Ecosystems are valuable in creating diverse and collaborative environments that enable businesses to innovate in ways that are much more difficult without them. However, business managers can be reluctant to participate in building ecosystems mainly due to lack of understanding. Specifically, businesses can be uncomfortable sharing resources, data, intellectual property and secrets with other ecosystem actors. Drawing on interdisciplinary perspectives from literature, we use a ‘design focused ecosystem thinking’ to propose a new type of Disruptive Innovation Ecosystem (DIE). Firstly, we discuss the significance of adopting innovation ecosystems to create shared value. Secondly, we conceptualize a new type of DIE and propose steps on how DIEs can be created and fostered. Finally, we discuss DIE roles in relation to Amazon, Apple, Uber, and Siemens ecosystem cases. This paper offers a new type of DIE design process which may be leveraged by businesses towards building sustainable innovation ecosystems.

Keywords: Innovation ecosystem, Disruptive Innovation, Disruptive Innovation Ecosystem, Design, Shared Value

Introduction

The word ‘ecosystem’ originates from the domain of biology, and it defines the interaction and interdependence of living organisms within their environment (Jucevičius & Grumadaitė, 2014; Ferdinand & Meyer, 2017; Su, Zheng & Chen, 2018). In business, an ecosystem is defined as a network of actors who are guided by shared goals to create market and customer-focused solutions (Lyman, Ref & Wright, 2018). Recently, business and innovation literature has started to use ‘ecosystems’ as metaphors to explain the process of innovation (Shaw & Allen, 2016), subsequently leading to the ubiquitous use of the term ‘innovation ecosystems’ which means the constellation of actors connected in a web-like system to co-create, deliver and appropriate value (Hwang & Horowitt, 2012; Iansiti & Levien, 2004; Rabelo & Bernus, 2015; Tsujimoto, Kajikawa, Tomita & Matsumoto, 2017; Lyman et al., 2018; Russell & Smorodinskaya, 2018; Dedehayir & Seppänen, 2015; Dedehayir, Ortt & Seppanen, 2017).

Innovation ecosystem actors collaborate to offer innovations in the form of new systems, new products, technologies and services to customers. Wal-Mart, Amazon, ALIBABA, Apple, eBay, Google, and Microsoft are some of the few examples of firms who successfully applied the concept of innovation ecosystems in the past (Lyman et al., 2018). The internet makes it easier for larger and denser innovation ecosystems to grow in ways that were more difficult without the internet (Rong, Hu, Lin & Shi, 2015; Zhongmin, 2018; Wu, Wu & Si, 2016; Yan & Guan, 2018). In the context of this study, we discuss innovation ecosystems as systems of shared value.
creation. However, before we discuss innovation ecosystems lets look at how Chesbrough, Vanhaverbeke, and West (2008) describe open innovations:

The use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. (Chesbrough et al., 2008, p. 2).

Chesbrough et al., (2008) claim that opening the innovation process by leveraging information flows from outside firm boundaries and sharing data with other actors and or competitors can profit the firm, and Cruickshank (2014) expand on the claims by signaling the significance of managing information flows to increase profit. Consequently, opening the innovation process to create shared value is achieved through innovation ecosystems. Best and Koria (2017) posit that shared value is the unexpected solutions arising from innovation ecosystems. We continue from the latter perspective and Rabelo and Bernus (2015) innovation ecosystem life cycle processes. To support these ongoing works of building sustainable innovation ecosystems, we follow a design focused ecosystem thinking to develop a new kind of DIE associated with mutual survival of innovation ecosystem actors within disruptive environments. Disruptive innovation occurs when established customers of mainstream products, services or systems leave and start using a different offering, often produced by a less established company (Valkokari, Seppanen, Mantyla & Jylha-Olilla, 2017; Christensen, Raynor & Mcdonald, 2015; Christensen, 1997).

Ecosystems empower businesses to innovate together to create shared value (Lyman et al., 2018; Senyo, Liu & Effah, 2019; Adner, 2017; Russell and Smorodinskaya, 2018; Bosch and Olsson, 2018). However, as higher numbers of actors become interconnected, interrelationships can become unclear and evolve in unpredictable ways (Gomes, Facin, Salerno & Ikenami, 2016). Real-world ecosystems provide a milieu of interconnected actors where businesses can leverage vast resources to create new offerings. Nevertheless, how designers and business leaders use innovation ecosystems to develop sustainable offerings is less understood (Shaw & Allen, 2016; Lyman et al., 2018). Specifically, managing disruptive innovations within ecosystems remain a significant challenge (Gomes et al., 2016; Dedehayir et al., 2017; Valkokari et al., 2017). It is essential to discuss the emergence and role of innovation ecosystems within business growth (Mortati & Cruickshank, 2011), and towards the delivery of disruptive innovations (Dedehayir, Mäkinen, & Roland, 2016). Best and koria (2017) opened a conversation around how silent designers may help create unexpected solutions from ecosystem ambiguities. These ambiguities are opportunities that are difficult to find through linear systems or models (Best & Koria, 2017; Lester & Piore, 2004).

While organizations are generally set up to create profits as their primary function (Russell & Smorodinskaya, 2018), throughout this paper, we emphasize that shared value associated with mutual survival of ecosystem actors is becoming crucial. Organizations and governments make huge investments across the globe towards the development of innovation ecosystems, but there is a dramatic shortfall in achieving set targets (Rabelo & Bernus, 2015). These shortfalls are partly ascribed to actor’s insufficient readiness and lack of knowledge and awareness about operating within ecosystems (Lyman et al., 2018; Rabelo & Bernus, 2015; Iansiti & Leven, 2004). Since ecosystems are regarded as ‘new thinking’ for value creation in today’s interconnected world (Russell & Smorodinskaya, 2018; Lyman et al., 2018), it is urgent to comprehend the process of innovation ecosystems in creating and delivering shared value. Lyman et al., (2018) and Senyo et al., (2019) observe that though some business managers appreciate the significance of adopting ecosystems, they can be reluctant to participate due to fear of relinquishing control and sharing resource, data and intellectual property with other actors or competitors.

This paper discusses some major innovation ecosystem challenges and conceptualizes a new type of disruptive innovation ecosystem (DIE), which may be a fundamental design process for DIEs. Secondly, we propose steps on how DIEs can be created and fostered. Through the ecosystem approach, we posit how DIEs may be fostered to emerge and create viable connections amongst entities by drawing insights from literature on ecosystem emergence and disruptive innovation (Gawer & Cusumano, 2014; Dedehayir et al., 2016; Iansiti & Leven, 2004; Adner & Kapoor, 2016; Adner, 2017; Christensen, Raynor & Mcdonald, 2017; Valkokari et al., 2017). Thirdly, we discuss and visualise ecosystem roles by using Amazon, Apple, Uber and Siemens innovation ecosystem case studies.

This paper is divided into four sections. The second section discusses innovation ecosystems and disruptive innovation concepts. The third section proposes a new DIE and visualises DIE roles. In the last section, we outline the main conclusions and future direction of the study.
Innovation Ecosystems and Disruptive Innovations

Challenges of designing viable innovation ecosystems

Innovation ecosystems can be useful for developing creative solutions to problems. However, thriving ecosystems often emerge organically and can be difficult to build from scratch. It would be vital to be able to design and build them from scratch, but the dynamics and behavior of innovation ecosystems can be difficult to understand (Roundy, Bradshaw & Brockman, 2018). To appreciate the structure of innovation ecosystems, it is generally explained in terms of either hub-centered star structures as shown in Figure 1(A), or flat mesh-like structures as shown in Figure 1(B) and are further elaborated in previous literature (Mazhelis, Luoma & Warma, 2012). This typology defines the power diffusion and challenges associated with managing connections within the ecosystem network roles which will be discussed thoroughly in the third section of this paper.

Figure 1: A typological visualization of innovation ecosystems: Showing A (star-shaped structure) and B (flat mesh-like structure).

Meanwhile, the openness of innovation ecosystems is usually seen as a management challenge more especially when dealing with many actors possessing different characteristics (Masys & Bennett, 2016), and contrasting socioeconomic and leadership models (Barile, Lusch, Reynoso, Saviano & Spohrer, 2016; Russell & Smorodinskaya, 2018; Mortati & Cruickshank, 2012). However, Best and Koria (2017) argue that designers may leverage from these supposedly problematic areas of innovation ecosystems to create unexpected solutions and improve ecosystem adaptability. Adaptability in the context of our study means the ability of the innovation ecosystem to adjust to new conditions imposed by the external environmental forces. Innovation ecosystems are exposed to rapidly changing environmental factors (Hwang & Horowitt, 2012; Iansiti & Levien, 2004), and characterized by ambiguities (Ferdinand & Meyer, 2017; Best & Koria, 2017).

It is difficult for leading and incumbent firms to evolve their innovation ecosystems and re-design their systems to cope with disruptive innovation, some examples of failed ecosystems include Intel (Iyer, Lee & Venkatraman, 2006), IBM (Christensen, 1997) and Nokia (Iyer et al., 2006). The challenges affecting the evolution of business ecosystems also affect the development of innovation ecosystems, albeit more ambiguous. The ambiguity of innovation ecosystems is partly explained in Christensen’s case study writings (Christensen, 2014; Christensen, 2013; 1997), though the author’s theory is inclined towards creating firms competitive advantage instead of innovation ecosystems shared value creation. Christensen (1997) explains that incumbent firms fail to respond promptly to disruptions thus allowing entrants to grow and ultimately taking their customers. Market disruptions challenge the business as usual ecosystems, in most cases causing the ecosystem networks to collapse when faced with entrant disruptive ecosystems (Christensen et al., 2015). The impact of entrant disruption to actors connected to incumbent ecosystems seems to be unclear from Christensen’s description (Dedehayir et al., 2017).

While innovation ecosystem challenges are well acknowledged in management research (Dedehayir et al., 2016; Lenkenhoff et al., 2018), disruptive innovation ecosystems related problems are less discussed and less
predictable (Dedehayir et al., 2017), although we argue that they are more intricate due to the complex nitty-gritty of managing disruptive innovations and innovation ecosystems. Hwang and Horowitt (2012) claim that innovation ecosystems need not be forced to exist, but rather emerge from a designed and shaped environment where they may thrive. The design and form of Innovation ecosystems are likened to the rainforest which does not predetermine the new biological species but provides the right environmental factors to foster emergence (Hwang & Horowitt, 2012; Shaw & Allen, 2016). Howkins share the same view and apply it to the emergence of creative ecologies (Howkins, 2010).

Identifying the right environmental factors for the design and formation of viable innovation ecosystems is one of the primary challenge confronting ecosystem designers today, just as it is challenging to plan for disruptive technologies (Christensen, 1997). In order to build successful innovation ecosystems, we need to consider the interdependence and interconnectedness of actors, individual actor models, strategic roles, evolution process, actor heterogeneity, and environmental factors. These are vital precursors for designing viable innovation ecosystems. These precursors may shift the attention from managing competition to coopetition as observed in (Isckia & Lescop, 2009; Ferdinand and Meyer, 2017).

To optimize shared value within innovation ecosystems, the theory of weak ties albeit old (Granovetter, 1973), may aid innovation and creativity within ecosystems. Mixing unreliable ties (weak ties) with reliable and established ties (strong ties) may provide new avenues for disruptive innovation (Cruickshank, 2010). The theory suggests that actors who are weakly linked to a network are most likely to provide the most valuable information for innovation as shown in Figure 2. However, in practice, weak nodes in networks are usually forgotten or ignored, but Hwang and Horowitt (2012) buttress that Google and Facebook were not distinguishable from weed in a rainforest or unwanted trees a few years ago, but today they are the most valuable amongst the search engines and social media platforms respectively. As shown in Figure 2, Ignoring the weak ties between IE-A and IE-C may lead to insufficient use of high-value data from both communities. Finding useful ways to take advantage of weak ties in designing innovation ecosystems is a great challenge and opportunity for designers.

Figure 2: Visualisation of weak ties vs. strong ties: IE-A link to IE-C represents a weak tie which connects to information outside immediate group, hence, high-value data for innovation. IE- A link to IE-B represent a strong tie which connects actors to data within the group, thus present low-value data for innovation.

To address the challenges, we propose a new kind of ‘disruptive innovation ecosystem (DIE),’ which is a combination of disruptive innovation and innovation ecosystem constructs.

**Disruptive Innovation Ecosystems (DIEs)**

**What is a DIE?**

‘Disruptive innovation ecosystem (DIE)’ is proposed here as an innovation ecosystem capable of delivering disruptive innovations. James F. Moore was the first author to coin the term ‘business ecosystem’ which
according to Su et al., (2018) and Gratacap and Isckia (2013) have been extensively applied to innovation management research in the past. Moore’s concept of business ecosystems has continually evolved into explaining social networks and community structures (Ansari, Garud & Kumaraswamy, 2016; Su et al., 2018; Elena & Avasilcai, 2016; Gratacap & Isckia, 2013). Today, understanding interrelationships within SMEs, digital spaces, government policies, communities, and prosumers may be critical than ever before. Businesses are slowly harnessing the power of ecosystems in developing their business models (Lyman et al., 2018). Examples of bubbling disruptive innovation ecosystems are Uber and Lyft in the taxi business, Airbnb and Breather in the hotel business (Libert, Wind & Fenley, 2014; Smith, 2016), and Apple iPhone in the smartphone business (Valkokari et al., 2017).

Though the theory of disruptive innovations continues to be explored in business management, business managers and strategists remain unaware of the possible remedies of disruptive threats in their incumbent innovation ecosystems (Christensen et al., 2015; Lyman et al., 2018; Khanagha, Ramezan, Mihalache & Volberda, 2018). While it is difficult to prescribe what needs to be done to tackle the disruptive threats from entrants’ ecosystems as argued in (Ozalp, Cennamo & Gawer, 2018; Dedehayir et al., 2017), Christensen et al., (2015) suggests that instead of incumbent firms competing directly with entrant firms, they may consider forming separate divisions to explore new disruptive models. Furthermore, Khanagha et al., (2018) suggest experimentations with disruptive innovations. We submit that experimenting with DIEs requires a design process and designers to build the process. Who are these designers?, How can they design DIEs?, What roles may DIE actors assume?

**Designers of DIEs**

Designers are divergent thinkers (Hernández, Cooper, Tether & Murphy, 2018), and dealing with ecosystems is a problem of a divergent nature where designers may provide solutions to build sustainable DIEs. Therefore, a DIE designer maybe anyone with a divergent mindset, willing to look beyond the boundaries of a system towards creating customer experiences by leveraging DIE ambiguities. When designing DIEs, one cannot just look at individual actions, the designer influences the design of the holistic DIE environment and form that connects the actors to the same objective, attract new actors and ultimately enable DIE to emerge and thrive. The designer may be the brain behind innovation ecosystems, clusters, value networks, and other social network structures. Building this kind of DIE is not easy. Researchers previously proposed business ecosystem designs but to no definite agreeable structure (Gomes et al., 2016; Rabelo & Bernus, 2015; Valkokari et al., 2017), and developed tools for modelling innovation ecosystems (Walrave, Talmar, Podoynitsyna, Romme & Verbong, 2018; Talmar, Walrave, Podoynitsyna, Holmstrom & Romme, 2018). Challenges associated with DIE ambiguities may be addressed by following a DIE design process to create unexpected solutions. As shown in Figure 3, designers may use weak ties between communities of DIEs to leverage these relationship properties or recipes of design to create new solutions. For example, IE-F is weakly connected to IE-D, the two communities may use the weak tie as a bridge to leverage information on both sides to create new offerings.

**Figure 3: Showing innovation ecosystem community (A, B, C, D, E, F) weak ties and where designers of DIEs may leverage ambiguous data of weak ties to identify design recipes for innovation.**
Designing DIEs

Design is the process that transforms new ideas and technologies into new usable systems, products, and services for customers (Hernández et al., 2018). Customers in case of DIEs may include co-innovators, distributors, retailers, end customers and others who are part of the DIE. Since design science is seen as a tool to gain competitive advantage in new radical innovations (Laureate & Spence, 2017), it can help the ecosystem actors to work collaboratively past specific firm challenges to ecosystems (Lockwood, 2018). Considering there is nothing like a single recipe for a thriving innovation ecosystem (Rabelo & Bernus, 2015), designing this kind of DIE embodies a creative process based on shared value to create, develop and define new products, services or systems that represents change. This may be a laborious exercise since innovation ecosystems do not have a formal structure of operation (Dedehayir et al., 2016). To constantly redesign shared value within Innovation ecosystems, we visualize the ideal ecosystem design approach shown in Figure 4 to aid the process of developing DIEs.

We draw insights from the fundamentals of open systems (Input-process-output) and show how this axiom interrelate with DIE factors. These interrelations may lead to unpredictable and unexpected DIE outputs. Understanding these interrelationships and environmental factors is crucial to DIE design process. As shown in Figure 4, DIE business models are interlinked to the DIE vision through customer demands and market needs. Market needs, DIE data, DIE network interrelationships, DIE shared vision, DIE material, and information flows are all crucial precursors for the design of viable DIEs. During the implementation stage, DIEs evolve in different shapes and forms depending on the disruptive innovations, value streams, new technology, information exchange, the culture of actors, talents and other factors as shown in Figure 4. Since DIEs form is evolving rapidly, it is challenging to develop a one size fit-all perspective. Our approach emphasizes understanding inputs, process, and environmental factors, which self-organize and evolve with time. Therefore, we argue that what is paramount is to position the designer at the early stages of DIE initiation, to influence the DIE evolution, management and sustainability.

![Figure 4: Ecosystem design approach: Showing Inputs, processes, environmental factors leading to DIE outputs.](image)

Actors aiming to start DIEs are confronted with many questions such as how to start, whom to begin with and when to start. These questions cannot be answered through a literature review alone. The openness of DIEs makes them fuzzy to design just like developing ecosystems as noted in (Dedehayir et al., 2016), hence the need to understand the evolution stages and factors that are likely to shape and influence the design of DIEs. Moore (1993) proposed a four-phase life cycle (birth, expansion, leadership, and self-renewal) in developing business ecosystems, which was later expanded by Rong, Liu, and Shi (2011) as follows; 1. Emergence, 2. Diversifying, 3. Converging, 4. Consolidating, 5. Renewing. We propose DIE design process stages and visualize the model as shown in Figure 5.
Figure 1: DIE process: Showing the non-linear interconnections between stages: 1. Initiation (information flow; 1-2, 1-4, 1-3, 1-5), 2. Development (information flow; 2-1, 2-3, 2-4), 3. Management (information flow; 3-2, 3-4), 4. Sustainability (4-1, 4-3, 4-5) and 5. Death and resurrection (information flow; 5-1).

DIE Initiation

As astutely argued by Christensen (1997), established firms usually wait for disruptive technology to be established in mainstream markets. In the past, IBM waited carefully for the unfolding of the market (Moore, 1993), but today it may be risky to wait. Therefore, the first consideration for DIEs design is to initiate the value proposition around the emerging new market needs. Defining value proposition is meant to initiate the process of collaboration as outlined in (Adner, 2017). The ecosystem initiators actuate the process of coalescence. It is at this initiation stage that trust, tolerance, data sharing, emergence, and shared visions are cultivated to build open connections as shown in Figure 5.

The value proposition is based on information flow, money, interrelationships and materials as described in (Parolini, 1999). Just like the flow of nutrients in the rainforest (Shaw & Allen, 2016; Hwang & Horowitt, 2012), we argue that data flow is the resource that links stakeholders of the DIEs. It is crucial at the initiation stage to establish potential roles or nodes in the DIE structure. Some researchers suggested actors who may be essential at this early stage of building innovation ecosystems such as Suppliers, manufacturers, users, universities and research centers, entrepreneurs, regulators (Cusumano & Gawer, 2003; Li & Garnsey, 2014; Dedehayir et al., 2016; Rabelo & Bernus, 2015).

We propose that the design of DIEs may be approached from the main players who possess a shared vision complemented by other actors. The leader may recruit actors and ensure their autonomy and diversity of ideas. The initiator may offer some incentives to attract more actors to the DIE. Moore (1993) defines the initiation stage as the birth stage, Rabelo and Bernus (2015) identify this stage as the seed phase. We emphasize that this initiation stage cultivates a nourishing environment for adaptable DIEs to emerge.

We argue that the use of weak ties to increase the network density may also increase interaction within DIEs, hence increasing disruptive innovation streams. Weak ties connect actors of differing capabilities, unlike strong ties as shown in Figure 3 above. The amorphous bridges created by weak ties (Baer, 2010), are valuable to the design of DIEs because they may increase network density and access to information outside core actors. The increase in density of non-linear interrelationships is proportional to an increase in ecosystem
efficiency (Ivanova & Leydesdorff, 2015). It is not about choosing the right actors during the design process but rather stimulating DIE environment, just like in nurturing the rainforest as observed in (Hwang & Horowitt, 2012). The initiation stage is more about defining the DIE vision, business case, market roadmap based on the critical environmental factors shown in Figure 5.

DIE Development

We expect the initiated DIE to expand in terms of coopetition dynamics. Instead of competing with new DIEs it may be fruitful to explore weak ties to bridge the information gap between the DIEs and foster coopetition. The development of DIEs can be supported by friendly government policies at this stage to enhance coopetition and information exchange between actors. Searching for new territories to create and capture new markets by recruiting niche players may further develop the DIE network. To attract new players, DIE actors may establish unambiguous value creation and appropriation guidelines which are open and public following suggestions from (Rong et al., 2015; Dedehayir et al., 2016). Though these suggestions are not designed explicitly for disruptive environments, we argue that they apply to the development stage of DIEs. Open relational contracts for shared value are encouraged to lessen conflicts and disgruntlement within DIEs.

DIEs may attract new players by first growing demand for their niche products and services. This may be possible through the design of innovation ecosystems. At this point, disruptive players can be recruited to expand the niche creating streams. Developing DIEs may involve planning, testing and piloting in the market. To grow the market, the DIE architecture is designed for future scaling and evolvability. Therefore it must be flexible and adaptable to environmental changes which are often unpredictable and ambiguous. DIE designers may also consider third-party opportunities to develop the ecosystem. Amazon benefits a lot from third-party proceeds due to its open ecosystem architecture (Isckia, 2009).

DIE Management

Detailed literature investigated by Gomes et al. (2016) indicates challenges in the management of disruptive innovations within ecosystems. We posit that a design-focused approach can help manage DIEs. In Lyman et al., (2018), 50 % of managers believe that they do not have the capacity to manage business ecosystems. The autonomy of actors to operate in multiple and horizontal ways enabled by shared assets may limit linear management tendencies as demonstrated in (Lyman et al., 2018; Iansiti & Levien, 2004; Power & Jerjian, 2001; Gemici & Alpkan, 2015). Management in DIEs implies, inter alia, the coordinated sharing of resources as opposed to hierarchical coordination. Sharing of DIE resources lead to the creation of shared value. The main players may directly coordinate by initializing niche and smart technologies and influencing DIE actors to innovate through a shared vision. Linear management styles are discouraged at this stage because DIEs are intended to create unexpected opportunities horizontally.

Management of DIEs may focus on nurturing the DIE environment to accommodate the heterogeneity of business models. The firm focused business ecosystem concept such as Moore (1993) at this stage emphasizes control of value streams, which may not be an ideal strategy for managing innovation ecosystems in today’s business milieu. Blackberry ecosystem’s collapse is attributed to lack of designing an effective strategy to manage its innovation ecosystem (Jacobides, 2013). We propose a ‘win-win’ kind of collaborative activities and strongly discourage ‘big brother’ mentality in sharing resources for innovation. This can be achieved through an elaborate strategic DIE role structure.

DIE Sustainability

At this stage, DIE actors may decide to revamp the activities of the network in line with new visions to tackle new disruptions which may be affecting the health and adaptability of the DIE as shown in Figure 5. The DIE is expected to ail with time and become less efficient. DIEs can resuscitate ailing networks by recruiting niche actors in their systems, who can be used to experiment on disruptive innovations until value interrelationships are fully developed. The theory of weak ties may be useful in expanding nodes towards actors outside the DIE community to increase information pathways for innovation or design recipes as shown in Figure 3 above. We reiterate that weak ties may increase the DIE resilience and adaptation leading to sustainability of disruptive innovations, in fact utilising weak tie data reduces destructive competition and increases shared value amongst heterogeneous communities.

DIE Death and resurrection
If DIEs fail to sustain its shared value at stage 4, it may cease to exist as a DIE by either a large part of the actors migrating to other DIEs or liquidating as individual entities, pulling others along with them. To survive the storms from competing ecosystems, DIEs may seek to slow the growth of new ecosystems by negotiating to collaborate partly or wholly, or worst-case scenario re-structure their DIE architectures to accommodate new players. However, the death of one DIE may lead to the emergence of another as shown by the dotted line in Figure 5 (relationship 5-1). Competition within DIE actors may lead to the destruction of the entire DIE and resurrection of a new type of DIE. DIEs may be dominated by either a keystone, dominator, hub landlord or niche actor. In the following section, we explore and visualise these DIE roles in detail.

**Strategic roles in DIEs**

Even though ecosystem roles are sometimes naturally emergent rather than prescribed (Dedehayir et al., 2016), it is crucial to understand the actor's roles in developing and sustaining DIEs. This can be achieved by understanding individual DIE actor capabilities they contribute towards shared value. Additionally, the power dynamics between actors need to be established to characterize DIE interconnections. To discuss the DIE roles, we re-imagine Iansiti and Levien (2004) strategic roles (Keystones, Dominators, hub landlord, and niche players) and generate visualizations to represent DIE roles. We then discuss Amazon, Apple, Uber, and Siemens case studies as examples of DIEs. We use graph visualisations to represent abstract properties like relationships, power, and interactions between DIE actors in a simple way to aid quick understanding of roles.

We use python tools to produce graph visualisations using random comma-separated values (CSV) data to facilitate ease of comparing main roles within DIEs following the visualisation framework as shown in Figure 6. Python libraries dedicated to graph visualisation such as Matplotlib, NumPy, and Networkx are used to demonstrate how actors (nodes) relate (edges) to each other in terms of position, connection and influence. CSV data is created depending on the description of each DIE role (keystones, dominators, hub landlords, and niche players) to represent nodes and edges of graphs. Larger nodes and higher connections represent more importance and influence in DIE network graph.

---

# To compare the DIE roles, we create CSV file for each DIE role based on the following properties:
Dominance (occupying many nodes), strong connections between nodes(weight), node degree (number of ties a node has) and centrality of a node (most important node).

# The CSV file is called run.CSV

### Source and target represent nodes and number of ties a node has which is determined by the node degree

<table>
<thead>
<tr>
<th>Source</th>
<th>Target</th>
<th>Type</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>undirected</td>
<td>4</td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>undirected</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>undirected</td>
<td>4</td>
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<td>1</td>
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<td>undirected</td>
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<td>5</td>
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<td>2</td>
<td>6</td>
<td>undirected</td>
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<tr>
<td>2</td>
<td>7</td>
<td>undirected</td>
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<td>n</td>
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<td>...</td>
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</tr>
</tbody>
</table>

The strength of node connections measured 1-5, (1 is weak connection and 5 is strong connection)

Type of connection indicate the flow of information between nodes, its both sides as opposed to directed

# Read and create graph as,

```python
import numpy as np
import matplotlib.pyplot as plt
import networkx as nx
input_data = pd.read_csv('run.csv', index_col=0)
G = nx.Graph(input_data.values)
```

# Visualise graph as,

```python
nx.draw(G, with_labels=True)
```

# To get different DIE graphs, we manipulated the CSV file to give us the kind of representation we need based on DIE role properties.

---

*Figure 2: DIE visualization framework showing the basic procedure taken to visualize actors’ roles using CSV data and represent their difference in terms of node importance, connection and influence.*
**DIE Keystones**

A keystone is an important and influential node that promotes stability, health and shared resources with other DIE actors. Just like in the context of business ecosystems (Rong et al., 2015; Iansiti & Levien, 2004; Hwang & Horowitt, 2012), DIEs cultivate co-evolution, creativity, and innovation by providing an open innovation environment. Removing the keystone node shown in Figure 7 may negatively affect the shared value. As shown in Figure 7, Keystones are represented in large nodes and edges occupying few positions in DIE networks. The remaining positions (small nodes and edges) are available to be occupied by other actors, thus dispersing power and authority across the network. By occupying the central positions, keystone nodes support innovations through the provision of DIE resources. Keystone node is trustworthy and has a good market reputation (Isckia & Lescop, 2009).

![Figure 3: Visualization of a DIE Keystone role: Keystone positions occupy the center nodes and connect through keystone edges to the rest of the network. Keystone positions are few in the network to lessen control and dominance.](image)

**Amazon as a keystone**

The growth of Amazon is attributed to its innovation ecosystem (Isckia & Lescop, 2009). Amazon as a keystone focuses on creating opportunities for other actors to access and leverage unlimited resources (Mazhelis et al., 2012; Gratacap & Isckia, 2013), without contributing to huge platform-specific investments (Zhu & Liu, 2018). Amazon maintains the autonomy of its partners pricing policies unlike other platform leaders such as Walmart and Apple (Moore, 1996; Zhu & Liu, 2018). Amazon integrates niche players within its ecosystem platforms as thus creating more value through web services and e-business incubation (Isckia & Lescop, 2009). Amazon has an excellent reputation for sacrificing profit for growth by fostering open-innovation within third-party players (Zhu & Liu, 2018). Therefore, Amazon appears to be a good example of a DIE keystone actor.

**DIE Dominators**

Dominators are DIE actors who have high control of value creation and capture streams in the network. Dominators are distinguished from Keystones through metrics of physical size as shown in Figure 8, one dominating actor occupying all positions indicated in large nodes (dominating nodes) in the network. Unlike keystones, dominators stifle diversity by the massive presence in the network and control most of the innovation streams (Dedehayir et al., 2016). Consequently, dominators within the DIE network may create and extract most of the value, thus starving its ecosystem. The behavior of dominators may limit the DIE to respond to external shocks and may eventually collapse the entire DIE.
Figure 4: Visualization of a DIE Dominator role: Dominator positions occupy the large nodes and connect through thick edges to the rest of the network. Dominator positions are many in the network to increase control and dominance.

Apple as a dominator

Unlike Amazon, we observe that Apple maybe extracting more value from the ecosystem by dominating its innovation networks. This is seen in (Valkokari, 2015; Jacobides, 2013) as a dominating factor. Apple maybe controlling the ecosystem by inhabiting value creating nodes as shown in Figure 8. Distinct from the Amazon ecosystem, Apple has been consistently reluctant to share value with others through licensing third-party developers. Though the company recently started supporting third-party apps, Apple continues to thwart third-party efforts by continually releasing new operating systems (Zhu & Liu, 2018; Song, 2010), whereas Amazon encourages the growth of third-party players. Though Apple has managed to navigate the disruptions in the smartphone business while maintaining a moat on its incumbent services (Back, 2014), it may be beneficial to open its innovation ecosystem further to support and create shared value to guarantee Apple DIE sustainability.

DIE Hub Landlords

Hub landlords are DIE actors who invest in value extraction only. As shown in Figure 9 hub landlords occupy few nodes in the entire innovation ecosystem shown in large nodes and thick edges. Actors holding hub positions are often faced with temptations to exploit their central hub position for short term gain to the detriment of other actors (Iyer et al., 2006). Dominators control value creation and capture most of it whereas hub landlords choose not to participate in the value creation, instead eschews control of networks and invest in value extraction only as elaborated in (Song, 2010), eventually turning successful keystones into hub landlords.
Uber as a Hub landlord

Uber relies on other people's automobiles by merely providing the hauling app to facilitate the sharing of actors' assets (Libert et al., 2014). Uber leverages dormant automobiles into valuable assets for drivers and riders (Smith, 2016). However, most of the value generated by drivers and customers are reported to be going towards Uber (Bensinger, 2017; Berger, Chen & Frey, 2018). Consequently, drivers and riders appear to be resentful over Uber’s value extraction and its inability to improve their well-being within the ecosystem (Ridester, 2018; Bensinger, 2017). Uber appears to be benefiting immensely from its ecosystem (Hall, Palsson & Price, 2018; Farrell & Bensinger, 2018).

Since Uber is not yet a public entity, its pricing algorithm is not publicly shared (Jiao, 2018), and it remains unclear as to how much is the actual unit cost per ride (Mims, 2017). Bensinger (2017) note that it is possible for Uber to lower fixed fees and commission charges to boost driver’s income. To sustain its ecosystem, Uber may need to look at its fixed costs and commission, and factor in maintenance costs, road charges and other charges associated with the drivers to turn it into a keystone player.

DIE Niche

While keystones provide a platform for innovation, niche players add value to the platforms by innovating (Rong et al., 2015). As shown in Figure 10, niche players have a meager physical presence in the DIE network yet collectively can create high-value solutions. Keystones rely on the presence of niche players to remain attractive to new actors. Niche players develop unique products and services different from what others do by leveraging resources provided by keystone players (Galateanu & Avasilcai, 2016).
Figure 6: Visualization of a DIE Niche role: Niche positions occupy the nodes located at the busiest points in the network. Niche positions are few in the network to contribute to innovation and creativity.

Siemens as a Niche

Adidas and Siemens are working towards forming something which may be likened to DIE niche service, to build an intelligent manufacturing speed factory. The factory is intended to make use of the power of customization in manufacturing shoes faster than using traditional or conventional methods (Lyman et al., 2018). Adidas as a keystone is leveraging the specialized services of Siemens within its ecosystem to transform their factory. By digitizing the factory, the DIE may produce new technological innovations and customizations faster than ever before as noted in (Adidas, Siemens Partner in Digital Production, 2017). In the Adidas speed factory DIE, Siemens occupies a niche position.

Conclusions

This discussion paper has two significant contributions. Firstly, it adds to the discussion of ecosystems as a new strategy to promote disruptive innovations by reconceptualizing a new type of DIE. Secondly, it visualizes and compares strategic ecosystem roles with case studies. Through these contributions, we explained how DIEs could be created and fostered. We identified the following steps as key towards designing viable DIEs: 1. Initiate, 2. Develop, 3. Manage, 4. Sustain, 5. Death and resurrection. The study positions a designer as the key actor in the development of a viable DIE.

The practical implications of understanding DIEs and positioning designers within the DIE design process may aid continuous re-design of DIEs to suit the ever-changing economic reforms in policy, SMEs business models, school’s curriculum, entrepreneurs and individual businesses. Understanding design and emergence conditions may help enterprises to better leverage DIEs in creating sustainable solutions. This paper provides a lens for future empirical research strategies and methods. The limitation of this study is that it is based on a conceptual discourse merely focusing on theoretical discussions with no practical examination.

Further work is now needed to explore current DIEs to establish how ecologies are likely to influence change in future business models, particularly in developing nations. It would be interesting to provide an empirical investigation on how DIEs are designed, evolved, managed and sustained to contribute to shared value. To develop our work on DIEs, we will be engaging with businesses in developed and developing nations to support our new DIE concept with empirical work.
References


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