Editor:
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Visual Analytics for Converging-Business-Ecosystem Intelligence

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Suppose there was a tool with which we could easily identify and analyze interfirm activities across an entire business ecosystem. Could we have predicted the introduction of revolutionary products such as the Apple iPhone or iPad, years before they launched? Would Nokia have pursued a different mobile phone strategy if it knew that it would be an outsider in the smartphone market? Would Palm, a mobile-computing pioneer and leader, still exist?

The idea of a crystal ball that provides capabilities to explore, make sense of, and perhaps even provide actionable insight into rapidly changing business ecosystems is enormously attractive to many decision makers, including technology executives, product strategists, and investors. Potential applications of business ecosystem intelligence include an understanding of the competitive landscape, identification of innovation opportunities and strategic collaborations, and prediction of possible product-market fit.

Visual analytics (VA)[1]—the fusion of analytical reasoning and computational data analysis with rich, interactive visual representations—promises to provide many relevant techniques for such next-generation business-ecosystem-intelligence systems. A number of domains, including engineering, economics, and the social sciences, have applied VA. However, until recently it has received only a little attention in innovation, strategic management, and enterprise science.

Converging Business Ecosystems

Driven by economic pressures, global competition, and the need to innovate, today's business ecosystems are characterized by large, complex, and global networks of firms.[2] These firms are from many different market segments spread across the globe and are collaborating, partnering, and competing to ultimately create and deliver products and services. Technological innovations often occur in seemingly "distant" market segments or are created by unknown firms. Often they occur behind corporate walls, hidden from the public. Appropriate levels of competitive insight are thus difficult to achieve and are generally limited to a firm's immediate market boundaries.

The Value of Ecosystem Intelligence

This situation has significant business implications. Firms might underestimate serious competitive threats and disruptive technologies, resulting in a loss of strategic competitive advantage or market share. How will new firms impact incumbents and alter the ecosystem's competitive landscape? How will a technological innovation affect current offerings, and what firms will come out on top? The ability to accurately answer these questions is not only essential but also highly critical for survival in today's rapidly changing business environment.

Business ecosystem intelligence is an important capability for decision makers in virtually all industries. Market analysts, for instance, seek to understand competitive trends, strategies, threats, and opportunities. Executives seek to identify potential strategic collaborators and customers and determine innovation white spaces. (White spaces are areas of unexploited opportunity for a company.) Venture capitalists would like to identify promising investment opportunities and determine how they fit in the overall business landscape. Intellectual-property attorneys and strategists might want to map a domain's structure and trace the litigation stream.

The Mobile Ecosystem

One prominent example of a converging business ecosystem is the mobile industry. With the convergence of enabling technologies, devices, and

 Published by the IEEE Computer Society

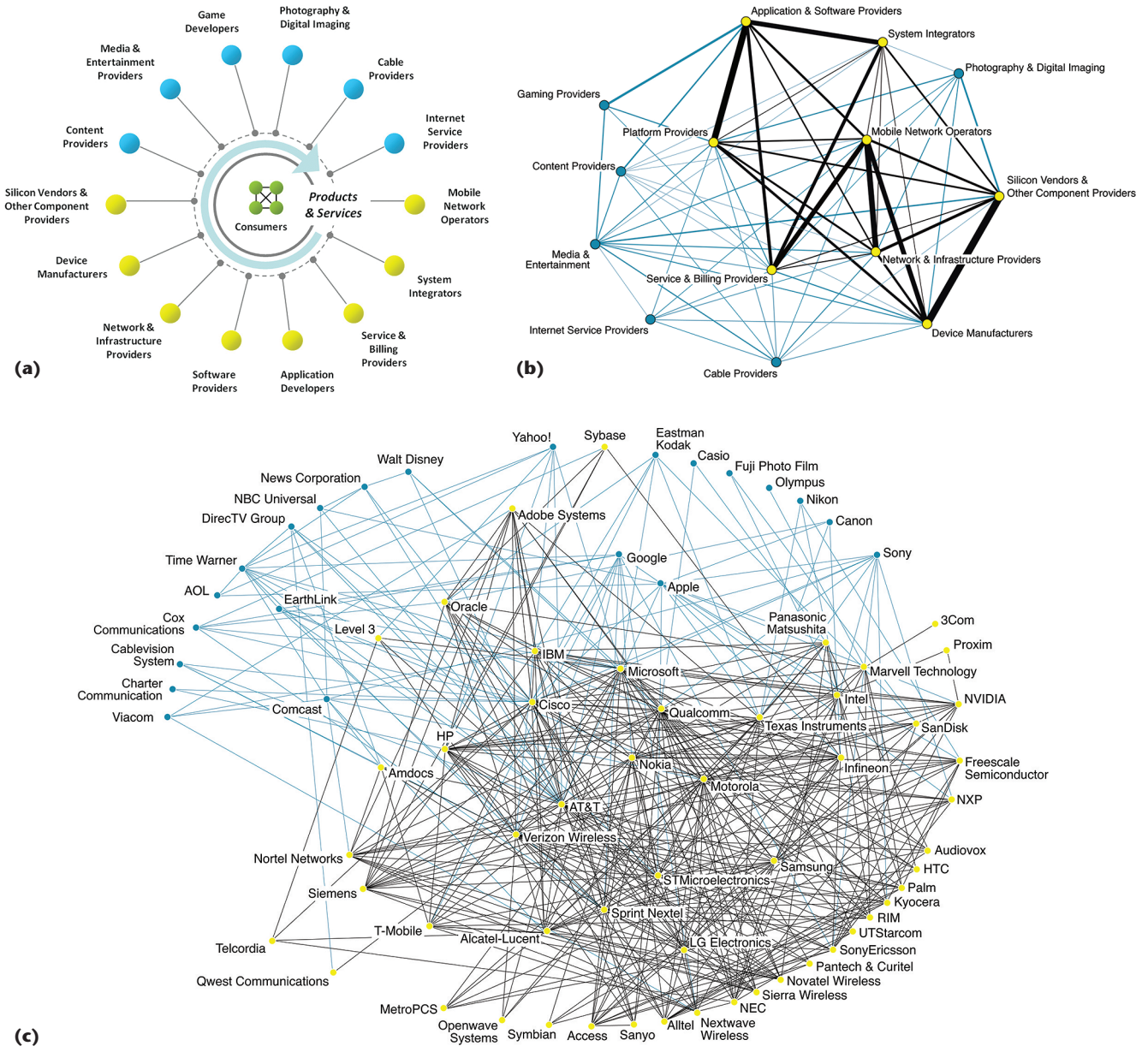

Figure 1. Static depictions of the converging mobile ecosystem. (a) Value cocreation between market segments. (b) Segment interaction. (c) An interfirm network of core companies.[3] Blue indicates emerging segment relationships. Generally, existing tools focus on a rigid set of firms, provide static snapshots and limited interactivity, and have little flexibility for highly dynamic industry data.

applications, the mobile ecosystem's complexity is increasing by leaps and bounds as new actors emerge, new interfirm relations form, and the traditional distribution of power shifts.[3] Participant firms come from a variety of market segments, including mobile-network operators, device manufacturers, platform providers, and application and software providers.

Potentially disruptive innovations can therefore also come from a number of areas. One example is the iPad, a device with hardware origins in electronic readers and tablet computers that, through battery technology and user interface advances, is dramatically transforming the mobile ecosystem. The remainder of this article focuses on the challenges of visualizing that ecosystem and our approach to these challenges.

Research Challenges

The analysis of a single, well-defined industry might be somewhat feasible with existing tools, albeit complex and resource-intensive. Generally, such tools focus on a rigid set of firms, provide static snapshots and limited interactivity, and have little flexibility for highly dynamic industry data (see Figure 1).

This approach, however, provides a highly myopic view of industries. Instead, an effective mobile-ecosystem-intelligence system must be able to visually and analytically capture the entire ecosystem's complexity. It must also be able to help users navigate the complex landscape from core to periphery, enable them to make sense of a variety of relevant ecosystem data, and provide an integrated perspective of salient business activities.

Data Characteristics

Converging-business-ecosystem intelligence requires identifying, organizing, and analyzing frequently disparate and unrelated data sources and carefully integrating and evaluating this data. Data sources might be structured (for example, alliance databases and patent filings) or highly unstructured (for example, press releases, product announcements, trade journal articles, and blogs).

The information in these sources might be validated and verified or highly speculative and unconfirmed. The data might contain multilevel entities of interest (for example, individuals, companies, market segments, and products) and might be multidimensional (for example, temporal, spatial, and categorical). For instance, companies might change their name through merger or acquisition. Company-specific information might also change over time—such as the number of employees, revenue, and leadership. In addition, connections between entities can be multiplex (for example, innovation, supply network, or strategic relationships) and might have directional characteristics (for example, unidirectional material flow or bidirectional knowledge exchange).

In many instances, data might be incomplete; detailed data might be available for some companies and not for others. For example, publicly listed firms provide access to financial information; this generally won't be available for small companies and start-ups.

In short, business ecosystem data is extremely complex and messy and requires careful curation. These challenges, however, present interesting and important opportunities for VA.

Visualization Metaphors

The business ecosystem data's complexity and heterogeneity make viable a variety of visualization techniques and metaphors. Company data is laden with quantitative measures—for example, market capitalization, the number of employees, and market share. So, traditional visual techniques such as bar charts, line graphs, and scatterplots seem appropriate. Furthermore, potential analysts' existing familiarity with such visualization techniques provides added evidence for their utility.

A business ecosystem's multiple levels (people, companies, sectors, and markets) provide a classic information hierarchy. Visualization techniques such as outlines, trees, and treemaps also seem well suited to portray such hierarchies.

Relationships are at the heart of business ecosystem analysis. How are firms and individuals connected? What products and services do they cocreate? Who licenses another firm's technology? Who are a firm's suppliers and customers? Visual metaphors for portraying such connections appear crucial to deeply facilitate ecosystem analysis. In the visualization community, network or graph representations showing vertex-edge connections are the most appropriate metaphor for representing such issues. Both node-link and matrix-based representations are common; they enable representation of both the structure and flow of business ecosystems.

The connection data's richness presents challenges for network visual metaphors, however. For example, if companies are vertices and connections between companies are edges, it might be desirable to present different quantitative or categorical values for each company. Similarly, edges between companies might indicate different relationships (such as partnerships, suppliers, or competitors) and might contain varying confidence or confirmation indices. These different attributes will tax all the visual variables available: position, size, color, thickness, and so on. Additionally, network analytics metrics such as clustering, betweenness, and centrality provide important information to analysts and should be communicated.

Finally, unstructured or semistructured documents' pervasiveness in business suggests that visual metaphors for portraying text data will be crucial. Documents present issues in terms of extracting or mining actionable information from the text and then determining appropriate methods for presenting that information. Clever visual representations sometimes can lessen the need for complex and often error-prone text mining and analysis, instead letting users rapidly review many documents and decide what's important.

Interaction Design

Designing an effective visualization interface doesn't end with implementing clever visual metaphors. Providing flexible interaction is just as important. We suspect that the diversity of ecosystem data will make using one visualization technique or metaphor insufficient. Instead, multiple, coordinated views seem necessary to adequately commu-

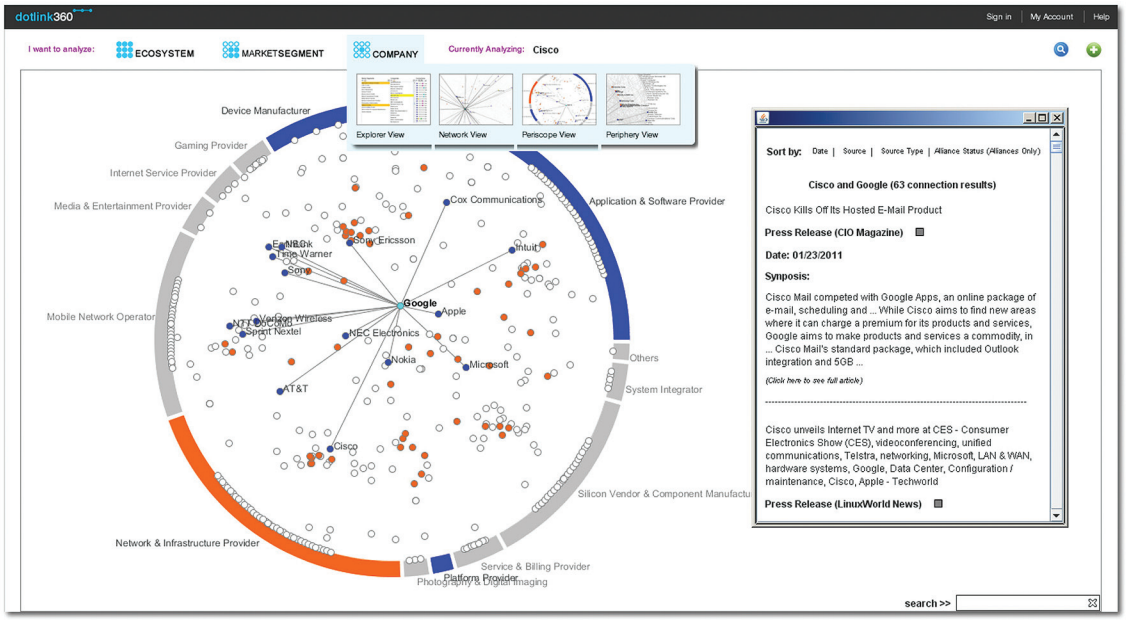

Figure 2. The dotlink360 interface with the Periscope view active. The focus is on Cisco and Google, and the interface highlights company market segments as well as primary and secondary connections. The investigative panel presents information pertinent to the analysis focuses. Here, it lists all press releases that mention both Cisco and Google, including a URL to the original source. A drop-down menu shows alternative visualizations supported in the company analysis mode.

nicate the breadth of data present. If interaction with a data element in one view highlights that element and its relationships in the other views (called *brushing*), viewers will be able to better understand the rich context of ecosystem data.

The data's potentially overwhelming scale makes other interaction techniques such as filtering and dynamic queries essential too. An analyst might wish to focus on companies of particular sizes or those maintaining specific kinds of relationships. Furthermore, ecosystems evolve over time; understanding this evolution can foster a specific type of insight about relationships. The ability to rapidly select values, intervals, or items of focus supports exploration and discovery.

Large-scale data presents another challenge in simply displaying all the relevant data elements at once. Interaction and display techniques for showing overviews and detail can assist here, as well as flexible zooming interactions. Simple geometric zooming might be insufficient, however. Semantic zooming that represents relationship data differently depending on the displayed items' scale and scope might be necessary.

dotlink360

We're developing the dotlink360 VA system to provide competitive intelligence for analysts, investors, and executives (see Figure 2). Its design was driven by practical motivations of competitive-intelligence practitioners. The system draws on a dynamic, integrated dataset of strategic alliances and corporate agreements from Thomson Reuters' SDC Platinum database as well as press releases and news articles, powered by Northern Light's SinglePoint portal.

The system presents this data through a series of interactive visualizations that let analysts explore

- the connections between companies and the connection types,
- how different companies have positioned themselves compared to others in their market segment and the entire ecosystem, and
- how these positions have evolved over time.

Analysts examine this information through three main perspectives. Ecosystem views show the set of relevant companies and provide a global overview. Market segment views show how companies connect in a particular sector. Company views highlight a selected company's agreements and alliances.

The different views share interactive operations, color mappings, and communication for a consistent user experience throughout. Because relationships between companies are so important, many of the views illustrate these relationships through node-link network visualizations. Different geometric positionings and layouts portray the relationships' characteristics. Each view can show relationships between companies, illustrate the relationship types, and summarize relevant information in a pop-up window. Figure 3 shows the

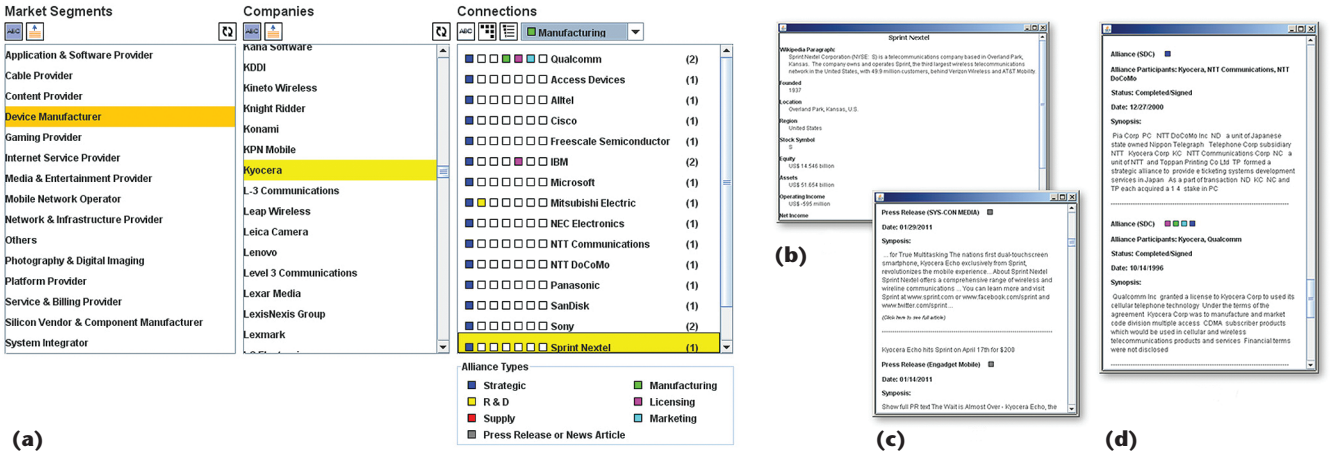

Figure 3. The (a) Explorer view with examples of the investigative panel showing (b) a company profile, (c) press releases, and (d) alliances. This view provides list-based information about market segments and companies, relationships, and related documents.

Explorer view, which provides list-based information about market segments and companies, relationships, and related documents.

We've conducted several targeted user studies of dotlink360 with potential user groups. The system was well received; participants felt that it was usable and effectively addressed a range of exploratory and information-seeking business-ecosystem-intelligence tasks. Several aspects of the system particularly resonated with users, such as the multiple connected views, the integration of traditionally separate data sources, and the ability to interactively explore firm relationships a few steps removed (or beyond the horizon) from the focus company.

Much work remains, however. dotlink360 currently shows only a portion of the ecosystem data we seek to communicate. It should show further company-specific data and interfirm relationship information, as well as other types of data such as patent filings. In addition, users requested the ability to include results of Web searches for complementary information. Presenting this data will require further visualizations. Our user studies also revealed the necessity to prespecify general tasks or include previously conducted tasks to reduce frequently used interactions. The system also can only rudimentarily communicate the ecosystem's temporal evolution. We're adding such capabilities to the system and further evaluating it with potential users through an iterative human-centric-design approach.

The domain of converging-business-ecosystem intelligence is much like many others—a broad, heterogeneous dataset is available, but the ability to gain actionable insight from it is hampered by the lack of VA tools that integrate the data into forms promoting investigation and exploration. The "Research Challenges" section highlighted specific issues we still face, such as the multiformat, multilevel nature of the data; missing or incomplete data; and the variety of analytics inquiries that might be addressed.

As with many other topics, deep knowledge of domain-specific entities, attributes, characteristics, and culture is vital in designing a useful analytic tool. VA researchers aren't likely to harbor such knowledge of business ecosystems, and you can't expect domain experts to be fluent in VA research. So, it appears that multidisciplinary teams of researchers are necessary to develop effective new ecosystem intelligence approaches and solutions.

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