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# Human Eye Behaviors Inform Systems Design for Inter-Building Communication

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Maria Lorena Lehman

Additional information is available at the end of the chapter

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## Abstract

Adaptive sensory environments optimize in real time to consistently improve performance. One optimization method involves communication between buildings to dramatically compound positive effects—but the way these buildings communicate, matters. To design such a communication framework, this chapter uses a biomimetic approach to derive lessons from the human eye and its focusing abilities. With each focusing action, coordination occurs as muscles move to expand and contract the eye's lens to achieve varying focal distances. And when both eyes focus together, they are able to achieve stereopsis, a field of depth and perception not attainable with only the focus of one eye. By dissecting this collaboration between eye muscle coordination and stereopsis, this chapter uncovers how a communication framework between adaptive sensory environments can create indirect, yet powerful, collective occupant and building behaviors. For example, communicating adaptive sensory environments evoke greener occupant behaviors, which, in turn, bring added benefit to the natural environment. Communication framework aspects include gamification, social media, and augmented reality that blur the boundaries between built-environments in different ways. These “communication bridges” allow buildings to take on new symbiotic relationships with each other to harness and enhance how entire urban areas uplift quality of life.

**Keywords:** adaptive architecture, interactive architecture, sensory design, biomimicry, eye accommodation, inter-building communication, green design, occupant-centered design

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## 1. Introduction

Buildings within urban areas today already communicate to a certain extent. Communication is inherent within their design, as a building's architect must create an environment that

“speaks” to its surrounding context of other buildings through its design. In other words, as a design is being realized, it is responding to its future surrounding context as its architect imagines it into being. Yet, once constructed, the design is often static, as it stands without adapting to the ever-changing context that surrounds it.

At times, such buildings work hard to meet certain needs and goals, but because they do not adapt to changing demands and desires, they remain limited. Also, there are times where other buildings within an urban area may conflict with the way a particular building reaches certain individual or collective goals. In this case, another building can actually undo the hard work a different particular building has been designed to do.

Thus, the way buildings communicate today is often fragmented, contradictory, and static. This is why it is important to better understand how buildings can use communication in positive ways that strengthen their design and performance. By thinking and designing consciously about the inter-building communication network within an urban area, new goals can be achieved in dynamic ways. After all, communication between architecture is more than just about making a statement; it becomes more about designing for consistent optimization for learning—where a design, once built, improves over time as it communicates.

This chapter serves as a guide on how to design a framework for inter-building communication by taking a biomimetic approach that parallels eye accommodation (eye focusing) and stereopsis in vision to how buildings can communicate to focus and harness performance. In simplest terms, the human eyes work together as a team that serves as a model for how to design inter-communicating buildings. This framework allows building communication to advance greatly as it would no longer be fragmented, contradictory, and static. Instead, communication between buildings would be convergent, collaborative, and adaptive.

For buildings to communicate successfully, they must pull from the power of adaptive sensory environments. These buildings are prime for an urban communication network since they are sensory designed environments that engage with occupants, other buildings, and surrounding contexts, in dynamic and adaptive ways. For this reason, inter-building communication for adaptive sensory environments holds the most promise for positive benefit at city-wide and individual levels.

This chapter demonstrates why such inter-building communication is important, as well as illustrating how, by learning from the design of the human eyes, it can be designed to work for maximum value at all scales.

## **2. Adaptive sensory environments improve performance**

Built-environments are gaining in their ability to not only interact with occupants and their surrounding context, but to also adapt. This occurs as new developments in sensor technology become integrated along with emerging design processes. Together, they yield environments that change in real time to meet occupant short-term needs and longer-term goals [1].

Within adaptive sensory environments, static and transient materials work together tuning to occupants, supporting them both directly and indirectly. This stems from the occupant-centered approach to design, which holds sensory design as a guiding principle. By adjusting a building's characteristics moment-by-moment, it becomes possible to not only meet a one-time occupant need but also meet ongoing occupant needs, which help achieve longer-term goals through processes such as learning.

Adaptive sensory environments bring great benefit to occupants because they allow for greater personalization through real-time tuning. This creates built-environments that do not just "house" function, but proactively work to "foster" function. For example, this is the difference between a hospital that contains healing, versus a hospital that nurtures healing [1]. In other words, the hospital environment becomes a participant of the "healing team."

In order for such adaptive buildings to function optimally, they engage in a two-way dialog with occupants. Thus, as occupants' needs and goals change and grow, the architectural environment does so as well. Each teaches and learns from the other.

In efforts to optimize such adaptive sensory environments, it is necessary to understand how communication between such buildings affects both the occupants that inhabit them as well as their surrounding natural environment. In this sense, adaptive buildings act as a "bridge" between occupants and their natural surrounding context. To do this, it is advantageous for such buildings to communicate with one another.

### **3. Inter-building communication for optimization**

An inter-building communication network can work to help such adaptive environments cooperate and collaborate with each other. By pulling from the best of what each building does, regardless of the building type, other buildings can learn and use what works to help both their occupants and their natural surroundings. And this can all happen in real time, moment-by-moment.

When adaptive sensory environments communicate with one another, they are able to grasp a "bigger picture" of not only what their occupant needs, but also of how they can help their occupants. Thus, the boundary of a particular building may shift as its occupant and their needs shift as well. For example, a hospital may learn from its patient's home environment about how their hospital room should function regarding light levels, daily habits, or ideal temperatures within which this particular occupant can thrive.

Inter-building communication between adaptive sensory environments helps occupants both individually and collectively. Yes, the adaptive architecture tunes to a specific occupant's needs and goals, but it also can coordinate and pull from the collective needs and goals of a group, city, or culture. This allows for a type of "teamwork" to occur where the built-environment works as a conductor, helping to pull the best from occupants, while also coordinating their efforts to meet a greater good that benefits all. Thus, inter-building communication allows occupants that are located in different places at different times to work together.

It is important to pull from the power of collective behaviors because larger positive impact can be achieved for certain goals. For example, one person that is engaging in greener behaviors to benefit the natural environment will have positive effect, but when an entire collective urban area engages in greener behaviors in a coordinated manner, a much larger positive impact will benefit the natural environment.

#### **4. Objectives for the design of a communication framework**

Inter-building communication matters, but so does the way in which this communication happens. It is not simply enough to design buildings that exchange information interactively. These buildings must also use information to help them adapt to the needs of their occupants and ever-changing surrounding natural context. Yet, what should buildings do with such information? What is their objective and goal?

With an adaptable inter-building communication framework, built-environments can learn from each other. By better understanding and incorporating what works, and what does not work with occupants and surrounding natural contexts, adaptive sensory environments can adapt and improve in entirely new ways. For example, a hospital building can learn how to better personalize its healing environments by interpreting information from a home. Conversely, a home can interpret information from a hospital to help a patient recover from illness post hospital stay.

Multiple simultaneous dialogs are critical for the successful design of an inter-building communication framework. Such built-environments must not only communicate with each other, but also must exchange information with occupants and the surrounding natural environment. In reality, adaptive sensory environments become a “bridge” that adaptively represents nature to occupants in harmonious, beautiful, and beneficial ways.

To optimize the learning and subsequent adaptation of sensory environments, it is important for designers to engage in a “growth mindset” during design [2]. This means that building occupants, and their buildings, strive to grow and change by learning from successes as well as failures. Thus, as buildings exchange information, it becomes important for each to learn from the other by not simply replicating what the other building is doing, but by adapting their architectural behavior to their own functional needs for occupants. In other words, a hospital building that receives information from a home is not to behave exactly as a home would behave, but instead can interpret the information to improve upon its own hospital behavior. For example, a hospital can synchronize a postoperative room for improved patient sleep, but it can do this by learning specifically how to personalize the sleep environment per particular patient by learning from their home environment sleep habits.

By achieving an inter-building communication framework, it becomes possible for buildings, the natural environment, and occupants to all benefit in unique ways. For example, by coordinating efforts, a “network” of communicating buildings can pull from the power of the occupant collective to promote, sustain, and enhance green behaviors. This becomes even more empowering as buildings exchange information to work together as a team, instead of having

each building work in isolation. With such inter-building communication framework designs, advancements can help to mitigate the negative effects of a changing climate.

## **5. Learning from human eye accommodation**

The human eye holds principles by which to better understand how buildings can work together through the exchange and interpretation of information. By uncovering how the human eye focuses, a biomimetic model forms. Eye accommodation, or eye focusing, allows the eye to adapt to ever-changing object distances with the goal of seeing clearly. Similarly, the buildings that comprise a city must adapt to meet the ever-changing goals of its citizens. But how can they coordinate efforts to change their “focus” as citizen needs and goals change in real time?

Within the human eye, there are muscles that simultaneously move to allow for the expansion and contraction of the eye’s lens. In essence, this muscle behavior allows for the harnessing of the lens’ power, which is to focus [3]. In following this model, one can see that buildings are akin to the eye muscles, while occupants are akin to the eye lens. In other words, adaptive sensory environments can adapt to harness and enhance the power of their occupants. This can help them to coordinate efforts and achieve milestones and goals not previously possible.

Communication between buildings can foster coordination and collaboration for learning and subsequent improvement. It is important to note that adaptive sensory environments, behaving in a muscle-like manner, are able to help boost occupant efforts through both teamwork and learning. The environment can help occupants with better collaboration, which in turn, can improve learning and overall goal attainment. For example, if city citizens want to engage in greener behaviors, then communicating buildings can target and focus upon different and complementary goals including increased recycling, reduced energy consumption, and less unnecessary waste. The inter-communicating buildings act as muscles that help empower the effort of city citizens to not only support their efforts, but to also coordinate and reward them.

## **6. Learning from stereopsis for 3D vision**

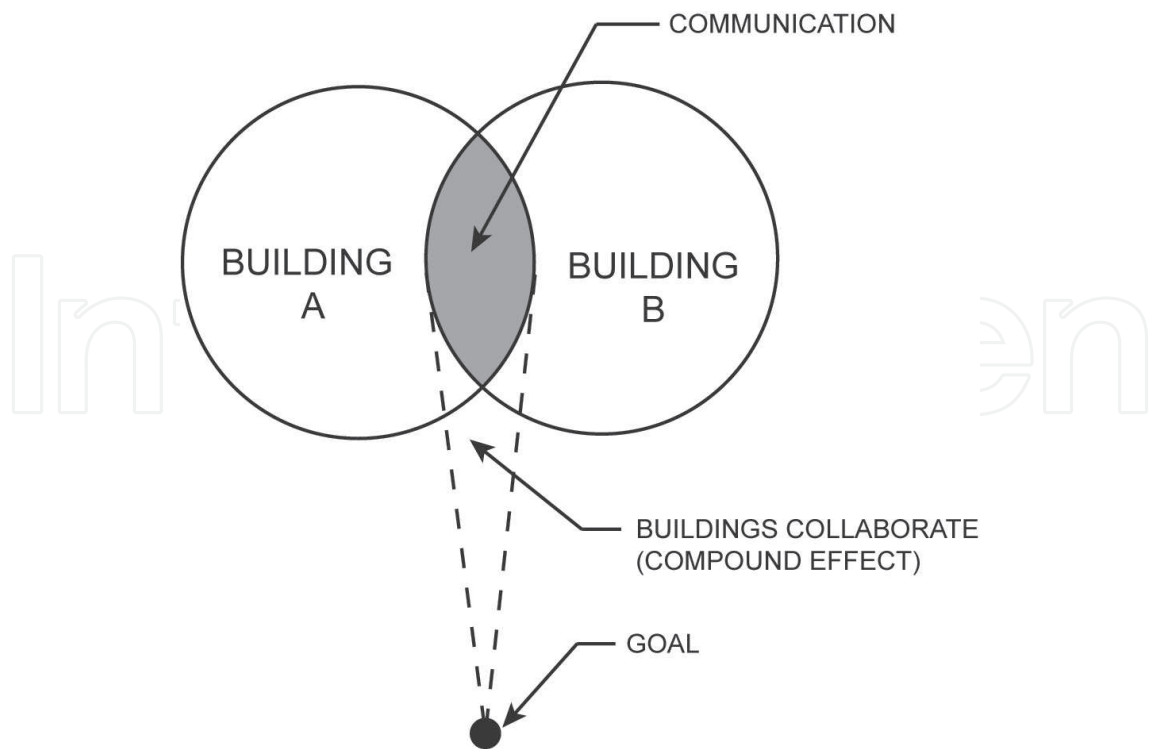
The human eyes provide an excellent example and model for how adaptive sensory buildings can communicate with one another. By studying and decoding how the biological system of the human eyes function together, architects and urban planners can expand their thinking about how to design beyond the typical boundaries within architectural and urban conditions. In particular, the eyes model how a design can work by continuously focusing on visual targets that are ever-changing, much like the real-world dynamics within which architecture and urban environments must adapt. It is by using the way human eyes coordinate as a biomimetic model that a “communication bridge” can be developed to allow for the “sensemaking” of data flowing from and to buildings so they can communicate. Just as muscles help the human eyes to focus vision, the communication bridge helps buildings to focus design behavior.



One human eye that focuses is quite powerful, but two eyes that focus simultaneously unlock the power of three-dimensional vision. Without both eyes focusing, depth of vision is not as evident. Thus, as buildings engage in communication with each other, just as two eyes do to create stereopsis; an entirely new third behavior is born. In other words, one eye focuses on an object, but both eyes can focus to see that object in perspective with depth. The same becomes true with the design of inter-communicating adaptive sensory environments. As buildings communicate, entirely new third behaviors are born.

Without inter-building communication, environments can work against one another. One building can literally undo what another has worked so hard to accomplish within a city. Similarly, a lack of stereopsis where both the eyes are not communicating with the brain as a team, can result in double vision; thus, detracting from the ultimate goal of the eyes, which is to see perspective clearly [4]. For this reason, when designers can learn from the way stereopsis works, they can begin to create urban inter-communicating environments that work together to unleash new collective building behaviors. Hence, adaptive sensory environments create a type of compound effect as can be seen in **Figure 1**.

In **Figure 1**, Building A and Building B communicate through a real-time collaboration where environmental features learn from each other to optimize building performance for goal-attainment. In essence, communicating buildings can “tune” their behaviors to guide, teach, and reward occupants as they strive to meet their goals, whether they are for an individual or for the collective. As both buildings work together to optimize their performance, a compound effect emerges as focused behaviors generate smarter citizen decision-making that



**Figure 1.** The compound effect of collective behaviors.

positively impacts entire urban areas. Thus, a two-way dialog between buildings and occupants becomes critical as each does their part to meet a particular goal.

## 7. Inter-building communication to target goals in real time

Buildings that learn from each other by cooperating and collaborating make a city more nimble in responding to needs. The third behavior formed as buildings cooperate with each other means that the built-environment is not working against itself. Instead, it is harnessing its resources to yield a cumulative positive impact. In addition, as needs and goals change over time, this third behavior can be focused upon different targets because adaptive sensory buildings can change and “tune” in real time.

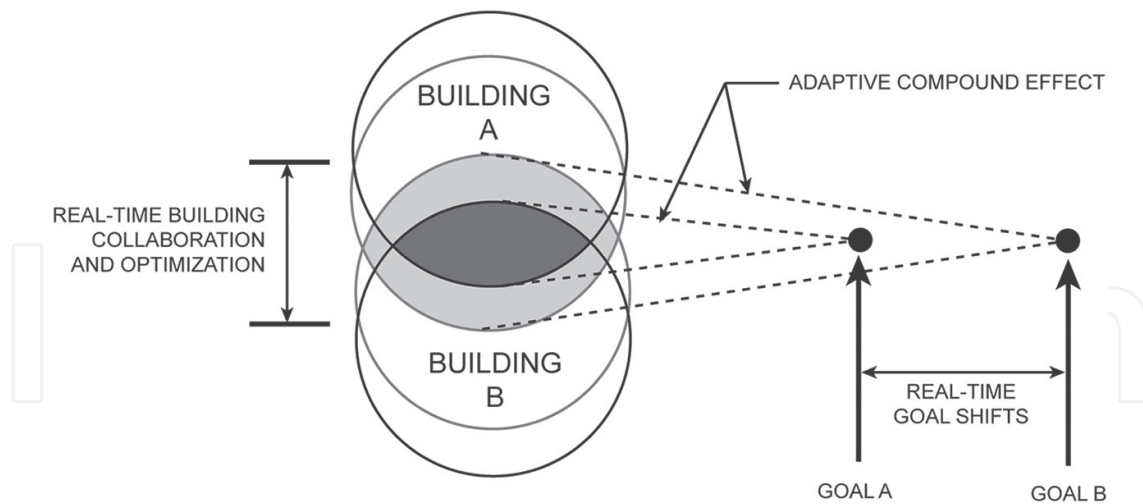
For example, if a city experiences a drought, citizens can work together to conserve water, “bridged” and supported by the adaptive sensory buildings. As these buildings communicate, they will nimbly optimize the way they guide, enhance, and reward city citizens. Then, as extreme weather conditions change, the city can adapt to mitigate new challenges, as these become new goals. Just as the human eyes are continuously focusing on different objects at different distances, the adaptive sensory buildings that communicate with one another can continuously adjust their aim as they target different needs and goals over time.

Inter-building communication amplifies and empowers collective occupant behaviors in real time. By using emerging technologies, such buildings can utilize social media, gamification, and even website design principles to optimize themselves with interpreted information from other buildings. These digital “doors” help adaptive sensory environments to have dialog with each other, with their occupants, and with the surrounding natural context. For example, information can be interpreted by a hospital through social media created by an individual or the collective, by recognizing winning or losing design behaviors through gamification, or by analyzing data regarding the design of different postoperative recovery rooms to see which configurations work best for a particular situation.

Thus, communication that is coordinated and collaborative is the linchpin to “focusing” or meeting ever-changing needs and goals. This becomes quite important as an overarching equilibrium point to keep the planet and occupants healthy is a primary aim, but the way in which to achieve health for the planet and occupants changes over time. Adaptability of an entire city can be harnessed through its buildings by pulling from the power of both the individual and the collective.

In **Figure 2**, one can see how buildings can work to exchange information that helps them to create a third behavior—where both occupants and buildings are working synergistically to focus on different urban needs and goals. As Building A and Building B engage with one another, the way they communicate and interpret information changes as goals shift over time. In other words, communicating buildings can collaborate in real time to meet simultaneous goals and/or shifting goals set by citizens. Buildings act as eye muscles that help occupants to focus their behaviors toward helping them reach their desired goals at micro- and macro-scales. Thus, through inter-building communication, it becomes possible to have





**Figure 2.** System design using the human eye as a model.

urban buildings work both independently and collectively for the good of both the citizen and the planet. All of this becomes possible with inter-communicating adaptive sensory environments.

### 8. Evoking beneficial occupant behaviors

Buildings that communicate can engage individuals to contribute beneficially through collective behaviors that achieve urban goals. Adaptive sensory environments that exchange information create a third behavior that is a hybrid behavior, which can tackle goals differently than if individual buildings never communicated. The benefit of this resides in the way such buildings can learn from each other—through designed competition, by applying tested design methods, or by learning directly from the preferences of city citizens.

For instance, inter-building communication evokes greener behavior in citizens, and thus, brings impact that is more positive to the planet. As weather has potential to become extreme, citizens need to coordinate their efforts to mitigate negative weather effects. An inter-building communication framework provides the amplifier by which citizens can pull individual efforts together to make a real difference.

An adaptive sensory environment can help its building occupants to engage in greener behaviors like recycling, using less energy, and walking or cycling instead of driving an automobile. Using gamification, it becomes possible to not only guide, enhance, and reward citizens for their greener behaviors, but it also becomes possible for the whole urban area to optimize itself as each building can adapt to incorporate design integrations that are successfully working in other buildings. Thus, the city is made up of self-optimizing buildings that work together, and not in isolation—as they learn through testing, correction, and adaptation. Citizens benefit as their usage of such buildings impacts what and how environments in such a city get optimized.

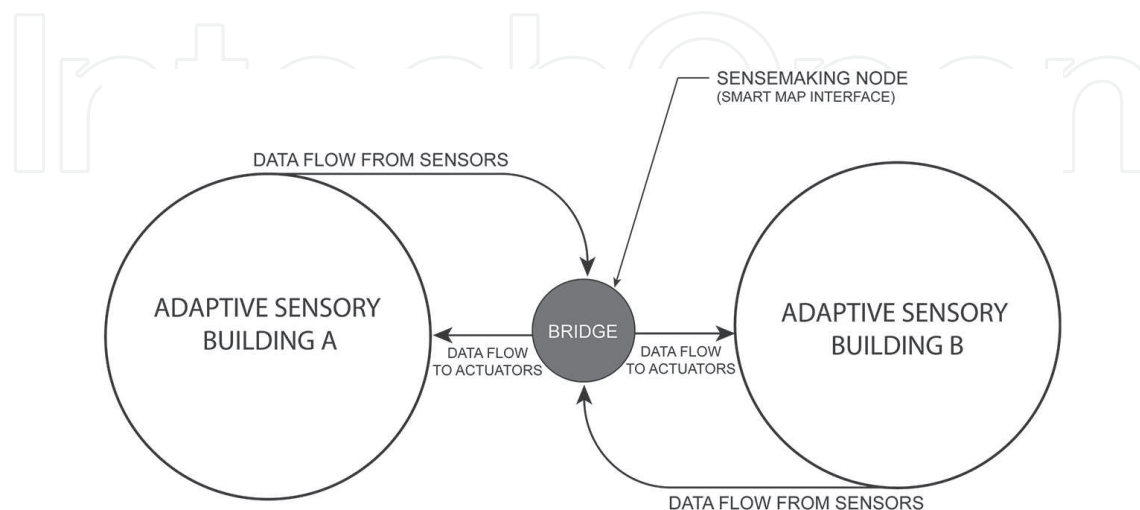
## 9. Creating an inter-building “communication bridge”

Creating an inter-building “communication bridge” is like seeing the city as a brain that flexes its muscles (the buildings) to focus its lenses (the occupants) to meet more collective needs faster and with higher quality. In essence, a city can mirror the plasticity of the human brain as it adjusts and changes over time to meet citizen needs and goals. The inter-building communication framework enhances such plasticity, as the third behaviors resulting from collaborating buildings allow for new kinds of evolutionary growth.

As a city works to optimize itself for its citizens, it must pull from its best features to uplift those weaker ones. As adaptive sensory environments communicate with each other, new ways in which to collaborate surface and city optimization can turn into faster and more profound evolution.

A framework for how such a city-wide inter-building communication system can be realized arises with the proliferation of nanotechnology, ubiquitous computing, wearables, micro-architectures, and the interconnection of everyday things. These sensing and data collecting devices can relay real-time data into the communication bridge. Cities can use one or multiple bridges by which to facilitate inter-building collaboration. By interpreting and correlating in-flowing data through pattern-detection methods, a “sensemaking” action occurs at the bridge, by which to make optimal city-wide decisions. From these data, building actuators can interact and engage with their occupants at more micro-levels. Thus, the communication bridge makes inter-building communication and collaboration possible (**Figure 3**).

An example of present-day technology that would help such a communication bridge to be realized can be seen in the Hexagon Geospatial Smart Maps. These smart maps create interfaces by which to visualize and assess quality and incidents of aspects like urban or building infrastructure and resources through a real-time dashboard that provides insights on conditions as they occur. Such maps have been used for the 2016 Brazil Olympics to help with real-time safety in Rio de Janeiro where the smart map interface allowed for 360-degree views



**Figure 3.** Inter-building communication bridge.

through a digital model of the real Olympic city along with the map interface by which to monitor and analyze incident place, time, and patterns. Again, all of this was key to help keep safety throughout the Olympic city [5]. Smart maps are also being used in the Netherlands to help assess and make decisions about infrastructure that is so critical in this location where road traffic, weather patterns, and water infrastructure must be monitored and evaluated continuously [6].

Smart maps are an example of how real-time data can be collected through sensors, analyzed, correlated, and used to make decisions not only after an event occurs, but also while it is occurring or even before it occurs (through predictive measures). With smart maps it becomes possible to engage in the sensemaking of data for building collaboration and coordination. These maps become a critical piece of the communication bridge.

Yet, the role of technology in creating an inter-building communication bridge is critical. While technology contributing to the Internet of Everything (IoE) helps to make inter-building communication possible, there are certain challenges that arise. For example, such technology should not isolate or confuse. In other words, one must beware of having a particular building or feature design become the majority that isolates or diminishes the minority [7]. In addition, inter-building communication technology should not create such complex design solutions that they become useless.

It also is important to preserve certain functions within building types that could become more hybrid. In this case, it may be beneficial to redefine building types to innovate functions that are better suited for meeting occupant needs and goals in this adaptive sensory design manner. For example, an office building may innovate its functionality by learning from a school, as it places more emphasis upon learning and free “play” time for creative thinking by workers. As such buildings communicate, new goals and priorities will arise—perhaps creativity becomes more important than productivity within certain businesses.

Furthermore, it also becomes important for adaptive sensory environments to nurture the occupant cultures they serve. In this case, a particular office building culture may be very different from another office building culture. Such inter-building communication that helps buildings optimize themselves must customize the way in which it interprets information from another building. An office building can learn from another without sacrificing what makes it unique.

In the end, inter-building communication between adaptive sensory environments is most effective when buildings learn from one another while also fusing into third behaviors that allow the city to “focus” on its prioritized citizen needs and goals.

## **10. The role of gamification, social media, and augmented reality**

Technologies for inter-building communication frameworks give rise to such usages as gamification, social media, and augmented reality. And these all can converge to form the real-time design and optimization of place. As gamification provides incentive, guidance, and reward

to occupants, social media can help such occupants to coordinate and collaborate for the common good. Augmented reality can help occupants to make more informed decisions since, with this technological advancement, they can see deeper into their environments. In this way, there will be a convergence between the digital and physical.

Just as the human eye works to form perception from physical objects, inter-building communication technologies will help occupants make smarter decisions from physical environments. These decisions can lead to greener, healthier, safer, and even more productive or creative behaviors. The guiding principle of all of this is to not only have adaptive sensory environments communicate with occupants within each building, but to also have buildings communicate with each other city-wide, so the collective of citizen behaviors can have more profound positive impact upon their future, particularly as these behaviors become smarter over time.

## 11. A/B split test for behavioral optimization

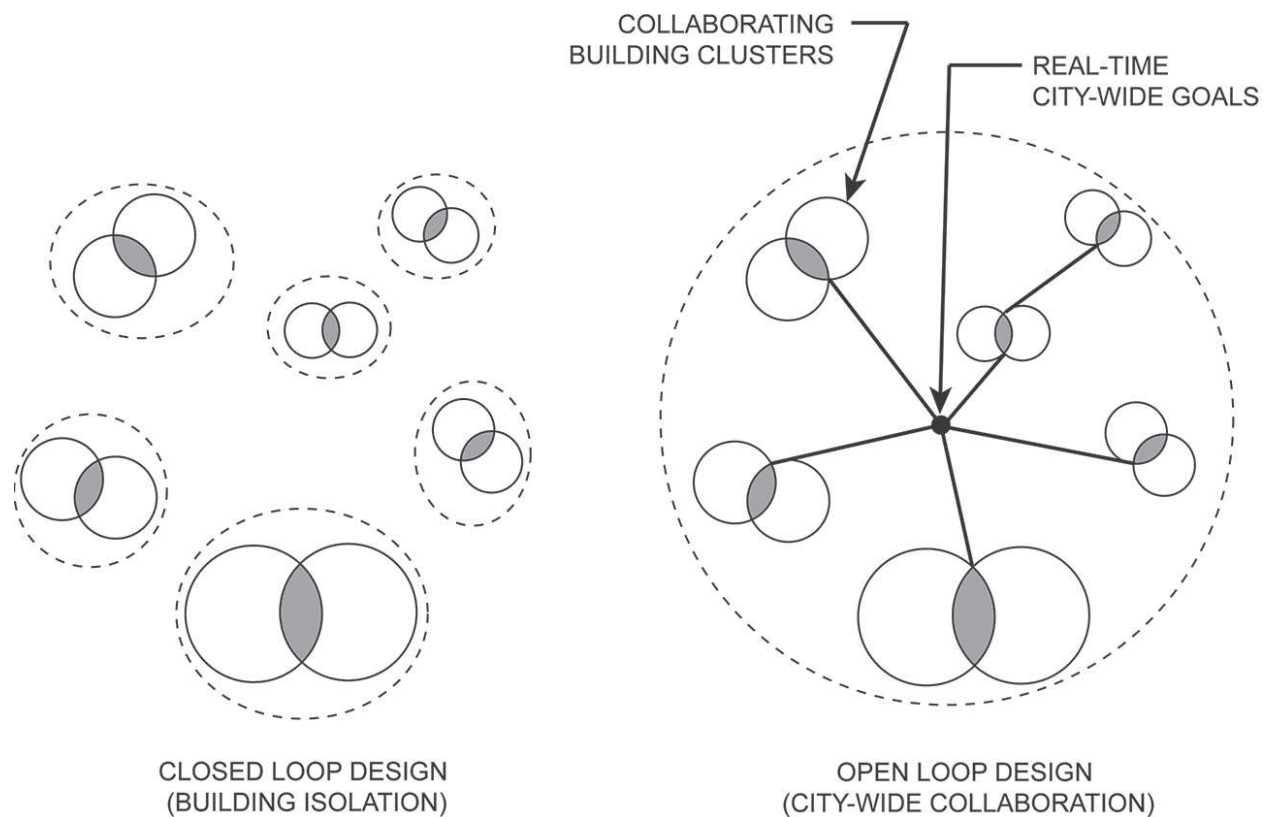
The brain adapts as it forms visual perceptions from what the eyes see, and this ability to compensate for visual discrepancies is very important. For example, if one eye is focusing more weakly than the other, then the brain will bias the stronger eye. Thus, a similar approach to inter-building communication can work as a healthy competition, or A/B Split Test can be used to optimize buildings in real time.

Healthy competition between buildings can work if a learning approach is at the core of the competition. An A/B Split Test, a term and practice used in website design, can be applied to inter-communicating adaptive sensory buildings. Since each building adapts to its occupants' needs and goals in real time, it is important for environments to not become design "echo chambers" — where architectural features optimize themselves in a closed loop.

In **Figure 4**, the difference between closed loop and open loop optimization can be seen. The key is to have adaptive sensory buildings interconnect through a communication network that allows collaborating building clusters to participate proactively in real-time city-wide goals. Furthermore, such a city-wide communication network can help building clusters to learn from one another. For example, one cluster may create a better A/B Split Test that can be replicated in another cluster. In the end, it is important for inter-communicating buildings to be connected for local, city, and global benefits. After all, highly successful building clusters can impact environments in different cities as they learn, interpret, and apply the positive results. An open loop design framework is vital for inter-building adaptive sensory communication.

Within an open loop design optimization of place, environments both reference themselves and other buildings outside of themselves to help them learn, adapt, and grow. This type of evolution can be empowered by adapting an A/B Split Test approach.

During a website design A/B Split Test, a webpage design element is tested against another alternative by tracking how website visitors interact with the element and page. For example, the winning design element may have the most visitor clicks.



**Figure 4.** Closed loop versus open loop design optimization.

A/B Split Testing can be used to help encourage the positive learning and growth of inter-communicating adaptive sensory design buildings. By allowing two or even three buildings to enter into such an A/B Split Test, particular design elements can be compared against one another to see which performs best. And since these sensory buildings adapt in real time, the winning design element can be interpreted and then incorporated to optimize the other designs.

Within an A/B Split Test, design features from one hospital can be compared against another hospital's feature. Or a hospital feature in a postoperative recovery room can be compared against a patient's home bedroom. In this case, the hospital room can better "tune" as it adapts itself to optimize for ideal patient healing.

Such A/B Split Tests can be used for any building type, as long as there is a network for the inter-building communication system. In essence, Split Tests can help buildings to improve themselves by not being so self-referential. At the city scale, this allows buildings to learn from each other, and at the global scale this allows cities to collaborate.

## 12. Competition for growth and healing

By learning from other buildings, adaptive sensory environments can grow, as they evolve into better forms of themselves. However, they may also be able to heal themselves in real time, at a multitude of scales—from building-scale to urban-scale.



Similarly, healthy competition can be used within one building as rooms can also learn from one another. Essentially, the inter-building communication system allows environments to optimize—by reaching out to distinctly separate other environments, be they right around the corner within the city, or within another city across the globe.

The human eyes cooperate with one another, and their “competing” views are actually very critical to how the human brain and mind work to form perspective and perception. Similarly, as two buildings compete with one another, they are simply offering alternative design solutions.

It is important to note that just because building designs may be involved in an A/B Split Test, the winning design is not necessarily the better overall design. Two buildings can learn from one another, as one environment may perform better with certain functions, while another environment performs better with other functions. Inter-building communication allows for the best design integrations to influence others.

The A/B Split Testing method is not a means by which designs should simply copy other designs. The interpretation of design usage in one place can influence the way a design operates in another. However, care should be taken to ensure that a place does not lose its authenticity.

As inter-building communication unifies city buildings through form, function, and even meaning, it becomes important for the authenticity of place to remain standing. After all, the certain culture of a particular office building, or the way a hospital nurtures its patients in a particular part of the world will likely differ. Yet, universal lessons can be learned, interpreted, and applied from building to building within different cultures.

By using healthy competition to improve designs in real time, larger leaps in design evolution can be taken. Adaptive sensory environments that communicate with each other become innovators, driven by the thumbprint of their original architectural designers.

In the end, such healthy competition helps to strengthen what works, and helps to eliminate design weaknesses. This is particularly advantageous as certain citizen goals surface. The aim of A/B Split Testing environments through inter-building communication is to find those key leverage points where optimal benefit can be pulled from a design to positively impact more people. Yet, healthy competition is only one way in which to use the system framework of inter-building communication.

As buildings advance in the way they are able to communicate and learn from each other, greater occupant customization will become possible through occupant control points. For example, an occupant can “bridge” their home office preferences with their office building workplace preferences—to either keep them different or similar. The key with inter-building communication is to allow personal choice for occupants when they need it, while also being versatile enough as a design to be able to present them with those choices.

As environmental designs learn from each other, the choices and variations they can provide occupants for certain situations will grow as well. Thus, buildings will be better able to adapt, to nurture, and to grow with the occupants they serve. This will strengthen design so as to

help it “fit” occupants at a more nuanced level. Again, this will help them to learn better, to make smarter decisions better, and to engage in more beneficial behaviors.

### 13. The emergence of symbiotic ecosystems

As inter-building communication links buildings together into a type of network, an ecosystem emerges. Much like the natural environment ecosystem, the city ecosystem cultivates the power to heal itself, particularly as buildings use such information “bridges” to learn from each other. And when both urban and natural ecosystems interact adaptively with one another, they become symbiotic.

By using teamwork at all scales: rooms within buildings learn from each other to optimize a building, buildings within cities learn from each other to optimize a city, and cities within the world can learn from each other to optimize for global goals. All of this teamwork can be thought of as an important collective “challenge” with missions that serve different scales.

As buildings work together through learning and adapting, they help to empower and enhance citizen efforts to improve their own individual quality of life, and the collective quality of life that serves the greater good. Similarly, the eyes that help the human body to see empower the person to improve their quality of life in new ways. In other words, citizens are the lenses of the city—giving the city focus through adapting buildings that work to meet goals by acting collaboratively.

In essence, the built-environment ecosystem can enter into a new type of dialog with the natural environment ecosystem. This symbiotic relationship serves to help each ecosystem enhance, grow, and heal itself. For example, as cities harness built-environment and citizen behaviors, they can positively impact the natural environment by adapting or even reversing disturbances.

Inter-building communication for adaptive sensory environments is key to magnifying the positive effects of beneficial behaviors. As the built and natural ecosystems enter into a two-way dialog, architectural design will keep occupants at the center, but in additional new ways. Inter-building communication extends the reach of beneficial citizen behaviors, while also pulling from these behaviors to harmonize with nature anew.

By strategically designing inter-building communication within cities, a renewed relationship between the built and natural worlds arises. This way of designing will raise the consciousness of citizens so they engage in smarter decision-making while also knowing that their behaviors have a tangible impact upon the greater context that is the planet. Thus, buildings can be designed to communicate so they can retain their individual authenticity but can also act together to create maximized positive impact.

Just as the eyes see to help a person visualize where they are going, with communication, the city can “see” to help citizens visualize where they are going. Furthermore, as inter-building communication is applied to adaptive sensory environments, those citizens will have the ability to optimize, enhance, and take action on behaviors that lead to their goals—including a safer environment, a healthier planet, and a happier world.

## Author details

Maria Lorena Lehman

Address all correspondence to: [mll@sensingarchitecture.com](mailto:mll@sensingarchitecture.com)

MLL Design Lab, LLC, Sensing Architecture® Academy, Massachusetts, United States

## References

- [1] Lehman ML. Adaptive Sensory Environments. Oxon/New York: Routledge; 2017. p. 1
- [2] Dweck CS. Mindset: The New Psychology of Success. New York: Ballantine Books; 2008. pp. 3-14
- [3] Nave R. HyperPhysics: Accommodation. [Internet]. 2016. Available from: <http://hyperphysics.phy-astr.gsu.edu/hbase/vision/accom.html> [Accessed: Mar 29, 2017]
- [4] Ang B. Vision and Eye Health: Stereopsis. [Internet]. 2017. Available from: <http://www.vision-and-eye-health.com/stereopsis.html> [Accessed: Mar 29, 2017]
- [5] Hexagon Geospatial. Hexagon Smart City Rio Project. [Internet]. 2016. Available from: <https://www.youtube.com/watch?v=YtOoLovYZZo> [Accessed: Oct 11, 2017]
- [6] Hexagon Geospatial. Making Smart Cities in the Netherlands. [Internet]. 2016. Available from: <https://www.youtube.com/watch?v=q1gbzJQfv2c> [Accessed: Oct 11, 2017]
- [7] Johnson S. Emergence. New York: Scribner; 2001. p. 161

