Chapter 21
On the Evolution of Service Ecosystems: A Study of the Emerging API Economy

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Abstract Service ecosystems can be described as complex, evolving systems of highly interdependent human and non-human stakeholders who co-create value and are shaped by institutions and social norms. The ecosystem lens is increasingly used by scholars and practitioners to describe and understand the complex nature of value creation and emergent industry structures, replacing traditional lenses of value creation. In this chapter we (1) provide a brief, retrospective view of the evolution of service value creation—from the traditional linear value chain perspective to service value networks and ultimately service ecosystems—and (2) describe, through a data-driven analysis and visualization, the emergence of a particular type of service ecosystem, namely the application programming interface (API) economy. The objective of our chapter is multifold. First and foremost is our desire to deepen the appreciation and appropriateness for using an ecosystem lens in the field of service science. Second, we want to underline the importance of digital relationships in service value creation and the particular growth of the API economy. Lastly, we provide a methodological approach for analyzing and visualizing service ecosystems with the hope to provide stimulus for future data-driven studies of service systems.

Keywords Service ecosystems · API economy · Network analysis · Visualization

21.1 Introduction

To understand a firm's actions, choices, and outcomes, "an ecosystem perspective is neither necessary nor sufficient, but increasingly critical" due to the fundamentally changing nature of economic activities (Adner 2017). Similar to biological systems consisting of a variety of different species with symbiotic relationships, ecosystems

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can also be characterized as a complex set of multilateral ties between a wide range of stakeholders (Iansiti and Levien 2004). These stakeholders can include firms, customers, non-profit organizations, and government agencies (Basole and Rouse 2008).

The ecosystem metaphor for describing economic activities and strategies is not new (see Moore 1996), but has only recently been formalized in the service science domain (Vargo and Akaka 2012). While service systems are a configuration of people, technologies, and other resources that interact with other service systems to create mutual value (Maglio and Spohrer 2008; Maglio et al. 2009; Spohrer and Maglio 2010), service ecosystems are not just networked actors and actions, but also dynamic, evolving systems that are shaped by institutions and social norms (Williamson 2000). According to the service-dominant logic view, and in line with other system thinking approaches, change is thus inherent to the definition of service ecosystems (Lusch and Vargo 2006; Vargo and Lusch 2006, 2016; Akaka et al. 2013; Lusch and Nambisan 2015).

Using this definition, many systems can thus be viewed as service ecosystems including companies, supply chains, and markets, among many others. Given the applicability and increasing importance of ecosystems in describing economic activities, it is thus not surprising to see a significant growth in studies using an ecosystemic lens across a variety of management disciplines including service science. Moreover, the rapid evolution of digital technologies is transforming economic activities at an unprecedented speed, scale, and scope. Indeed, traditional interfirm relationships are increasingly complemented and replaced by digital relationships between companies. This is particularly visible in the emerging application programming interface (API) economy, in which firms are offering access and the ability to recombine their digital services and products for novel value creation.

The overarching aim of this chapter is to (1) provide a brief, retrospective view of the evolution of service value creation—from the traditional linear value chain perspective to service value networks and ultimately service ecosystems—and (2) describe, through a data-driven analysis and visualization, the emergence of a particular service ecosystem, namely the API economy. In doing so, we hope to contribute to our understanding of service science in multiple ways. First, we will deepen the appreciation and appropriateness for using an ecosystem lens in service science. Second, we will underline the importance of digital relationships in service value creation and the particular growth of the API economy. Lastly, we will provide a methodological approach for analyzing and visualizing service ecosystems with the hope to provide stimulus for future data-driven studies of service systems.

21.2 From Chains to Networks to Ecosystems

The traditional view of understanding and analyzing industries has largely been shaped by the concept of a value chain, which assumes a linear value flow and where resources flow through "chained" dyadic relationships from raw material providers and manufacturers to suppliers and customers (see Fig. 21.1a) (Porter 1980). This view has long been proven appropriate for understanding economic activities within

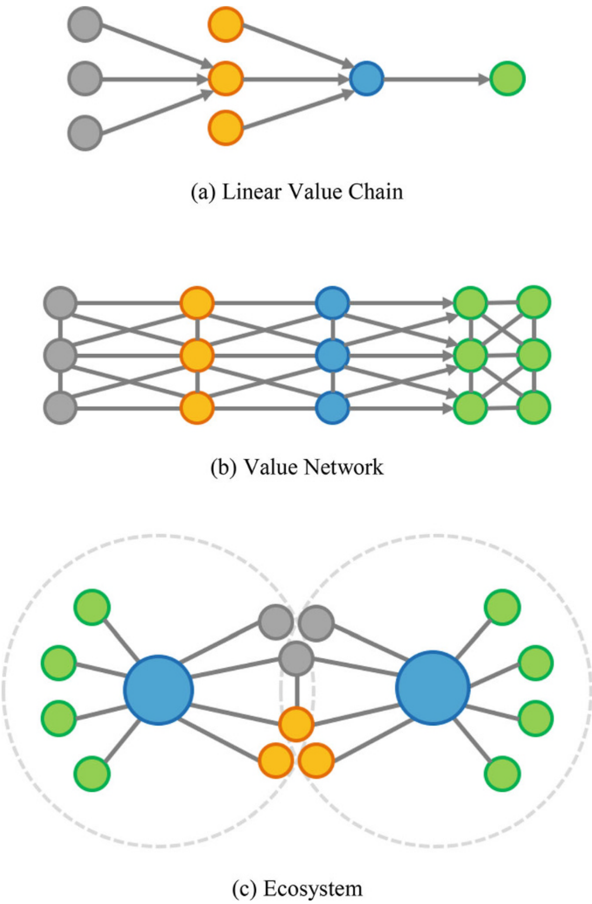

Fig. 21.1 Conceptual representation of the evolution of value creation configurations

traditional industries, in particular manufacturing. Within this economic view, the product was the primary focus and there was clear demarcation between producers and consumers. This perspective framed our ideas of value and value creation for many years.

Critics, however, found that the linear view of economic activities did not adequately describe and capture the multidirectional nature and complexities of the potential myriad of relationships between different stakeholders. There was a growing recognition that the network, rather than the individual firm, was becoming the focal point of economic and business activities (Buhman et al. 2005; Dyer 2000). Driven by increasing competition on a global scale, market pressure to innovate, and continuously changing customer demands and expectations, product and service creation and delivery transformed from a linear value chain flow into a complex web, or value network, of large-scale interfirm activities (see Fig. 21.1b) (Basole and Rouse 2008).

In these networks, value is provided by a myriad of multidirectional relationships across and between stakeholders. As a result, products and services are designed, created, delivered, and provided to customers by enterprises comprising a complex web of processes, exchanges, and relationships (Chesbrough and Spohrer 2006; Vargo and Lusch 2004). The value network assumes firms to be part of a larger complex networked system of enterprises that together create (i.e., co-create) value (Spohrer et al. 2007; Basole and Rouse 2008; Dyer 2000). The value network approach thus views the activities of a firm in a holistic, rather than a fragmented manner. Consequently, the network perspective shifts the focus of a resource-based view of the firm to a perspective in which examination of resource dependency, transaction costs, and actor-network relationships is critical (Spohrer and Maglio 2008; Basole et al. 2011).

More recently, there has been growing recognition that industries exhibit complex, emerging, dynamic characteristics typically found and exhibited by natural systems. Strategy scholars found the use of using an ecosystemic lens to be particularly useful in describing economic activities, stakeholder roles and relationships, and their emergent dynamics (Iansiti and Levien 2004, Adner 2017). In his seminal work, James Moore (Moore 1996) described (business) ecosystems as:

> "An economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organism also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the direction set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments, and to find mutually supportive roles." (Moore 1996: p. 26)

Following this definition, an important tenet of ecosystemic thinking is that an ecosystem is composed of multiple firms that symbiotically create value. Each firm has their own ecosystem strategy corresponding to their structure, position, and risk profile (Adner 2017). These ideas follow the Iansiti and Levien (2004) definition of ecosystem role archetypes that firms assume. Firms can be keystones, niche players, dominators, or hub landlords. The evolution of these value configurations and roles mirror the idea of market evolution. In an ecosystem-centric world, core firms assume a platform position, connecting two-sides of a market (see Fig. 21.1c) (Dhanaraj & Parkhe 2006; Parker et al. 2016).

Figure 21.1a–c provide a conceptual representation of the evolution of these industry structures. Value is generated at each interconnection between the stakeholders and is ultimately captured by the consumer (Basole and Rouse 2008; Rouse and Basole 2010). In the ecosystem configuration, platform companies (depicted in blue) are critical in connecting different stakeholders (such as suppliers and partners (depicted in orange and gray) and consumers (depicted in green) in the ecosystem.

Conceptually, our lenses of studying economic activities have evolved over time from dyads to chained activities of multiple actors to networks and webs of interactions. In part our lenses have evolved and adapted to the realities of economic activities from simple relationships to increasingly complex configurations of firms. This evolution has largely been driven by different forces, including economies of scale, vertical/horizontal differentiation, specialization, and globalization.

The prevailing thread throughout this evolution has been the rapid prominence of information and communication technologies (Westerman et al. 2014; Akaka and Vargo 2014; Rogers 2016). While humans and social entities are centric to service systems, we are increasingly observing that entire economic activities are replaced by human to machine (H2M) and machine to machine interactions (M2M) (Weill and Woerner 2015). Consider how consumers interact with the customer service function of firms. Customers dial a customer service number and are frequently initially greeted not by a human but rather by an automated message system that routes the call using complex decision rules. Indeed, many human-centric services are augmented by computerized systems and chatbots. Some economic activities in fact are now entirely delegated to machine to machine transactions, such as financial trading services.

This new sphere in the service ecosystem ecology is amplified by the growth of digital connectors and control points that allow various parts of the infrastructure to be interconnected and made smarter to respond, act, learn from the action (Pagani 2013). These digital control points, sometimes also referred to as boundary resources, have been critical to the growth of the digital economy (Ghazawneh and Henfridsson 2013). In fact, it has been argued that traditional interfirm service relationships will be increasingly replaced and augmented by these digital boundary resources (Iyer and Subramaniam 2015).

21.3 Case Study: The Evolution of the API Ecosystem

One digital service ecosystem that is gaining substantive importance is the application programming interface (API) ecosystem. APIs can be described as “bits of code” that act as digital control points which set the terms with which digital data and services can be efficiently shared or called over the Internet (Tilson et al. 2010). The API economy has grown exponentially over the past decade, with most leading firms offering some APIs for their services and products. According to recent reports, there are more than 18,000 publicly available APIs across a wide range of market segments (ProgrammableWeb 2017). APIs are not really a new concept. Interconnecting digital resources using “interfaces” has been a feature of computing infrastructure for many years. However, with the rise of mobile computing devices, significantly lower cost of data storage, and the explosive economic value of making digital data available to the public, the growth rate of these digital control points has been staggering. Today’s leading firms all offer APIs and handle an enormous number of calls daily. Recent reports, for instance, have shown that companies like Google, Amazon, Facebook, and Netflix easily handle over a billion API calls every day.[1] It is not surprising that firms are racing to create and join this form of digital service ecosystem. Prior work has examined the overall structure of the API

[1]https://www.forbes.com/sites/ciocentral/2012/08/29/welcome-to-the-api-economy.

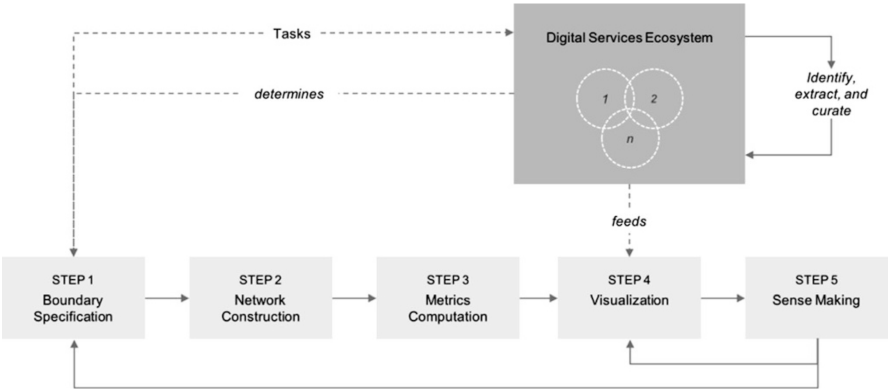

Fig. 21.2 Multi-stage ecosystem analysis and visualization methodology (adapted from Basole et al. 2015a, b)

ecosystem (Evans and Basole 2016), sectoral differences in the use of APIs (Basole et al. 2018), and the geographic distribution of API offerings (Huhtamäki et al. 2017). In this data-driven case study, we build on this prior work to illustrate how the API ecosystem has evolved over time, thereby offering an important evolutionary lens on this type of digital service ecosystem.

21.3.1 Methodology

Following Basole et al. (2015a, b), we propose a five-step process for understanding the evolving structure of the API ecosystem. The effectiveness of this method has been demonstrated in several service domains, including the mobile ecosystem (Basole and Karla 2012), innovation ecosystems (Russell et al. 2015), and the emerging FinTech ecosystem (Basole and Patel 2017). Specifically, our approach includes the following steps: (1) ecosystem boundary specification, (2) network construction, (3) metrics computation, (4) visualizing, and (5) sensemaking. Figure 21.2 provides a conceptual overview of the overall approach. In doing so, our approach builds on the well-established information visualization reference model (Card et al. 1999) which advocates for a balance between data management, visual mappings, computer graphics, and interaction.

21.3.1.1 Step 1: Boundary Specification

An important first step in service ecosystem analysis is the specification of boundaries. The challenge in defining boundaries is that service ecosystems are evolving systems, with stakeholders (firms, customers, suppliers, machines, etc.) continuously entering and leaving. Rather than taking a firm-level centric approach, an alternate view is to select relevant market segments that make up the service ecosystem.

However, even when using segments we face a similar inclusion challenge as segments are often related to each other. Ultimately, the choice of what to include is driven by the nature and intent of the problem, the questions being asked, and the costs involved (Basole et al. 2015a, b).

In our study context, boundary specification involves determining the primitives of the API ecosystem architecture (Ahuja et al. 2012), including nodes, node types, relationship types, and specification of the desired analysis timeframe. We used a top-down approach, first identifying all APIs and then filtering down to those most commonly found. In doing so, we eliminated APIs that were not widely used and/or relatively novel.

One of the most widely used datasets for the study of APIs is ProgrammableWeb (PW), a socially curated directory of publicly-available APIs and Mashups. Several prior studies have used PW (e.g. Evans and Basole 2016; Huhtamäki et al. 2017). ProgrammableWeb contains a range of API descriptors, including a description, category tags (e.g., Mapping, Social, etc.), API endpoint URL, types of protocols an API uses (RESTful, etc.), security, some measures of popularity and social share, and a list of Mashups that use it. As of March 15, 2017, there were 17,132 APIs listed. It needs to be acknowledged that using publicly-available APIs only is a limitation. Many firms offer private APIs that are only shared with their direct customers and suppliers. To the best of our knowledge, however, there is no single data source that comprehensively captures all publicly- and privately-available APIs. We thus only focused on publicly available ones. Since our focus was on the most commonly used APIs, which have been used in mashups, our sample reduced significantly.

21.3.1.2 Step 2: Network Construction

We constructed the API ecosystem network consisting of APIs using a weighted adjacency matrix approach, with cell entries marked as the total number of mashups formed between a pair of APIs and 0 otherwise. In doing so, we explicitly accounted for the differing degree of funding flow that may exist between firms. Moreover, as mashups are inherently non-directional, our ecosystem network resulted in an undirected unipartite graph. Given our interest in the structural evolution, we used the release date of an API to create annual temporal snapshots of the API ecosystem from 2005–2016.

21.3.1.3 Step 3: Metrics Computation

The advantage of conceptualizing API ecosystems as networks is the availability of a wide range of established metrics. There are many social network as well as information and graph theoretic metrics that have proven to be useful for understanding the structure and dynamics of a business ecosystem, in general, and API ecosystems in particular. The selection of metrics is generally driven by the insight objectives and decision processes. Broadly speaking, metrics fall into two levels of analysis: the node level and the network level (Zaheer et al., 2010). Node metrics provide insight at the individual entity level, while network metrics describe the entire ecosystem. Based on prior related work (Iyer et al. 2006; Rosenkopf and Padula 2008; Basole et al. 2015a, b; Basole and Karla 2012), we compute several metrics at the network level using NetworkX, a Python-based library for graph computations.[2]

One of the most commonly used graph-based ecosystem metrics is node centrality (Wasserman and Faust 1994). Centrality refers to the relative importance or prominence of a firm in the ecosystem, where firms with higher levels of centrality are found to have more power and control over peripheral firms. There are many variants of centrality, such as those based on direct ties (degree), shortest path (closeness), geodesic distance (betweenness), or recursive importance (eigenvector). Each captures a different aspect of firm power and influence in an ecosystem. In our study, we use degree, weighted degree and betweenness centrality to understand the importance of APIs in the API ecosystem. Another node-level measure of frequent interest is the clustering coefficient, defined as the proportion of a firm's direct links that are also directly linked to each other. In the context of ecosystems, firms with dense clustering have been shown to experience greater collaboration, resource pooling, and problem solving due to increased trust among partners (Schilling and Phelps 2007).

At the network level, density refers to the proportion of ties in the network over the maximum possible number of ties. The more dense the ecosystem, the more interconnected it is. Another common measure in understanding the structure of ecosystems is the average path length. Average path length measures how far (i.e. "steps") any two APIs are in an ecosystem. The shorter the path length, the more accessible and interconnected an ecosystem is. Modular communities are defined as groups of densely interconnected nodes that are only sparsely connected with the rest of the network (Blondel et al. 2008). Small-world networks have characteristics of high clustering and small average distance between nodes.

21.3.1.4 Step 4: Visualization

Visualizations are a fundamental component of human learning and understanding and a key step in transforming data to knowledge (Card et al. 1999). They can be used to explore, interpret and communicate data and aid decision makers with overcoming cognitive limitations. By mapping data to visual encodings, visualizations of ecosystems make the "what, why, how, and who" explicit. Prior work has provided important novel and complementary insights into the structure, dynamics, and strategy of business ecosystems (Basole 2009. 2014; Basole et al. 2013; Iyer and Basole 2016).

[2] https://networkx.github.io/.

There are many different visual representations available, ranging from simple to complex. A comprehensive review is beyond the scope of this paper, but interested readers are referred to Card et al. (1999) and Heer et al. (2010) for excellent overviews. Given that the structural aspect is of particular interest in this study, we leverage network visualization techniques to depict the interconnections between APIs in an ecosystem. Network visualizations require the development of appropriate types of representations, placement of graph elements on the screen, and efficient mapping of visual attributes for improved readability.

There are many examples of network visualizations including biological and ecological networks, social networks, the Internet and citation networks (Newman 2003). Visualizations of industry networks are also emerging and are used as complementary analyses to traditional statistical summaries (e.g. Rosenkopf and Schilling 2007). It has also been shown that graph visualizations are particularly valuable for understanding and analysing business issues, including competitive intelligence, strategy, scenario planning and problem-solving (Basole et al. 2013).

Ecosystem visualization, however, is challenging and resource-intensive. As discussed above, complete or even comprehensive ecosystem data is generally not available. At the same time, even if the data is collected and appropriately curated, the amount of information can often be overwhelming to the analyst if not presented appropriately (Tufte and Graves-Morris 1983). Effective visualizations must therefore ensure a careful balance between detail, abstraction, accuracy, efficiency, and aesthetics (Card et al. 1999).

We use Gephi 0.9,[3] an open-source software for visualizing and analysing large network graphs, to create graphical representations of the structure of the API ecosystem (Bastian et al. 2009). Specifically, we use OpenORD, a force-directed network layout (Martin et al. 2011). A force-based layout is based on the idea that network entities are shaped by mechanical laws, assigning repulsive forces between nodes and attraction forces between endpoints of edges. The use of a force-based layout is particularly appealing when the motivating issue is to identify central or prominent nodes, peripheral actors, or clusters in an ecosystem. The OpenORD layout uses five stages that leverage different physical "laws": liquid, expansion, cooldown, crunch, and simmer. We use an initial parameter configuration of these stages to emphasize core, periphery, and clusters (Liquid: 25%, Expansion: 25%, Cooldown: 25%, Crunch: 10%, Simmer: 15%). Moreover, to ensure readability and aesthetics, we followed several visual design principles, including no node overlap and edge crossing minimization. In all our network visualization, node size is proportional to the firm's importance as measured by degree centrality. To gain insight into the distribution of API categories in the API ecosystem, we color encode nodes with the corresponding primary category (see Appendix A for color encoding details). We use a NoOverlap algorithm to space out nodes and address potential visual occlusion issues.

[3] http://www.gephi.org.

21.3.1.5 Step 5: Sensemaking

The ultimate purpose of visualizations is not to create pretty pictures (although aesthetics matter), but rather human insight and foresight (Card et al. 1999). While visualization is primarily about data transformation, representation, and interaction, it is also about harnessing human visual perception capabilities to help identify trends, patterns, and outliers with computational capabilities (Card et al. 1999). It involves the formation of abstract visual metaphors in combination with a human information discourse (interaction) that enables detection of the expected and discovery of the unexpected within massive, dynamically changing information spaces (Thomas and Cook 2006).

Sense-making has its roots in cognitive psychology and many different models have been developed. The consensus across these models is that the sense-making process is cyclic and interactive, involving both discovery and creation (Basole et al. 2016). During the generation loop an individual searches for representations. In the data coverage loop, we instantiate these representations. Based on these insights, we shift our representation and begin again. Together this forms a complete sense-making loop. Visualization of digital service ecosystems can therefore be seen to support the electronic market sense-making process. Through visualizations we look for confirmation, inconsistencies, and possible "aha" moments. If confirmation is not achieved, we return to develop alternative visualizations or specify new boundaries.

21.3.2 Results and Analysis

Prior to our visualizations, we provide a summary of the evolution of structural characteristics of the API ecosystem (see Table 21.1). Specifically, we present our results across three main periods (2005–2008, 2009–2012, and 2013–2016),

Table 21.1 Evolution of API ecosystem metrics

	2005–2008	2009–2012	2013–2016
Nodes (API)	192 (MC[a]: 132, 68.75%)	412 (MC: 314, 76.21%)	488 (MC: 449, 92.01%)
Edges (Mashups)	293 (MC: 289, 98.63%)	868 (MC: 860: 99.08%)	1230 (MC: 1198, 97.4%)
Average degree	3.052	4.214	5.041
Avg. weighted degree	8.491	11.092	12.681
Network diameter	6.000	7.000	9.000
Density	0.016	0.010	0.010
Modularity	0.240	0.285	0.300
Avg. clustering coefficient	0.706	0.658	0.653
Avg. path length	2.645	2.810	3.008

[a]The main component (MC) of a network refers to the largest connected subgraph. It is also often referred to as the giant component

denoting different epochs of the API ecosystem. First, and not surprisingly, we observe that there has been a rapid growth in APIs over the past decade. APIs represent service value providers and enablers. Interestingly, the number of mashups, or service value recombinations, have grown significantly more, suggesting that much of the core digital service functionalities is already present and that service value innovation is occurring more frequently through recombinations. While the overall density in the API ecosystem has decreased (highlighting the asymmetric growth between APIs versus novel mashups), the average number of recombinations per API has increased (as evidenced by the average degree). Interestingly, the average clustering coefficient, which is a measure of how interconnected APIs are for a given focal API, has slightly decreased, suggesting that focal APIs play a more important role in the API ecosystem. Lastly, while the overall API ecosystem is growing in size (number of APIs), both the network diameter and the average path length have modest increases, suggesting that the overall interconnectedness and reach are growing potentially due to some possible niche value creation.

While summary statistics provide a quick overview of the overall nature of the API ecosystem, visualizations are more suitable for understanding the underlying structure, including prominent APIs, clusters, and outliers. Figure 21.3a–c presents three visualizations, each representing one of the time periods. Based on our aforementioned ecosystem analysis and visualization approach, nodes represent APIs and edges are mashups. Nodes are proportionally sized by the degree of the API and color-encoded by their primary category.

The visualizations quickly confirm the findings from our statistical analysis that the overall size of the API ecosystem has grown significantly over the past decade. Moreover, we can see that several of the early APIs in the ecosystem are core actors throughout all periods. These include Google Maps, Facebook, Twitter, Amazon Product Advertising, eBay, and YouTube. The visualizations, however, also reveal that Google Maps plays a particularly central role in the API ecosystem. Indeed, mapping (dark blue), e-Commerce (light blue), and social (orange) APIs are the most relevant APIs today. We also note that analytic, finance/payment, and health/wellness related APIs are relatively recent offerings, suggesting temporal differences in value creation in the API ecosystem.

The temporal structural analysis and visualizations of the API ecosystem confirm that significant sectoral differences exist, suggesting potentially diverging value creation paths (Basole 2016). The visualizations also reveal that while there was initially one core cluster, the API ecosystem is emerging to have a core cluster with several peripheral clusters focused on specific areas of service value creation. At the same time, we note that core APIs remain highly influential over time, suggesting that there are economies of scale that can be gained by providing relevant digital service offerings. Of course, some differences appear and further analysis is needed.

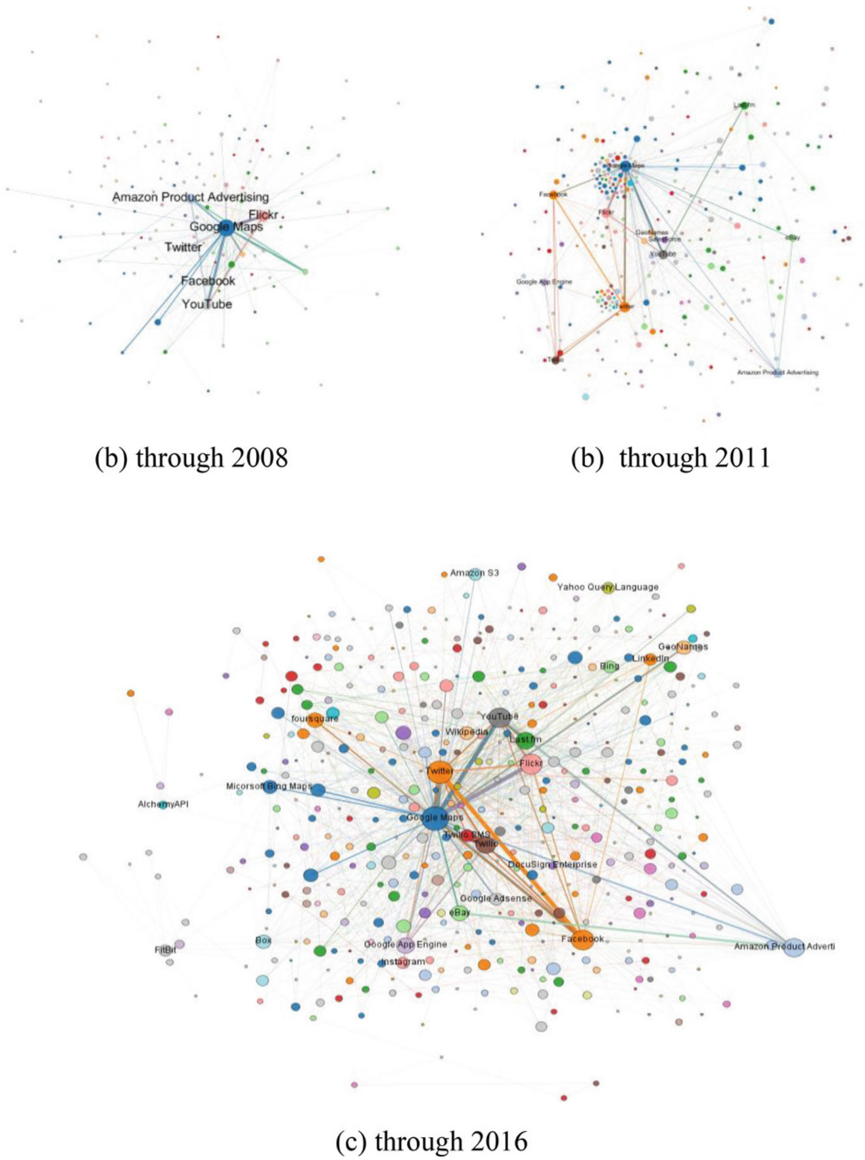

Fig. 21.3 Snapshots visualizing the evolution of the core component of the API ecosystem (2005–2016). Nodes represent APIs, edge are mashups. Nodes are sized by degree and color encoded by their primary category

21.4 Concluding Remarks

In this chapter we provided a brief view of the evolution of service value creation, proposed a methodology that can be applied to analyze and visualize any service ecosystem, and illustrated our approach through a data-driven analysis and visualization of one rapidly emerging type of service ecosystem, namely the API ecosystem.

Historically, technologies have always disrupted and transformed (service) ecosystems. The evolution, however, appears to have accelerated in this new age of APIs. The importance of APIs is particularly amplified with the emergence of the idea of the "everything-as-a-service" (XaaS) paradigm, which envisions business capabilities, products, and processes not as discreet vertical offerings operating individually in silos but, rather, as a collection of horizontal services that can be accessed and leveraged across organizational boundaries.

The implications of digitally-connected products and services are wide ranging. With everything connected, service ecologies are naturally bound to grow in scope and scale. APIs will enable firms to pursue rapid experimentation and innovation in addition to value provision. New value propositions will emerge through novel API recombinations. Many contemporary enterprise systems are already designed with an API-centric model. However, companies are increasingly layering APIs on top of their legacy systems to modernize their core infrastructure making it possible to reuse, share, and monetize core assets and data in the XaaS world. It is critical to note that simply deploying APIs is not sufficient to succeed in today's digital services economy. Firms must also carefully craft an appropriate API management strategy that considers the plethora of issues involved in designing, exposing, contracting, servicing, metering, and billing based on API usage.

While there are many positive effects of this new service ecosystem reality, there will also be massive service ecosystem challenges. Technological challenges, for instance, will include an ability to manage and integrate a diversity of "actors", provide sufficient control and security mechanisms, and create architectures that continuously scale and adapt to changes. Economically, these new service ecosystems will demand new ways of conducting business, requiring different types of business models that facilitate a diversity of expectation and transactions, perhaps more loosely connected than ever before. From a policy perspective, these new service ecosystems have massive implications for governance, taxation, and geographic boundaries. For instance, data in these service ecosystems may be geographically distributed, and if so, what data residency requirements will apply? How will privacy and security be ensured? And how will policies be enforced? Each of these challenges provide fertile ground for fundamental service science research.

Ultimately, the reality in these emerging service ecosystems is that no firm is and will be an island by itself. It interacts through complex, evolving relationships - whether material or digital - with a myriad of different stakeholders. It can be reasonably argued that for firms to succeed over time they need to adopt service ecosystem strategies, structures, and positions that can adapt to changing institutional and environmental conditions. In an increasingly digital world this means adopting flexible digital infrastructures with open control points (i.e. APIs) that allow dynamic value configuration and (re)combination.

Appendix

For consistency and ease-of-interpretation, we used a consistent color encoding scheme of the APIs in the ecosystem visualizations. We leveraged the Tableau 20 palette to encode 20 API categories (including Others). The color legend is shown in Fig. A1.

Fig. A1 Color legend for visualizations

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