," a radical and perhaps even eccentric thinker on architecture, technology, culture, and nature. That perception in turn has led many to dismiss Alexander's work as too idiosyncratic to be operationalized in the pragmatic world of planning and building. Here we show, however, that Alexander's core ideas have strong parallels in contemporary network science, mathematics, physics, and philosophy, and in the pragmatic world of technological design (including computer software). We highlight a remaining gap in translating Alexander's work into practical tools and strategies for implementation—a gap that is tantalizingly near to being bridged.

**Keywords**

Christopher Alexander; design patterns; network science; pattern language; wiki

**Issue**

This article is part of the issue "Assessing the Complex Contributions of Christopher Alexander" edited by Michael W. Mehaffy (Sustasis Foundation) and Tigran Haas (KTH Royal Institute of Technology).



## 1. Introduction

There can be little dispute that Christopher Alexander, who died in 2022, was one of the most influential architecture and design theorists of the late 20th and early 21st centuries (Wania, 2015). At this writing, Google Scholar reports 24,800 scientific papers that include his name, as well as 36,900 that include the term "pattern language"—his seminal design methodology introduced in the 1977 book *A Pattern Language: Towns, Buildings, Construction* (Alexander et al., 1977).

It is also clear from the record that Alexander's legacy was a controversial one, with many researchers and critics finding fault with his work. One can find numerous examples such as the scathing essay by Alexander's Berkeley colleague Jean-Pierre Protzen (1978) titled "The poverty of the pattern language." Professor Kim Dovey (1990) documents a number of other hostile criticisms in his paper "The pattern language and its enemies." One can also find many papers that refer to Alexander's contentious reputation, such as that by Jones and Wong (2008, p. 1), in the first sentence of its abstract (it begins "Christopher Alexander is a controversial architect who…"). A 2003 profile in *The New York Times* takes a similar view, describing Alexander as "something of a prophet without honor in his own profession" (Miller, 2003).

Alexander himself provided evidence for this perception—and may have fueled it—by providing his own harsh criticisms of conventional architectural and planning practice, and offering (by his own description) radical alternatives. In the cover text of *A Pattern Language*, he and his co-authors stated that they intended to offer "an entirely new approach to architecture, building and planning, which will we hope replace existing ideas and practices entirely" (Alexander et al., 1977). Even more directly, Alexander described himself and his allies as being in a "Battle for the Life and Beauty of the Earth" and in "A Struggle Between Two World-Systems," in his last published book with that title and subtitle, respectively (Alexander et al., 2012).

Even those who admired Alexander's work often expressed skepticism about his ability to implement his ideas at a large scale in the real world of contemporary building. Andrés Duany, co-founder of the Congress for the New Urbanism and a noted campaigner for urban reform, pointed out that:

> Chris' methodologies do not wish to lower themselves to the required level of communication with the existing protocols. They create their own much smarter ones. But I don't think that we have time to break the existing ones down, nor to build up comprehensive new ones….And the problem isn't just financial. As I have said, it is the interlocked system which is so comprehensive that one has to grant it an awesome beauty, like that of a vast, smoothly functioning empire. (Duany, 2004)

For UCL professors Mike Batty and Stephen Marshall, the problem was compounded by what they saw as Alexander's eccentric theories of nature:

> Part of the problem of trying to apply Alexander's ideas is the extent they are bound up with his own very specific unorthodox view of how nature (and the universe) works. This is a particular problem for what some regard as his magnum opus *The Nature of Order*, a work that across four volumes runs to thousands of pages (without an index), whereby it is rather difficult to pin down precise definitions of concepts or trace their relation to mainstream science. (Batty & Marshall, 2017, p. 8)

Judging from the record, Batty's and Marshall's is a prevalent view in the fields of architecture and urban planning. Indeed, as these findings suggest, it is common to see Alexander's ideas referred to as "unorthodox" and not ready for the real world, and other words to that effect (often less politely stated).

Yet there are other fields where Alexander's ideas—even his deeper philosophical ones—have found a much warmer reception, and even a greater degree of practical application. Perhaps surprisingly, one of those is the eminently practical world of computer science and software design.

## 2. Alexander's Influence in the Software World

The methodologies of computer software designers produce outcomes far more rapidly than do the methodologies of environmental designers. A computer's software will often either run properly, or, in many cases, quickly manifest "bugs"—strange results, unintended consequences, or even the malfunction of the computer, i.e., a software "crash." For obvious reasons, there must be a premium on the efficacy of implementation.

For that reason, it may be rather surprising that software designers took inspiration from an architect—and one with something of a reputation as a mystic, no less—to develop one of their most ubiquitous design methodologies. In this case it was Alexander's pattern language, whose common usage in the software world is indicated by a simple Internet search of the term. Google's search engine returns 412,000 hits for "'pattern language' architecture," but 851,000 hits for "'pattern language' software"—more than twice as many hits. The term "design pattern"—the equivalent term used by software designers—returns 21 *million* hits.

The Wikipedia entry for "pattern language" begins to offer clues about the utility of patterns in software. Rather than describing problems that are peculiar to the built environment, the entry makes a broader summary: "A pattern language is an organized and coherent set of patterns, each of which describes a problem and the core of a solution that can be used in many ways within a specific field of expertise" (Wikipedia, 2023a). The "field of expertise" under this definition could vary enormously, and could indeed include software.

Similarly, the Wikipedia entry for "design pattern" suggests its broader utility: "A design pattern is the re-usable form of a solution to a design problem. The idea was introduced by the architect Christopher Alexander and has been adapted for various other disciplines, particularly software engineering" (Wikipedia, 2023b).

The widespread adoption of pattern language methodology in software began when a small group of engineers, among them Ward Cunningham and Kent Beck, received copies of Alexander's book *The Timeless Way of Building*, the companion volume to *A Pattern Language: Towns, Buildings, Construction*. Cunningham and Beck were struggling to find a reliable methodology to clarify a particular software design using the object-oriented Smalltalk software language. Cunningham and Beck saw a promising opportunity to try out Alexander's ideas, particularly those involving user participation. As an experiment, they gave two user representatives, a trainer and a field engineer, a series of rudimentary patterns of their own creation, and directed the user representatives to finish the design. They "were amazed at the (admittedly spartan) elegance of the interface their users designed" (Cunningham, 2011).

Other software designers had begun to converge on similar applications of Alexander's ideas, and, following several software conferences and workshops where Cunningham and Beck had presented their results, a larger group gathered at a mountain retreat in Colorado to develop the foundations of software patterns and to launch a new organization, the Hillside Group, and a new conference series, Pattern Languages of Programming, or PLoP for short. As Cunningham recalls:

> We agreed that we were ready to build on Erich Gamma's foundation work studying object-oriented patterns, to use patterns in a generative way in the sense that Christopher Alexander uses patterns for urban planning and building architecture. We then used the term generative to mean creational…. (Cunningham, 2011)

Many of the participants in the early pattern language work went on to play outsize roles in other pioneering software development, including Agile Methodology, Extreme Programming, Scrum, and wiki, the basis of Wikipedia and many other websites. Design patterns are themselves ubiquitous in software design today, including most games, many operating systems, and many other systems. Far from being impractical and esoteric, pattern languages of programming have proven themselves eminently practical and even robust.

The development of wiki is particularly revealing. As Cunningham makes clear, wikis were invented as a means to exchange patterns among users, and moreover, the structure of a wiki itself follows that of a pattern (Cunningham & Mehaffy, 2013). As with the structure of a pattern, each wiki page identifies a topic with a name, a description of a problem or issue, a section analyzing the problem, and then a conclusion that provides a configurational solution. Moreover, there are hyperlinks from higher-level topics at the top, and lower-level topics at the bottom, which allow the wiki page (or pattern) to be linked in a web relationship with many other patterns (the structure of Wikipedia is even closer to Alexander's pattern structure, often with an iconic photo, and ubiquitous hyperlinks, although the topic of each wiki page is not a "problem" per se but a broader topic of knowledge, e.g., the wiki page "pattern language" itself.)

Wikipedia has even become a powerful resource in the development of artificial intelligence. Most text-based AI systems, like IBM's Watson and OpenAI's GPT3, draw on the Wikipedia dataset (Wikipedia, 2023c). This is not a coincidence, since large language models and pattern languages share a similar hyperlinked or web-networked structure. Indeed, the salient feature of many complex systems is their highly interconnected network patterns, or "deep nets." Since the pattern language methodology is open-ended, like language itself, in principle, pattern languages could be vastly complex, and intricately customizable to a wide range of modeling projects.

One such modeling project is a collaboration between the author and Ward Cunningham to develop a pattern language-based urban design tool, known as a "scenario-modeling tool." The research, conducted at Delft University of Technology in the Netherlands, drew on Bayesian methodology, neural networks and other capabilities, to construct a wiki-based set of patterns, that could be adapted to calculate "externalities," e.g., greenhouse gas emissions, or other impacts of various urban design scenarios. The prototype or "alpha test version," developed as proof of concept, employed four of Alexander's patterns, rewritten more precisely to allow quantitative measurement. Designers using the tool could vary the parameters of each of the patterns, resulting in variations of the predictive outputs of the "externality" metrics. This could be highly beneficial in, for example, evaluating the benefits of various design changes so as to improve public good, and thereby to "monetize" those benefits to encourage the change in scenarios.

The model is known as WikiPLACE, an acronym for "Wiki-based Pattern Language Adaptive Calculator of Externalities." The tool is a calculator for use by urban designers, allowing them to make usefully reliable predictions about the various choices of urban design parameters they might make (density, distribution of destinations, etc.) The model uses patterns to adapt to the various scenarios, and, using real-world data to generalize the impacts of these variables, it makes an evidence-based model output of the predictive value of one or more "externalities"—in this case, greenhouse gases per capita, although in principle it could be used for any externality for which there is reliable modeling data (or indeed, any calculation that is not an economic externality as well, so long as data is available to develop the model).

In the initial test, the prototype or "alpha test version," shown in Figure 1 (author's screenshot), was applied to three scenarios, each of which was then compared to a known dataset for the equivalent real-world scenario. For one dataset (emissions per capita of cities in comparison to their countries) the correlation of prediction to known values was within 17%. For the second dataset (different cities within the USA) the correlation of prediction to known values was within 5.32%. For the third dataset, a comparison of neighborhoods within Austin, Texas, the correlation of prediction to known values was within 8.2%.

This research demonstrates that Alexander's work with pattern languages—and its translation into wiki, and other software applications—does indeed have great potential for practical application. It is noteworthy, however, that it took a departure into the domain of computer science in order to demonstrate this usefulness.

## 3. Alexander's Influence in Other Fields

There are also other remarkable applications of pattern languages in a wide range of other fields. A Google Scholar search of the term "pattern language" produces over 39,000 hits in a dizzying number of topics, including "a pattern language for learning management systems" (education), "a pattern language for security models" (cryptography), "a pattern language for communication revolution" (sociology), "contract as pattern language'' (law), "an ontology pattern language for service modeling" (business), "towards a pattern language for quantum algorithms (quantum physics and computing), "a pattern language for costumes in films" (film), "a pattern language for composing film music" (music), dynamical patterning modules, a "pattern language" for development and evolution of multicellular form (molecular biology), and seemingly endless others.

It is worth noting that many of these are documenting eminently practical applications, not only in functional software design, but in engineering, business, law, music and the arts, and many other disciplines. One paper even documents "A pattern language for writing patterns" (Meszaros & Doble, 1998)!

The last item, "a 'pattern language' for development and evolution of multicellular form," is perhaps more theoretical than most, but also particularly instructive.

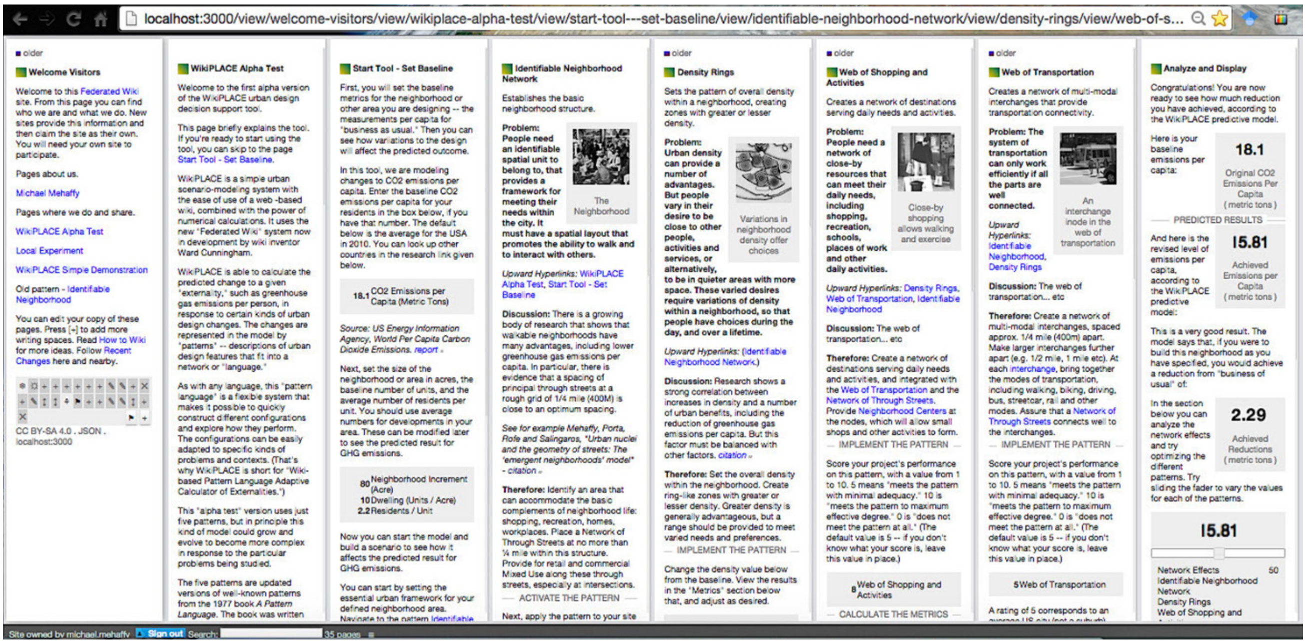


**Figure 1.** The complete structure of the WikiPLACE urban design scenario-modeling tool, as it appears in a screenshot of its maximum zoom out on a desktop, showing all the patterns used in the alpha test version. From left to right, the introduction and startup page, the Start Tool—Set Baseline page, the four patterns, and the final display page. Users can adjust the values of the patterns, or change the order or number of patterns. Following the protocol of a wiki, users can also edit the patterns as they desire, or even write new ones on their own local copy, which can be shared with others, if desired, through the federated network.

The paper, by molecular biologists Stuart Newman and Ramray Bhat of New York Medical College, considers the mystery of the origins of multi-cellular organisms around the time of the so-called Cambrian Explosion, approximately 550 million years ago. They propose that something analogous to a pattern language structure occurred in the genetic code. As they explain in the abstract:

> We propose that DPMs, acting singly and in combination with each other, constitute a "pattern language" capable of generating all metazoan body plans and organ forms. This concept implies that the multicellular organisms of the late Precambrian-early Cambrian were phenotypically plastic, fluently exploring morphospace in a fashion decoupled from both function-based selection and genotypic change. The relatively stable developmental trajectories and morphological phenotypes of modern organisms, then, are considered to be products of stabilizing selection. This perspective solves the apparent "molecular homology-analogy paradox," whereby widely divergent modern animal types utilize the same molecular toolkit during development. (Newman & Bhat, 2009, p. 693)

In other words, the model of a pattern language helps to explain the enormous generative possibilities of multicellular life, while the local adaptation and natural selection produce the particular forms that exist in a given environment.

Newman and Bhat's paper attracted considerable attention, with over 225 citations on Google Scholar as of this writing. Bhat went on to explore the pattern language model even farther, exploring a more direct analogy between pattern languages in biological systems and in human architectures. After further research in the Life Sciences Division at Lawrence Berkeley National Laboratory, he published a paper, "Understanding complexity through pattern languages in biological and man-made architectures." Bhat describes the aims of the paper in the abstract:

> The advances in the theory of complexity have come not just from biologists, but also from architects and urban theorists. In this essay, I discuss how theorists from both life and architectonic sciences have come to a similar conclusion: that patterned and organized form ensures proper function and, ultimately, life. I show how deviation from this principle in biology leads to cancer and death; in architecture, the deviation allows the takeover of mechanical and imagery-based building ideologies leading to dysfunctional and "lifeless" building and public spaces. (Bhat, 2014, p. 8)

In so doing, Bhat clearly implies that Alexander deserves credit (as an architect) for contributions to the theory of complexity, and furthermore, Bhat, and his colleague Newman find highly useful explanatory benefits from Alexander's pattern language, even perhaps helping to explain the origins of multi-cellular life, and even the nature of cancers. This is, of course, in addition to the practical applications of pattern language methodology in a seemingly endless number of fields, far beyond its already prodigious contribution to software.

## 4. Problems in the Architecture Field

We now face a puzzling question: Why, then, has the pattern language methodology not been more successful in the very domain for which it was originally developed, architecture and the built environment, yet had such remarkable success in other fields? Three related reasons seem apparent.

First, the original 1977 book became a victim of its own success. Instead of serving, as stated in the introduction, as only the start of a vastly larger open-source collaboration producing "countless thousands of other languages," the original collection of 253 patterns became a classic—but also the "final word" on what patterns could be. This outcome was in stark contrast to what the book actually said:

> We hope, of course, that many of the people who read, and use this language, will try to improve these patterns….You see then that the patterns are very much alive and evolving. In fact, if you like, each pattern may be looked upon as a hypothesis like one of the hypotheses of science. In this sense, each pattern represents our current best guess as to what arrangement of the physical environment will work….But of course, no matter what the asterisks say, the patterns are still hypotheses, all 253 of them—and are therefore all tentative, all free to evolve under the impact of new experience and observation….The fact is, that we have written this book as a first step in the society-wide process by which people will gradually become conscious of their own pattern languages, and work to improve them…it is possible that each person may once again embark on the construction and development of his own language—perhaps taking the language printed in this book, as a point of departure. (Alexander et al., 1977, pages xv–xvii)

The problem is further complicated by the copyright of the original book, still held by Oxford University Press and the estate of Christopher Alexander. In effect this means that no future pattern language can contain any of the original 253 patterns in the book—in spite of the fact that many of the patterns are archetypal, as Alexander and his coauthors themselves observed: "We doubt whether anyone could construct a valid pattern language" without many of the patterns in the book (Alexander et al., 1977, p. xvii). This amounts to a fatal handicap: no other pattern language could be valid, unless it violated the copyright of the original book.

This situation had the effect of "freezing" the original 253 patterns in an unalterable, inflexible, bible-like volume, forever frozen in the language of 1977. That was in stark contrast to the world of software, where tens of thousands of patterns could be freely exchanged, altered, added to, discarded, and otherwise adapted to fit varying needs and changing circumstances (one egregious example of an inflexible pattern that posed just such a problem was "South Facing Outdoors," a pattern that is only valid in the Global North, and literally invalid on half of the planet).

But there is a second apparent reason that the pattern language methodology did not find a warm reception in the world of architecture and the built environment: its critical and even hostile position toward the architecture profession, an attitude that was apparently reciprocated by that profession. The book's authors expressed their intention to "replace existing ideas and practices entirely" (Alexander et al., 1977, cover) and to remedy the problem "that the [pattern] languages which people have today are so brutal, and so fragmented, that most people no longer have any language to speak of at all—and what they do have is not based on any human, or natural considerations" (Alexander et al., 1977, p. xiv).

As described by Dovey (1990) et al., the response from many architects was overtly hostile (e.g., "the pattern language and its enemies"; "the poverty of the pattern language" and others). Many architects are also known to dislike restrictions in their design freedom, including design codes, formulae, etc., which are seen as too prescriptive. For many of them, as Dovey makes clear, the pattern language was far too prescriptive. For Protzen (1978), it failed to embrace the open-ended nature of good design, and the frequent need to innovate beyond what any code or regulation might specify.

But this sensibility failed to understand what the sciences had been increasingly recognizing in the late 20th century: that generative systems *do* use rules and constraints, and indeed, that is the basis of their complexity. The process of morphogenesis does not abandon the genome and proteome and construct willfully creative forms. As Newman and Bhat argued, it uses something very much like a pattern language to guide what is certainly a vastly complex and interactive process.

This brings us to the third factor that may account for the failure of pattern language methodology in the built environment: The failure of the architecture and planning professions to understand or embrace what Jane Jacobs (1961, p. 429) referred to as "organized complexity," or the dawning sciences of complex adaptive systems. For Jacobs (1961, p. 429), these insights revealed to us "the kind of problem a city is"—a problem in which the variables are interactive in complex ways, but they are not random. Indeed, they form a web-network, of exactly the kind described by pattern languages. Jacobs (2000, p. 26) herself argues that it was essential that we must begin to operationalize this "web way of thinking," as she referred to it.

It is also not a coincidence that Alexander had earlier and famously criticized "tree-like" cities, whose variables were neatly segregated into hierarchical relationships, in his landmark 1965 paper "A city is not a tree."

The remedy for tree-like hierarchies was nothing other than the web-like structure seen in pattern languages.

## 5. The Problem of Geometry (and Symmetry)

There was yet another problem with the pattern language, and one that Alexander himself identified. The methodology did not yet deal sufficiently with the problem of geometry and form. The elements dealt with in the pattern language did not guide users to actually shape places, or to shape them in sufficient detail, to produce results that were profound, or ultimately satisfying. This realization set him on a 25-year project to describe "The Nature of Order," or as the subtitle calls it, "An Essay on the Art of Building and the Nature of the Universe." As Alexander explained it:

> So what is *The Nature of Order* all about? Took 25 years to write, four big fat books, or big thick books, unfortunately a little expensive, about 60 dollars a book, thousands of lovely colored pictures—anyway, what's it all about? When I finished the pattern language, I thought that I had come close to solving the problem of making good human environments. And that if people went to work and used all those patterns, something very beautiful and good would follow, in the hands of ordinary people, and just from the use of that pattern language. That turned out to be not true.....I think people did things that were very very helpful to them and some of them are quite lovely, just in the sense of being informal and being about that person or this person or that place, and so forth. But…. the buildings, and the groups of buildings and so forth, were not really beautiful, to put it quite simply. They weren't. Luckily, I was at that time still relatively early in my professional life. And so I had time to think about this. And what *The Nature of Order* is about is, what does it take to make the things beautiful—really and truly beautiful, in the old-fashioned meaning of the word, um so that it touches you in your heart? And what these books attempt to do is to describe what is involved in thinking about that, what's involved in doing it, what's involved from a practical point of view, in terms of construction contracting and so forth, what's involved from a spiritual point of view, so that you as the maker, whoever that is, are in a sufficiently harmonious state to be able to make a beautiful thing. So, it's really the gamut of all of that, is what these books are about. And um, I certainly got closer, in those books than I did in the pattern language. A *lot* closer. (Alexander in Sustasis Collaborative, 2021; emphasis added)

Once again, Alexander seemed to be veering off into esoteric topics, including spirituality, beauty, harmony, and the like. This was the problem that Batty and Marshall alluded to when they described "his own very specific unorthodox view of how nature (and the universe) works," and noted that "it is rather difficult to pin down precise definitions of concepts or trace their relation to mainstream science" (Batty & Marshall, 2017, p. 8)

However, a careful analysis shows that Alexander's ideas do in fact track very closely with mainstream science, particularly the evolving field described as a "science of cities." Mehaffy (2019) analyzed *The Nature of Order*, and described a number of contributions it made to the emerging science of cities:

- Adaptive morphogenesis and the growth of form;
- Building process as the interaction of multiple distributed agents;
- City evolution as a comprehensible (and modifiable) emergent outcome of complex adaptive systems;
- Aesthetics as a non-trivial indicator of life-supporting order in cities;
- A more human-centered application of data and metrics.

Mehaffy concluded the analysis by noting:

> We see, then, that in spite of Alexander's heretical reputation within the architecture profession, his idiosyncratic formats and mistakes, and his own disinterest in drawing parallels, the actual work was always situated deeply within recognizable and often ancient topics of science and philosophy, from his early work on the synthesis of form to his late-career work on "the art of building and the nature of the universe." Topics of mereology (part-whole relations), hylomorphism (the transformations of matter), ethics (what is good architecture, and what is good practice), ontology (the nature of reality), and other perennial human concerns, can be seen throughout his work. (Mehaffy, 2019, p. 15)

Another parallel between Alexander and the work of others (past and present) can be drawn in the domain of symmetry theory—a moribund topic in the field of architecture, where it is often dismissed as simplistic mirror symmetry, but a rich topic in physics and mathematics (and it is also a richer topic than is often recognized within the history of architecture). Alexander (2003) reported in *The Nature of Order* that he could describe "fifteen fundamental properties" that are common to many beautiful structures, and in turn they are generated by fifteen fundamental transformations. These properties can also be described as forms of symmetry (e.g., scaling symmetry, mirror symmetry, rotational symmetry, translational symmetry, information symmetry, and various combinations; Mehaffy & Salingaros, 2021).

The scheme is shown below, with Alexander's property on the left, and the equivalent form of symmetry on the right:

1. "Levels of Scale" (scaling symmetries);
2. "Strong Centers" (rotational, reflectional symmetries);

3. "Boundaries" (rotational, reflectional symmetries);
4. "Alternating Repetition" (compound symmetries);
5. "Positive Space" (net convex symmetrical spaces);
6. "Good Shape" (coherent symmetrical shapes);
7. "Local Symmetries" (reflectional symmetries within symmetry breaking);
8. "Deep Interlock and Ambiguity" (translational symmetries);
9. "Contrast" (reflectional symmetries);
10. "Gradients" (translational symmetries);
11. "Roughness" (translational symmetries);
12. "Echoes" (information symmetries);
13. "The Void" (symmetry void);
14. "Simplicity and Inner Calm" (symmetry simplicity ratio);
15. "Not-separateness" (ultimate symmetry, with symmetry breaking, of all things).

Thus, in spite of the apparent esoteric sound of some of these properties, they can all be accounted for by well-established concepts of symmetry in mathematics and physics. Their contribution is in how they are applied to specific problems of design, and, as Alexander describes in great detail, the specific configurations necessary for good design.

As with Alexander's other work, although he was disinterested in drawing parallels to others in architecture, the sciences and philosophy, the many parallels are evident. There is also a unique and notable contribution, which may offer practical benefits on the level of Alexander's previous pattern language work. This is certainly a tantalizing prospect.

## 6. Reforming the "Operating System for Growth"

We are, however, left with the question: How can Alexander's insights, with their parallels to network science and others, their demonstrated efficacy in software and other fields, and their apparent relevance to urgent issues of quality and sustainability in the built environment, actually be operationalized, beyond what has occurred only minimally to date? What are the remaining barriers, and how must they be tackled?

At the heart of Alexander's critique of contemporary methods is an analysis of our "modern" technological systems, and their tendency toward excessive abstraction, fragmentation, oversimplification, and, in a word, crudeness. This was the precise problem that software engineers identified and tackled, embracing Alexander's generative and web-like approach, and his methodology not for the composition of elements, but rather, for what we might call the "genesis of wholes" (Mehaffy, 2007). This was manifested not only in their embrace of pattern languages, but in their "Agile" methodology, their generative methods, and their open-source, networked approach to collaborative design.

Alexander describes a historic transition, occurring as part of the Industrial Revolution, to what he termed "System B"—a system that relies too much upon mechanical and linear methods of composition, instead of the more organic and web-like methods of biological systems, and indeed of an earlier stage of technology—what he termed "System A" (Alexander et al., 2012, pp. 43–62). We assumed that we were more advanced by adopting the more rational methods of System B, he notes—but we threw out the baby with the bathwater, so to speak. The challenge now is not to go back to the world of System A—that is probably impossible, and likely ill-advised—but rather to reform System B to incorporate more of the powerful and sophisticated (if overlooked) capacities of System A, perhaps a kind of "third stage" of technology, one that has learned from previous failures, and found its way to a more resilient, more life-supporting kind of technology.

It seems that parts of our technological society are more advanced in dealing with this challenge (like software and the biological sciences) while other parts are relatively backward (like architecture and urban development). There are particular obstacles when it comes to the built environment, comprising what we might think of as the "operating system for growth." These are the processes that govern real estate development, finance, planning, design, engineering, entitlement, construction, etc. They include all the codes, standards, laws, regulations, models, incentives and disincentives, that govern what can be built, what will generate profit or loss, and what can even be conceived or executed.

This "operating system for growth" functions as a kind of "massive multiplayer game," in which rules and interactions generate activities and results, and feedback influences the results. If there is insufficient feedback—for example, economic feedback from so-called "externality" impacts, like greenhouse gas emissions, or health benefits, or other negative or positive outcomes—then the system is less likely to be responsive to the need to manage those results for greater human benefit.

Jane Jacobs wrote perceptively about this challenge, and particularly its economic dimensions. In *The Death and Life of Great American Cities*, she noted that "in creating city success, we humans have created marvels, but we left out feedback. What can we do with cities to make up for this omission?" (Jacobs, 1961, p. 252). It is indeed feedback that we need, of exactly the kind that biological systems use to achieve complex results—complex, adaptive, networked.

This is precisely the technological challenge that the software innovators have used in developing pattern language technology, and later Agile, wiki, and other adaptations. Perhaps we must now take a lesson from their success?

## 7. Horizons of Pattern Languages

Christopher Alexander was once asked by this author whether he considered adapting the pattern language methodology to be able to incorporate more of the geometric and transformational insights of *The Nature of Order*. "Yes, I did," he reported, "but I chickened out" (personal communication, 2008).

Alexander himself was always interested in the next question and the next challenge, and quick to move on from previous work. That approach served him well over a prodigious and remarkably influential career. Perhaps, however, the remaining challenge is to ask how some of these achievements could be brought together into a more effective "operating system," taking lessons from the successes of the software world.

One such project is the book and companion wiki titled *A New Pattern Language for Growing Regions* (Mehaffy et al., 2020). This project takes the guidance of Alexander's foreword as inspiration, "that each person may once again embark on the construction and development of his own language—perhaps taking the language printed in this book, as a point of departure" (Alexander et al., 1977, p. xvii). The book is a collection of 80 new patterns, addressing new challenges not covered by the original book.

As the book's summary states:

> This new collection emerged in part from a five-year collaboration with UN-Habitat to address new urban challenges, including rapid urbanization, slum upgrading, sustainable urbanism, emerging technologies, and new tools and strategies to meet these and other challenges. However, there remains an urgent need to develop and share tools and strategies grounded in research evidence, and subject to revision, addition, and refinement, with new findings from new collaborators. (Mehaffy et al., 2020, back cover)

Importantly, the book was simultaneously published open-access as a PDF, a printed text (available for sale to cover the cost of printing) and a companion wiki, created by wiki inventor Ward Cunningham (also one of the pioneers of pattern languages of programming). It is available on the web to anyone at npl.wiki (Figures 2, 3, and 4).

The new pattern language incorporates a number of topics and issues not present in the original volume, including "patterns of process":

- *Geometric patterns*: echoing Alexander's 15 properties, there are patterns for "Local Symmetry," "Fractal Pattern," and "Framing."
- *Project economics patterns:* There are financial tools like "Tax-Increment Finance" and "Land

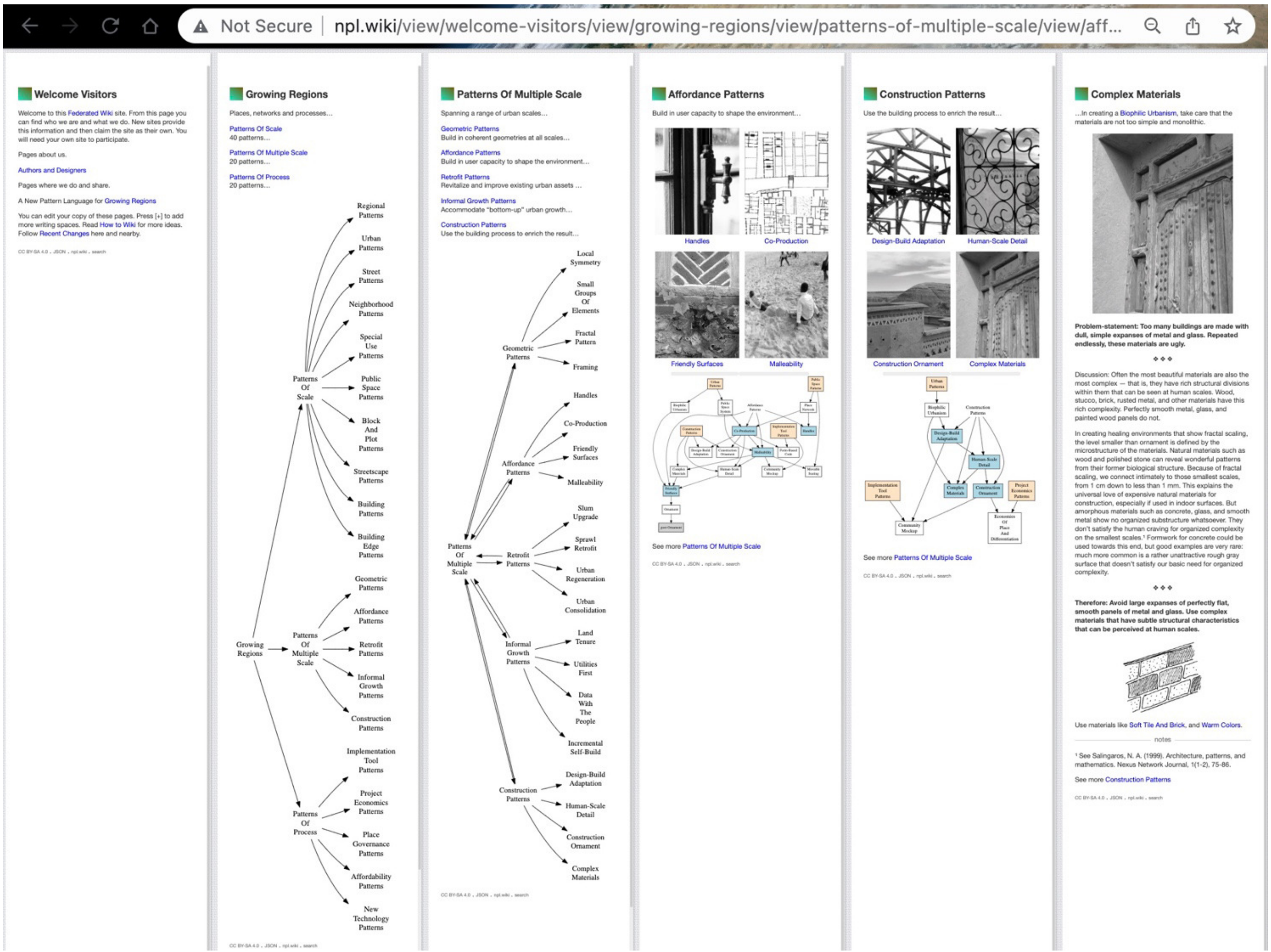


**Figure 2.** The wiki version of *A New Pattern Language for Growing Regions*. Source: Mehaffy et al. (2020).

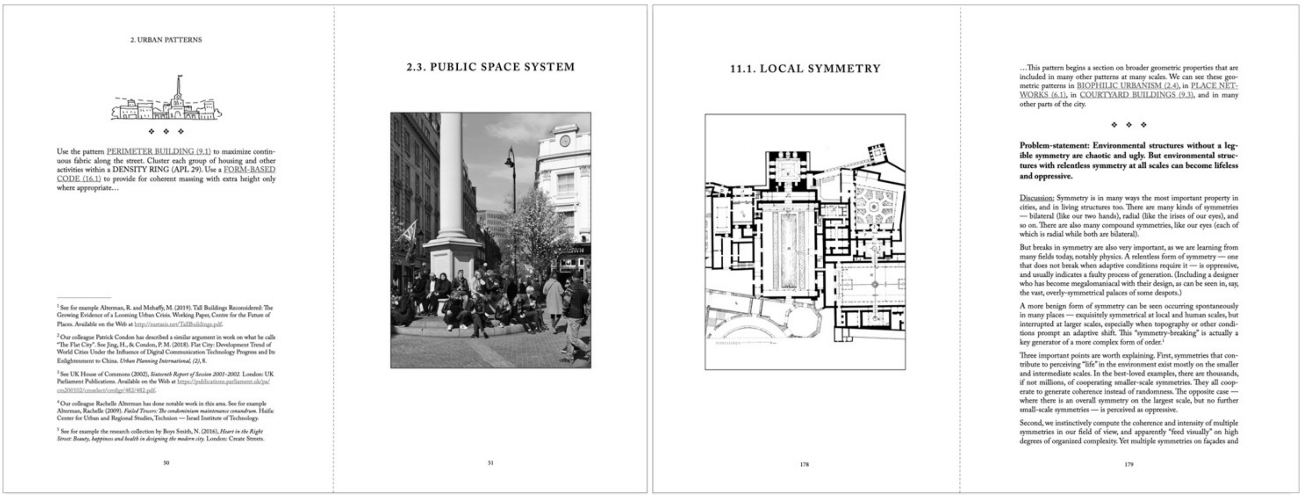


**Figure 3.** Pages from *A New Pattern Language for Growing Regions,* showing new kinds of patterns, like geometric patterns, and those relating to the New Urban Agenda, like public space patterns. Source: Mehaffy et al. (2020).

Value Capture," as well as broader patterns of "Externality Valuation" and "Economies of Place and Differentiation"—meant to balance current lopsided economies of scale and standardization.

- *Informal growth patterns:* Many of the patterns are aimed at the current challenge of rapid urbanization, including patterns in this category: methods of securing "Land Tenure" for residents of informal settlements, "Utilities First" to provide basic infrastructure, "Data With the People" to provide basic information like addresses, and "Incremental Self-Build" to provide a pathway to homes for all.
- *Retrofit patterns:* Strategies for transforming existing places to better-quality human habitat, including "Slum Upgrade," "Sprawl Retrofit," and "Urban Regeneration."
- *Affordance patterns:* These are patterns that empower people to change their own environments, including "Co-production," "Handles," and "Malleability."
- *New technology patterns:* Empowerment of citizens with neighborhood-based technology, including "Citizen Data," "Augmented Reality Design," and "Responsive Transportation Network Company."
- *Implementation tool patterns:* These patterns are most closely aimed at the challenge of implementation, and they include patterns meant to replace or supplant existing elements of the "operating system for growth." They include "Form-Based Code," "Neighborhood Planning Center," and "Entitlement Streamlining"—a kind of "plug and play" approach to approving plans that have already been developed with and supported by the community.

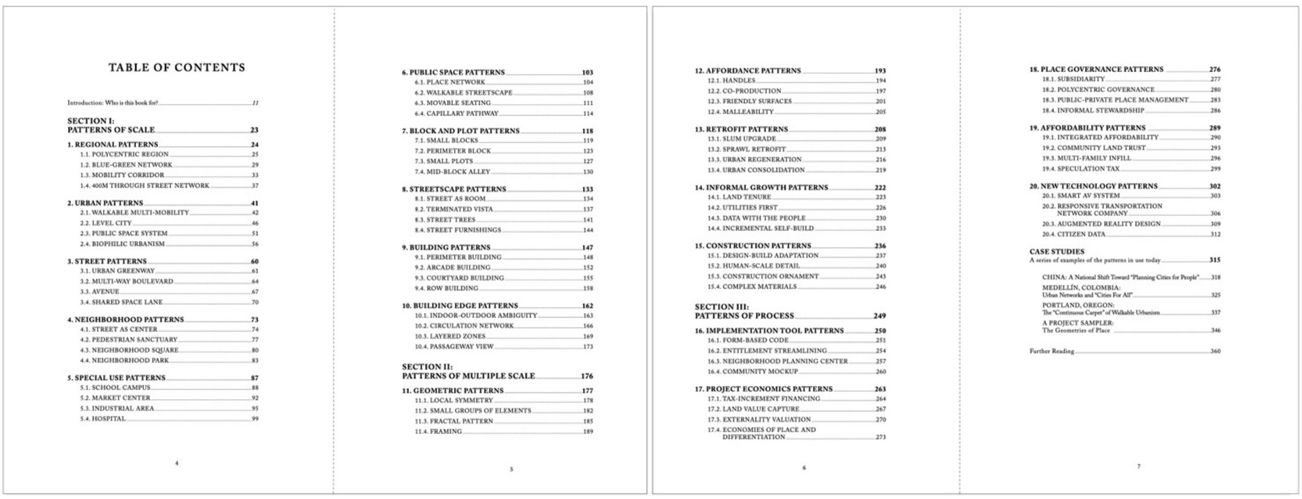


**Figure 4.** The table of contents of *A New Pattern Language for Growing Regions,* showing the many different kinds of new patterns. Source: Mehaffy et al. (2020).

## 8. Conclusion

The aim of *A New Pattern Language for Growing Regions* was not to provide an exhaustive collection of patterns, but to break open the restrictions and show what is possible, offering "proof of concept" for many different kinds of patterns (geometric, financial, process, etc). All of these patterns, along with the original 253, as well as others developed in custom contexts, are now being used in a number of consulting projects internationally, with encouraging results. They are indeed serving to bridge the gap to implementation, and operationalizing a "web way of thinking" (and acting) that addresses our profound contemporary challenges. This reported project is only one of many projects that a number of collaborators are developing. It does suggest, however, that Alexander's isolation within the built environment professions may be coming to an end, as the methods so successful in other fields—and among some in the built environment, like the New Urbanists—begin to bear fruit.

In this context, it is important to close by noting a historic event, and its relation to this work. In December 2016, all 193 member states of the United Nations adopted by acclamation the New Urban Agenda, the outcome document of the Habitat III conference in October of that year. That document contains many of the elements that are under discussion in this paper: addressing rapid urbanization, finding more joined-up approaches, using new economic and process tools, and new technologies (including open data and peer-to-peer sharing). The document's focus on public space networks is notable, as is the inclusion of other elements covered in *A New Pattern Language for Growing Regions.* That the book emerged in part from a five-year collaboration with UN-Habitat is evidence of the growing valuation of Alexander's potential contributions to our challenges.

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## Conflict of Interests

The author declares no conflict of interests.

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