Get Out of Your Comfort Zone: Externalization in Architecture to Increase Social and Environmental Connectivity

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Abstract

Buildings currently account for 39% of energy-related carbon dioxide emissions annually, worldwide. Despite the acceleration of climate change, architecture is increasingly designed as hermetically sealed boxes, requiring increased conditioning, which in turn further contributes to the greenhouse gas emissions warming up our planet. In addition to disassociating people from the natural environment, this also creates spaces where people disconnect from their community, and live within boxes both physically and socially. Though current research addresses many environmental and human health concerns that arise from internalized architecture, it does not address the social disconnection nor is there any specific terminology and research that focus on externalizing programming as a strategy. To fill this gap, this synthesis establishes important terminology and research to support 'externalization', and explores the environmental and social impacts of externalizing programs through both design evaluation and morphology. Through thorough literature review, case studies research and analysis, the importance and impacts of externalization is defined. Then an externalization taxonomy is developed to support designers in two ways – as a design evaluation tool and as a design support for integrated architectural design and innovation that would better demonstrate how externalization can create integrated designs that provide layers of environmental, social, and health benefits while reducing the total building energy demands. Especially in the context of the current pandemic (COVID-19), externalization is evermore important. The synthesis provides the necessary groundwork to allow for externalization to be researched further, and provide designers the necessary framework to shift towards externalized design approaches.

Keywords: Externalization, Sustainable Living, Climate Change, Social Sustainability, Architecture

Introduction

Currently the challenge is twofold- there is increase in designs where spaces are disconnected from the outdoor environment, which not only has energy demand and environmental implications, but also health and wellbeing implications. Second, by designing internalized spaces that disconnect people from the outdoor environment, designers have also created socially disconnected spaces that are not conducive to increased social interaction. Without the ability to hear neighborhood chatter and noises of the community from outside our window, people gain increasing levels of isolation, and lose a sense of belonging within their local communities. Loss of community vibrancy and a lack of diversity in terms of interactions between occupants, and an understanding result in a sense of insecurity and anonymity within the neighborhood that can greatly affect the social and cultural vibrancy and resiliency of communities.

For environmental connectivity, externalization provides building performance and energy savings, biophilic benefits for health and wellbeing, and biodiversity benefits for the environment. In terms of building performance and energy savings, robust research on passive design strategies (Wang et al. 2014), mixed mode design (Loftness 2014; Loftness and Haase 2013; Watson 2013; Liebard and Herde 2009), and daylight and thermal autonomy all increase the overall environmental connectivity while reducing the overall energy demands. Dynamic envelope design is crucial as architecture becomes increasingly flexible based on weather conditions and activity levels as it reduces the energy demand of the building, but also provides alliesthesia (thermal delight) to the occupants. Furthermore, simulation softwares enable designers to further explore the potentials of integrated passive designs to best balance between the indoor and outdoor environments given local contexts.

Another benefit of increased environmental connectivity is increased biophilic benefits in terms of occupant health and wellbeing. Biophilia is a human's innate biological tendency to seek connection with nature, which can have emotional, mental, and physiological impacts on our wellbeing. Based on Edward O. Wilson’s biophilia hypothesis, biophilic design focuses on designing in connection with nature (Wilson 1986). Notable research by Stephen Kellert and Bill Browning solidified the importance of biophilic design within architecture, as well as highlighted its impact on human wellbeing (Heerwagen, Kellert, and Mador 2008; Browning, Catherine, and Joseph 2014; Terrapin Bright Green 2012). For example, several studies indicated that connection to nature could lower tension, anxiety, anger, fatigue, and confusion, and could positively influence mood and self-esteem (Alcock et al. 2014; Barton and Pretty 2010; D. K. Brown, Barton, and Gladwell 2013). Biophilic design supported the connection of humans to nature encouraged the strengthening of indoor-outdoor relationships as there are studies that indicate that application can provide both biophilic and environmental benefits to architectural practice (Dreiseitl 2019).

Lastly, increased environmental connectivity can support local biodiversity through regenerative design or the creation of nature corridors and hotspots. In research by Hes and Du Plessi, regenerative design that focused on designing for local ecologies helped rejuvenate damaged ecosystems (Hes and Plessis 2014). This encourages for a close relationship between occupants and nature. Given growing climate change and biodiversity concerns, ecologically driven approaches become increasingly important.

The integration of nature and porosity within architecture can support the migration and growth of flora and fauna within an urban setting, providing both occupants biophilic benefits while also allowing nature to have spots of habitation amongst the urban concrete jungle (Jain 2019).

Building program externalization also contribute to enhanced social connectivity, which can reduce isolation, improve community cohesion and vibrancy. In January of 2019, the Health Resources and Services Administration issued the "Loneliness Epidemic", which notes that nearly 1 out of 3 older Americans now live alone, which can result in serious mental and physical health effects (Health Resources & Services Administration 2019). "Loneliness and social isolation can be as damaging to health as smoking 15 cigarettes a day", and thus serious actions need to be taken to address this concern (Health Resources & Services Administration 2019). Though spatial conditions are not the sole contributor to the loneliness epidemic, there are studies that support the impact of spatial conditions on isolation. Social capital is also a growing research topic, as social connectivity becomes a growing concern within predominantly urban design (Putnam 2020). However, what are the building level implications when there is minimal social connectivity, when one cannot open the window to hear children playing, when there is not a porch where people can interact in passing? How has the internalized approach to architecture started to discourage social interaction and connectivity, and what impacts and implications it may have? These questions are explored to varying degrees by researchers, though there exists a missing link between externalization and social connectivity.

This thesis links both environmental and social connectivity, and establish why designing for externalization would be better than the current internalized approach. Especially now in the context of COVID-19 pandemic and social inequity, what role can externalization play? Existing research already support the importance of externalization as people lean towards balconies, porches, and other externalized spaces that allow them to regain connectivity in a forced disconnected environment due to quarantine (Ottoni et al. 2016; Martin 2020; Nisenson 2020). Additionally, flexible boundaries such as sliding doors or outdoor classrooms enable schools to continue teaching while enforcing safe distancing, which are all enabled through externalized design (Bellafante 2020; Superville 2020; Couzin-Frankel, Vogel, and Weil 2020). Given this new context, externalization grows in value as we become increasingly aware of the disconnectivity of existing spaces. With improved social connectivity, study also show its impact on safety and wellbeing within lower-income communities, as spaces designed often don't encourage social interaction or allow for community identity to develop (Saegert, Winkel, and Swartz 2002; Knapp et al. 2019). This can greatly affect vulnerable communities, which can lead to more severe mental and physical health impacts due to poor ventilation, lack of access to nature, etc.

Externalization Palette

First set of criteria is the environmental connectivity of building programming - based on how the space is sealed, how much daylight is available, and what kind of activity takes place in these spaces. The worst scenario is a space that is fully sealed with full mechanical support and no access to natural daylight. Then the introduction of natural daylight opportunities while remaining fully sealed and full mechanical support is the next improvement towards environmental connectivity. With the introduction of versatility, the dynamically sealed spaces allow for added operability and access to passive strategies and natural daylight. Then externalized low function spaces introduce fully externalized transitory spaces. Lastly, the most amount of environmental connectivity represent fully externalized high function spaces where social living spaces would be fully externalized. Considerations for environmental connectivity could result in a significant amount of energy savings due to the decrease in conditioned internalized space. Additionally, this allow for an increase in physical activity and circulation, which can increase the overall social connection. Through environmental externalization, there is added visual richness and connectivity, and well as auditory and sensory richness. This allows for the community to gain a sense of vibrancy through architectural design.

Second set of criteria is the social connectivity of building programming, which focuses on the amount of social connectivity that the space enables for its occupants. The most socially disconnected is individual and disconnected spaces. Then it moves onto individual but visually connected spaces, which are typically spaces with glass facades where you can see, but not hear or interact. Then it moves onto the building community, which allows for the occupants within a building to socialize and interact with one another. It then moves onto higher levels of public engagement with the neighborhood community connection and finally the urban community connection where it is fully open to the public. The increased social connections allow for the success, resiliency, and longevity of the externalization strategies through increased social connections, an increase in the amount of outdoor activities, and allow for increased socio-cultural richness. Additionally this encourages people to communicate and develop a level of tolerance through a sense of community, which can increase the community resiliency in times of crises such as the current COVID-19 pandemic.

When both the environmental connectivity and social connectivity are overlapped, it creates a larger palette that can then evaluate architectural design through this color schema - The Externalization Palette. The palette allows for immediate understanding of a design's externalization quality in regards to its social and environmental considerations and creates a set of vocabulary for building program externalization that can then evaluate architectural design through the criteria of environmental and social connectivity. Architectural design can then be evaluated through this palette to better understand the externalization quality of a design through this evaluation color palette. This palette is arranged so that both criteria must be considered during evaluation as both levels of connectivity determines the quality and effectiveness of externalization in application, and diversity in the types of connectivity within a design is also crucial to its overall success. This palette does not seek to over-simplify the depth of spatial quality and social spaces, but aims to better consider the multiple layers through a more defined set of criteria and vocabulary. In doing so, a better understanding of building program externalization could be reached, and result in more appropriate applications of externalization in architectural design practice.

Externalization Taxonomy

The externalization taxonomy is a series of fifty strategies that help support designers when thinking about externalization in architectural design, it doesn't serve as a comprehensive list or a copy-paste solution, but as a series of potential inquiry sparked by existing design strategies stemming from prior case study research. However behind each strategy generated within the taxonomy also lies deeper literature review and research that support the importance and value of the strategies generated. The full taxonomy can be divided into the following four broad categories:

- Externalize Circulation
- Externalize Family
- Externalize Community
- Embrace Ecology

Each category contains several externalization strategies, each of which includes an explanatory diagram, a description, scientific research that supports the environmental and social benefits of the strategy, and a precedent study that utilizes the specified strategy. The layout of each taxonomy is shown in Figure 1. These strategies will not be shown in this paper itself, though are accessible online.

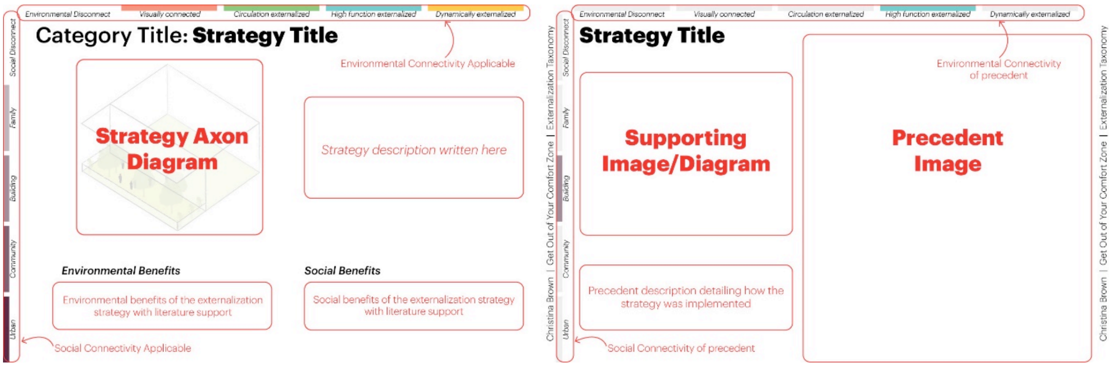

Figure 1: Externalization Taxonomy Layout

Externalization Taxonomy to Support Design

How can designers could use the 50 externalization taxonomies in design - and what are the qualitative and quantitative benefits of implementation? Four specific strategies were chosen and applied to a case study in Pittsburgh to better understand its impact on the building's design, its daylighting and energy performance, and lastly its experiential impact. The four specific strategies chosen where the shutter facade, dynamic facade, periphery social, and terraced garden strategies. These four strategies were applied to the Environmental Charter School (ECS) in Garfield to explore the value of externalization in architectural design.

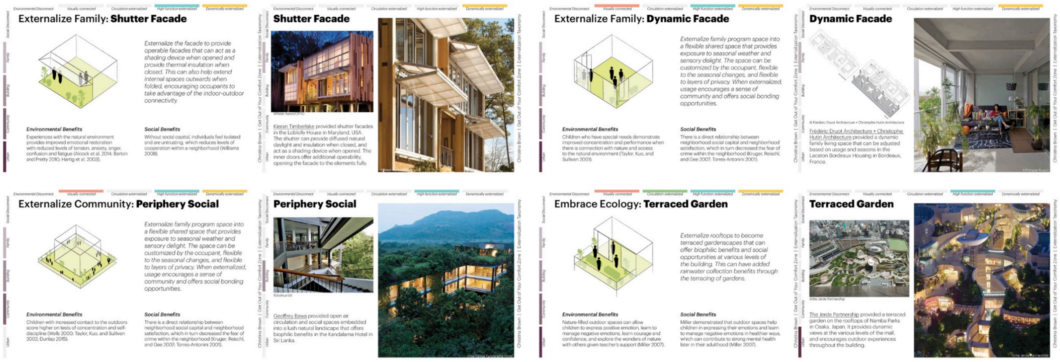

Figure 2: Four Externalization Strategies Applied to ECS

The existing ECS building is an enclosed building with thick brick wall construction due to how old the building is. The window sizes and overall building performance was enhanced with the renovation prior to the school's opening, though all windows in the building are inoperable to the outdoors. This results in a fully internalized spatial experience that does not encourage students and school staff to experience and connect with the outdoor environment despite the school's out-the-door learning approach. Analyzing the current baseline, the school is primarily enclosed with 71.8% of the total school providing visual connection to the outdoors alone (in red) as shown in Figure 91. The paved area on the southern side of the school as well as the parking lot on the northern side of the school is used for students to play, which is 6.3% of the total program area and the only area that is high function externalized to the outdoors. Due to the lack of greenspace located on the site itself, the adjacent open greenspaces (both located on steep hills that prevent easy access) as well as parks further away are relied on. Spatially and architecturally, the baseline does not allow the school to take advantage of the outdoor environment at all. The school follows a standard educational layout with a central circulation and classrooms facing both the north and southern facades, and the building is three stories tall. The school building does not contain a traditional gym space, so the activity room on the ground floor (a larger classroom area) along with the outdoor spaces are used in lieu of the gym space. Physical activity is crucial to children's physical and mental development, making the importance of the outdoors evermore important due to the lack of gym space for physical activity. Given the evident limitations to the baseline ECS building, how can externalization provide valuable impacts to the experience and performance of the existing architecture? This is explored in increasingly more drastic applications – starting with the shutter façade externalization strategy from the externalization taxonomy.

The shutter façade aims to externalize the façade to provide façade operability that can act as shading devices when opened while providing thermal insulation when closed. When opened, the shutters can provide shading and rain/snow coverage to allow for use as long as temperature is permitting. This can also help extend internal spaces outwards when folded, encouraging occupants to take advantage of the indoor-outdoor connection. Passive strategies such as natural daylighting and natural ventilation can also be utilized with this approach. The use of the shutter façade allows the building externalization ratio to shift from a predominantly internalized space to primarily dynamically externalized space (73%). The amount of environmentally disconnected and high function externalized spaces do not change however due to the strategy mainly influencing the building façade design alone.

However, the northern and southern outdoor areas are landscaped to provide improved outdoor areas that had better encourage students to play outside. Additionally due to the inclusion of the shutter façade, the ground floor classrooms are able to spill out to the nearby greenspaces due to the operability of the design. This approach does not greatly affect the cafeteria or circulatory experiences of the school, but given that students are spending most of their time in classroom settings, this approach can still have profound impacts with biophilic benefits for the students and faculty at ECS. Furthermore, due to the shading provided by the shutter when opened, the natural daylight simulations indicate great levels of spatial daylight autonomy (83.1%) while having very little possibilities of glare. This means that classrooms could take advantage of natural daylight strategies without worrying about issues of glare, which is especially important for the classroom experience given that issues of glare usually deter school staff from taking advantage of natural daylighting opportunities as much. Blinds are still available given that the use of projectors and other technologies may require the classroom to be fully dark at times, though the opportunity to use natural daylighting rather than artificial lighting will have profound impacts on the student's wellbeing as well as the operational costs of the school as a whole.

In addition to the natural daylighting benefits that resulted from the shutter façade, the overall building energy use intensity (EUI) also is impacted. Due to the use of natural daylighting and natural ventilation strategies, the total building EUI would be as an astonishing 24.17 kBtu/ft^2/year. This is only slightly above the 2030 EUI Target for educational buildings. Given the use of passive strategies that would reduce existing cooling, heating, and lighting loads, it results in the equipment becoming the highest energy load for the whole building instead. Additionally, using Cove.tool, a simple cost analysis was conducted to see the various renovation options possible, which aims to calibrate between the amount of money spent relative to the building's energy performance. As shown in Figure 196, the lowest cost bundle is making no further changes from the design iteration, though for $1,321 the energy could be optimized even further, resulting in a less than 2-year payback and a 2% energy savings.

Another strategy with greater alterations to the baseline is the dynamic facade, which provides even more porosity and flexibility into the architectural design. The dynamic façade externalizes internal program into a flexible shared space that can provide exposure to seasonal weather changes and provide sensory delight. The space can be customized by the occupant and allow for layers of privacy. When externalized, the usage encourages a sense of community and offers social bonding opportunities. Given the strategy and climate type, a dynamic buffer zone is also added on the southern facade to take advantage of thermal capture in winter months. This strategy allows for mostly dynamically externalized spaces, but increases the amount of high function externalized spaces through balconies. This results in great increases in teachable area, social area, and playable area through the added buffer space and balcony additions. Due to this implementation, there is 73% dynamically externalized building community space, and a combined total of 8% circulation externalized and high function externalized spaces. There is still a significant amount of internalized spaces in the center of the building, though it does improve slightly from the original baseline building externalization ratios (BER). Additionally in this iteration, unlike the shutter façade, there are programmatic and spatial impacts. With the implementation of dynamic façade, there is a 24% increase in the total teachable areas, a 109% increase in the total social areas, and a 79% increase in the total playable area. This is due to the inclusion of balcony spaces and the dynamic buffer space. This strategy delivers a very different connection to the outdoors for the students given that this strategy acts more like layers of indoor-outdoor-ness (much like an onion), while still providing many of the externalization benefits that the shutter façade offered.

In terms of daylight performance, this iteration provided even higher spatial daylight autonomy (sDA) of 94.9%. However, this also resulted in increased annual sunlight exposure (ASE) of 28.3%. The increase is to be expected given that this strategy does not offer shading solutions, so additional shading strategies could be explored to address the visual comfort concerns. Similar to the shutter façade, the dynamic façade also had a similar EUI value of 24.39 kBtu/ft^2/year. Moreover, like the previous iteration, the equipment load is the main dominant load for the whole building energy use intensity breakdown. However, unlike the previous iteration, the cost analysis showed that significant energy savings could be made with actually less cost. This indicates that the design of the school provided more energy savings with less construction and system costs. The most optimized bundle offers a $26,730 reduction in cost for an added 3% energy savings, which would result in immediate payback!

The third strategy is the terraced garden, which aims to embrace ecology while offering both social and biophilic benefits. Terraced garden aims to externalize rooftops and facades to become terraced gardenscape that can offer biophilic benefits and social opportunities at various levels of the building. This can have added rainwater collection and other ecological design strategies integrated into the design process. In this iteration, there are terraced landscapes west of the building that embraces a bigger outdoor play area for the students. The parking lot is in return moved offsite to the adjacent open space. The southern paved area is now transformed into a flexible garden space and outdoor kitchen space with balconies on the second and third floors. This approach greatly increases the amount of high function externalized spaces, with the majority of the design being either dynamically or fully externalized to the outdoors. This also results in incredible increases in the total teachable area (41%), social area (159%), playable area (297%), and circulation in the outdoors (154%). In this iteration, the BER shifts from a predominantly dynamically externalized building to one that is mostly dynamically externalized or high function externalized. This indicates that a large amount of occupied space is actually fully externalized to the environment. For ECS with their out-the-door curriculum, this ratio best aligns with their educational beliefs.

For daylight performance, the terraced garden iteration actually performed lesser than the two previous iterations. This was likely due to the more intensive structures added on the southern façade, which resulted in less optimal daylight performance. The overall performance was still high, though more formal considerations would need to be taken prior to its implementation. For this exploration however, that level of detail will not be explored further. However, in contrast, the EUI analysis showed that the terraced garden iteration performed better than the shutter façade or dynamic façade, which could be due to the impact of the dynamic structure added to the southern façade that acts as a thermal buffer and storage during winter months. Understandably, the heating load becomes miniscule, with added focus on equipment loads becoming the largest building load. Lastly, the cost analysis indicated that similar to the dynamic façade, reduced construction cost can actually serve to improve the overall building performance by a slight amount. In the most optimized scenario, $11,082 can be saved while providing 1% payback in energy savings. This would result in improved energy performance in addition to reduced construction costs.

Last of all, periphery social completely transforms the school by pushing the circulation to the perimeter of the building. Periphery Social pushes circulation to the periphery edge of the building while incorporating social spaces and community gathering spaces into the circulation itself. This allows for a richer and engaging circulation that allows for spontaneous interactions, collaboration, and social activities to take place in traditionally "transitory" spaces. Additionally, this can be combined with greenscapes or vegetation to provide added environmental benefits in addition to the social richness that stems from this strategy. In this iteration, the use of the periphery social pushes the central circulation to the perimeter of the building, which hollows out the building center to create a new atrium that can allow natural daylight to penetrate in. This also provides the school flexibility to adjust the building's porosity based on seasonal conditions on all sides given the dynamically externalized double skin. The approach makes the building largely dynamically externalized (at a combined 91.5%) based on seasonal conditions, and offer more natural daylight into the whole building. However this does reduce the amount of high function or circulation externalized spaces, which reduces the amount of diversity and gradients of externalization is provided in the design, as well as can result in the "over cladding" of the double skin. In this iteration operability becomes highly important, influential in the success or failure of externalization (based on occupant behavior), and proposes new challenges in terms of construction cost, material cost, and questions of excess. The newly created atrium space allows for improved daylighting qualities all the way to the first floor, removing large amounts of originally environmentally disconnected spaces, but results in a seemingly less efficient circulation design for the building. Though the strategy does not perfectly fit the case, it does provide important environmental and social benefits that should be further considered, while the design's drawbacks should also be re-evaluated for future design development.

For the natural daylight performance of this iteration, the large additions did not benefit the overall lighting performance of the building. The spatial daylight autonomy decreased to 62.4% (in comparison to previous iterations), and the annual sunlight exposure was still at 21.7%. This indicated that this iteration provided the most natural daylight challenges, meaning the approaches from other iterations provided more successful natural daylight design solutions in comparison to this iteration. Further exploration and simulation would be needed to improve the building performance of this design. This iteration similarly performed well compared to the 2030 baseline, though comparatively less than the shutter façade and terraced garden iterations. This indicated that the approach was not ideal given its (comparatively) poor daylighting performance with no evident improvement in the EUI performance either. Lastly, similar to the previous two iterations, periphery social actually benefitted from improved energy savings with less upfront cost. The construction would save $16,190 with 2% improved energy savings based on the most optimized option found in Cove.tool. This is once again likely due to the thermal storage of the double skin that allows for performative savings that may result in some building system machinery being too high-tech relative to their overall usage/impact on the total building energy load.

In terms of building performance, each iteration performs at roughly half of the US national median EUI for schools through externalization, which equipment now becoming the main energy load factor in each iteration. Due to the implementation of externalization along with the use of passive strategies, the heating, cooling, and lighting loads are all significantly reduced. This results in the equipment load being the dominant load for each iteration. These iterations are still slightly above the 2030 target of 18.33 kBtu/ft^2/year, but through an iterative design process, these preliminary designs could likely reach the 2030 target. Especially considering that, these four iterations are all preliminary designs to explore the value of externalization; these results highlight the potential of externalized thinking. Additionally natural daylight analysis shows that the daylight quality improves greatly through these designs due to increased connections to the environment, though to varying degrees. Overall, their performance are still quite meaningful.

Conclusion

From the growing impacts of climate change and concerns for building energy loads to the established importance of nature on human health and wellbeing as we become increasingly urbanized to the growing concerns for isolation and social disconnectivity, how we understand 'boundary' and shape our spaces become ever more critical. The conventional approach of internalization was supported and bolstered by the development of technology, but as new concerns arise in the 21st century, it is necessary for architecture to shift from the internalized design approach that have become the 'norm' to a new externalized design approach that reconnect people to the environment and to each other. Especially in the age of pandemic where quarantine, isolation, and social distancing have become commonplace, externalization becomes a crucial design approach that serves to support the necessary connections that are needed while abiding by the many health and social restrictions that define the current lifestyle.

This synthesis establishes foundational research, framework, and design work to encourage and support design professionals in shifting from the current internalized design approach to an externalized approach that allows its occupants to embrace both nature and the community, so that we can create spatial environments that embraces connectivity rather than isolation.

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