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On modeling value constellations to understand complex service system interactions

Cheryl A. Kieliszewski *, Paul P. Maglio, Melissa Cefkin

IBM Research — Almaden, 650 Harry Road, San Jose, CA 95120, USA

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Complexity;
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Summary Urban centers face complex challenges in managing their services to continually improve their citizens' quality of life. They also face complex challenges in managing citizens' perceptions of the effectiveness of services to continually improve their resulting quality of life. We view urban areas as dynamic sociocultural systems, meaning that effectively and dynamically understanding and addressing their challenges means confronting the full complexity of factors that interact to make up the system. More precisely, we understand these systems to be complex service systems, arrangements of multiple entities and stakeholders that interact to co-create value. Decision makers of urban centers face the design problem of arranging the entities so that the most mutual value emerges from their interactions. To analyze and understand such complex systems, we suggest a new approach to *service system analysis* based on model composition to design and evaluate stakeholder relationships through what-if scenarios. Applied to the intriguing real-world scenario of crime and perceptions of crime in the London Borough of Sutton, we show how service system analysis — analyzing value constellations to find opportunities for reconfiguring roles and relationships that unlock value — can be applied to a sociocultural service system by focusing on the complex relationship among components that can influence complex questions, such as safety and quality-of-community. Modeling and simulating the value constellations of complex service systems can help us discover which interventions and reconfigurations will be effective and which will not.

Introduction

Urban settings everywhere face complex challenges in public safety. The possible combination of realities affecting criminal acts and the prevention or control of them is extensive. Education, city planning, employment, and policing practices can all play a role in combating crime. Beyond these factors, perceptions of crime and crime management introduce additional elements, including how law enforcement communicate their approaches, how crime is covered in the media, and how different populations experience law enforcement. For instance, the London Borough of Sutton (LBS) faces the dual challenge of simultaneously reducing crime and the perception or fear of crime (Andreu, Ng, Maull, & Shadbolt, 2010). The LBS (and any urban area) is a dynamic sociocultural system. Effectively and dynamically understanding such a system means confronting and examining

* Corresponding author.
E-mail address: cher@us.ibm.com (C.A. Kieliszewski).

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the full complement of factors that interact to make up the Borough before being able to address complex challenges. To understand how to reduce fear of crime in LBS, we must consider not only bounded systems, for instance the dyad of criminal acts and police presence, or graffiti and initiation of special programs to manage it, but the full cluster of problems in which the parts are related to one another.

Identification and examination of patterns — and hence modeling of patterns — in such systems have traditionally been done on parts rather than on the whole (von Bertalanffy, 1968). Understanding the relationship between the police force and those who create graffiti, for instance, is only part of the story. A constellation of elements impact perceptions of safety (e.g., population migration, employment, social services, and so on) in LBS. Accordingly, we must consider the full complexity of the system-of-systems that interact to make up LBS, including citizens, government, businesses, police force, healthcare providers, and more. It is also necessary to consider where apparent solutions to one area may have unintended consequences to others — what Banathy (1996) called the ''problematique''. In contrast to the tradition of developing isolated models of phenomena, we address the question, can we use computational modeling and simulation to help policy makers think about and address complex policy and planning problems in a holistic way? Specifically, our effort aims at computational modeling and simulation of real-world complex systems — problematiques — by integrating models and data of component systems together into more comprehensive models (Maglio, Cefkin, Haas, & Selinger, 2010).

In this paper, we describe a framework that supports integration of multiple models, simulations, and data to understand complex service systems, illustrating the potential of the framework through the LBS case. First, we provide background on value creation and the systems perspective on value creation. Second, we describe our composite modeling method in some detail. Third, we go through an exercise in applying our method to the LBS case. Finally, we discuss what we learned about composite modeling and about the LBS case.

Background

Value results when multiple entities work together to create mutual benefit; that is, value creation emerges through the design and orchestration of the relationship and interactions (e.g., Normann & Ramirez, 1993) among these entities. These entities are collections of resources including people, technologies, organizations, and information (Spohrer, Maglio, Bailey, & Gruhl, 2007). Entities interact by granting access to one another's resources (Spohrer & Maglio, 2010b). Together with the service-dominant worldview (Vargo & Lusch, 2004), the service system can be understood as the basic abstraction of the study of value co-creation (IfM & IBM, 2008; Maglio & Spohrer, 2008; Maglio, Vargo, Caswell, & Spohrer, 2009; Spohrer & Maglio, 2010a; Vargo, Maglio, & Akaka, 2008). The service system incorporates multiple interacting entities, such as governments and citizens. When both firm and customer bring together resources, including capabilities and competences, and take joint actions that leave one another better off, we see that as effective value co-creation (Vargo et al., 2008). In the simple case of two entities, a provider and customer (or a government agency and the citizenry) form a service system. In the general case, value co-creation among stakeholder entities might span the range from interpersonal relationships to whole nations and civilizations (Banathy, 1996; von Bertalanffy, 1968). In considering a case such as perceptions of crime in the LBS, it becomes clear that there is not a single provider—customer dyad (e.g., IfM & IBM, 2008) that will serve as a sufficient unit of analysis for addressing the challenges.

Value

We see examination of the service system as a vehicle for the study of *value co-creation*, useful changes resulting from communication, planning, or other purposeful interactions among entities (Maglio, Kieliszewski, & Spohrer, 2010). *Co-creation* focuses on the interactive nature of service, the sharing of resources and capabilities across entities. What exactly is *value*? In one view, value results when one entity perceives the benefit of some transaction or interaction as greater than the cost. We take a more general view: value results when interactions among entities leave the entities better off, such as better fit to their environments or better able to adapt to changing circumstances, than they were before the interactions (Vargo et al., 2008). Goals and environments change, and better-fit entities are those that can adapt. Incorporating the capabilities of others is one key way to improve fitness and adaptability. For example, the ability of a manufacturing firm to transform itself into a service firm, such as IBM (Maglio, Nusser, & Bishop, 2010) and Rolls-Royce (Ng, Maull, & Yip, 2009); or the ability of a service firm to evolve its delivery processes and its offerings by focusing on core competencies and on establishing partnerships, such as taking advantage of the capabilities of customers (Prahalad & Ramaswamy, 2000). Value results when entities work together to improve or enhance one another's capabilities to act in specific situations or environments in a mutually beneficial way (Vargo et al., 2008). An assumption of this work is that some interactions can be more effective than others in creating value, and therefore some arrangements of resources can be better than others at setting a system up for effective value co-creation.

In a goods-dominant view, value of a good or a service is added by entities positioned along a value chain, making business strategy the art of positioning a firm in the right place on the chain (Normann & Ramirez, 1993). More precisely, *firms add value* to goods or services before they are delivered to or used by customers. For example, an automobile manufacturing firm adds value to raw materials, such as steel, glass, rubber, etc., by configuring these parts just so; building an automobile that someone wants to buy. The key point is that value lies in a firm's creation of a thing, the right parts delivered and added to the automobile at a given point: the focus is on creation through retention. For a goods-dominant view, the question for firms is where to position themselves so that the parts get added prior to the good being sold or used. Where along the chain does one firm add the most value?

In a service-dominant view, value is created by interactions among a constellation of entities, making business strategy the art of continuous design and redesign of complex business systems to connect knowledge and relationships (Normann & Ramirez, 1993). Establishing a system of interacting stakeholders — rather than establishing a position along a value chain — will result in improved leverage and resilience of connected resources (people, technology, capabilities). Key to the service-dominant view is that value lies in the use of extended capabilities afforded by interactions with others rather than added ahead of time.

IKEA is a seminal example of how understanding the roles and capabilities of stakeholders in a value constellation can lead to improved value creation. It changed how customers relate to home furnishings by harnessing customer capabilities to transport and assemble furniture (Normann & Ramirez, 1993). To make its changes effective, IKEA worked with suppliers so that the furniture was designed, built, and packaged for easy transport (in customers' vehicles) and assembly (enclosed tools and graphic instructions), among other changes. IKEA did not simply transform its furniture: it transformed the roles and relationships of its stakeholders in a complex system of service interactions. As the IKEA example suggests, one effective approach to improving value creation in a constellation is to keep improving the fit among firm competencies, supplier and other stakeholder competencies, and customer competencies (Normann & Ramirez, 1993). The key point is that value is created in the context of fitness, rather than at the time of creation, specifically through interactions among multiple stakeholders.

Service requires entities to coordinate their actions to improve their situations or capabilities to co-create value. There are two basic processes at work in value co-creation: (1) across entities, there are *processes of coordinating* activities among individuals, organizations, and firms — often intimate relationships that involve sharing resources, risks, and rewards; and (2) within entities, there are *processes of valuing* that enable decisions about what to coordinate (Spohrer & Maglio, 2010b). Both processes might be implemented effectively as symbolic processes, for instance, using language or other symbol systems to coordinate joint activities (e.g., Clark, 1996) and using mental or computational models to project future consequences of actions (e.g., Newell & Simon, 1976). For entities to agree to work with another, they must come to terms (coordinating) and individually evaluate the costs and benefits (valuing). For instance, IKEA offers ready-to-assemble furniture to customers, coordinating action through catalogs and instruction sheets; and IKEA customers project the consequences of bringing home unassembled furniture to evaluate the costs and benefits.

Service systems and the value constellation

Service system entities are arrangements of resources that interact with other entities by granting and obtaining access to one another's resources (Maglio et al., 2009). A firm, a family, and a nation are all examples of service system entities. For instance, a retail firm interacts with suppliers and with customers, providing value by creating a distribution channel through which suppliers and customers interact; a family interacts with an electric utility, paying for the use of its power generation and distribution capabilities; and a nation interacts with another nation when forming a trade agreement, establishing rules by which national firms can interact and create value together. Of course, firms interact with families, and families interact with nations, and so on. In all cases, multiple service system entities form service systems through interaction with other entities that create mutual benefit.

Often service systems can be understood reasonably well as dyadic relationships between just two entities. For instance, in a service system involving a family and its electric utility, it probably does not matter to the family how electricity actually is produced, such as through third party agreements in which generators contract with the utility. From the family's perspective, it is the utility that produces and distributes electricity, and any other arrangements simply do not matter for them to make effective use of electricity. Understanding the service system as interactions solely between family and utility may be sufficient for some analytical purposes, such as considering the effects of different provider incentives on household utility use.

In many cases, service systems must be understood as a constellation of relationships among multiple entities. For instance, when nations enter into trade agreements, the specific set of relationships matters — exactly which goods and services are regulated and how, which firms can participate, which government agencies are responsible for oversight, and so on. In this case, it may be difficult to analyze the perspective of any single stakeholder without taking account of the perspectives of many other stakeholders. Though it is often easier to understand dyads than it is to understand constellations, the complexity of real world situations forces us to make sense of ever more complicated arrangements of service system entities.

One key question is how to bound a service system for analysis. There is no general answer, but we see four different stakeholder perspectives that ought to be taken into account: customer, provider, authority, and competitor (Maglio & Spohrer, 2012). The idea is to start with a focal system, a provider—customer dyad, and consider the authority governing each and the potential competitors of each. Each provider or customer may in turn be a customer or provider in another system, and so on. Obviously, this sort of recursive analysis could go to any depth, but in many cases, going one-deep around a focal dyad may be enough to capture what is needed to understand the operation of the system. Exploring the breadth of relationships is often critical for analyzing service systems because service innovation depends on establishing an effective set of locally connected service systems (Normann & Ramirez, 1993). Any individual customer or provider may be part of other systems that play roles in the focal system (e.g., as suppliers or as partners). Consider IKEA again. The firm created a network of suppliers that built furniture to its specifications for ease of assembly and packaged furniture for ease of transport. The firm created stores that enabled customers to mix and match styles and to retrieve items themselves. Customers rely on their own vehicles to get to and from stores, and they rely on the mail and internet to access catalogs. IKEA's suppliers and stores and a customer's transportation and access to information constitute the basic value constellation around the focal IKEA-customer dyad.

Our main goal here is to demonstrate a method for expanding service system analysis out from the traditional

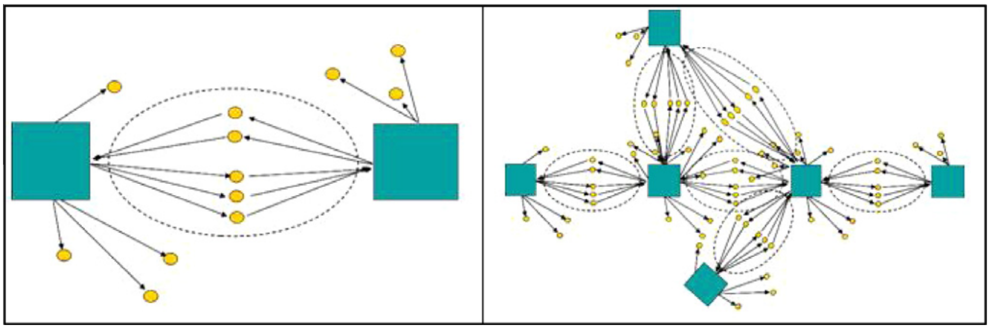

Figure 1 Customer—provider dyads (left) and complex service systems (right).

dyad toward a more comprehensive and realistic value constellation (Figure 1), and apply this method to understanding complex service interactions in the London Borough of Sutton. We now turn to our method, composite modeling.

Composite modeling methodology

How can we model value constellations of complex service systems, such as one that represents a dynamic sociocultural system, to discover which sorts of relationships and reconfigurations are likely to be effective and to create value? We have been working on Splash (Smarter Planet Platform for Analysis and Simulation of Health), a platform that supports the integration of multiple, heterogeneous existing models, simulations and data that represent parts of a broader ecosystem (IBM, 2011). The goal of Splash is to facilitate the creation of composite system models supporting ''what-if'' analyses by stakeholders and policy makers. As such, providing a way to consider the effects of change on the whole system rather than through the independent lens of individual constituent components (i.e., as data, statistics, models, or simulations). Splash is intended to help us consider as much about the environment as possible to avoid negative unintended consequences — to avoid Banathy's (1996) ''problematique'' — using the relevant constituent components for the desired level of system abstraction and analysis.

A typical approach to examining a complex problem is for each stakeholder to use the individual constituent components they are familiar with, identify possible changes, and then make assumptions about the impact of changes to these components on the larger problem. Given such a narrow focus, intended and unintended consequences are difficult to identify and evaluate in advance of implementing change (Haas, Maglio, Selinger, & Tan, 2011). For example, in the scenario of the family–electric utility dyad, the electric utility may provide incentives to increase enrollment and usage of an automated, demand-driven household utility monitoring device. The device would afford the utility improved delivery efficiencies to corporate clients but may reduce the flexibility of on-demand usage for residential customers resulting in a boycott and poor public relations for the utility company.

By contrast, the approach used in Splash is to examine a complex challenge by first understanding the level of abstraction to be examined and then identifying the relevant component models that represent the larger ecosystem in which the challenge sits. Once the respective component models are identified, they can be stitched together to then examine the impact of change to one or more components on the entire ecosystem. In Splash, models are ''stitched together'' through the exchange of relevant data to simulate and examine the larger ecosystem (Cefkin et al., 2011; Tan et al., 2012). The goal of ''stitching'' models together through data exchange is to (a) enable ease in adding and removing models to modify the ecosystem simulation as circumstances change, and (b) encourage reuse of existing models to avoid having to rewrite or recode for extended use.

Creating system simulations by coupling models and data sources is not new. There are a number of ways to create complex simulations through model integration, and these can be classified into three types (see also Tan et al., 2012):

- **Integrated modeling** relies on a uniform modeling framework in which models are compiled together as a single simulation, for instance, the Spatiotemporal Epidemiological Modeler (Ford, Kaufman, & Eiron, 2006) and the Community Climate System Model (Collins et al., 2006).
- **Tightly-coupled modeling** uses an agreed upon common interface through which models communicate, such as the Open Modeling Interface (Gregersen, Gijsbers, & Westen, 2007), or a customized logic for synchronized communication across models, such as the Discrete-Event System Specification (DEVS) framework (Wainer, 2009).
- **Loosely-coupled modeling** allows different algorithms, datasets, and tools from different domains to interoperate, such as CIShell (Börner, 2009) and Splash. The main difference between the two is that CIShell requires algorithms and data sources be packaged as Open Service Gateway initiative bundles to interoperate with other CIShell components, whereas Spalsh requires only metadata to describe components.

Integrating component models typically requires work to integrate data sources or to recode models and simulations so they conform to a particular protocol or standard. By contrast, Splash enables the creation of composite models by automatically translating data from one component model into the form needed by another based on metadata descriptions of component models and data. Splash has been used to stitch together multiple heterogeneous models and data in applications related to health system modeling (Tan et al., 2012).

Splash platform

A composite model in Splash is constructed as a workflow of component model execution and data flow (Tan et al., 2012). To understand the semantics of models and to support design-time model composition and run-time model execution, Splash relies on metadata about models and datasets (Figure 2). Each model and dataset is associated with a metadata description. Data source descriptions include the schema, where the data is located, and other metadata such as ownership. Model descriptions include the type of simulation model, the input and output schemas of the model, the interpretation of time and space in the model, the invocation command, and so forth. Because models are loosely-coupled via data exchange, part of model composition is the design of required data transformations. Splash supports semi-automatic design of these transformations using a schema-mapping design tool to create declarative descriptions of transformations or schema mappings. Such schema mappings may contain time-alignment functions to aggregate, interpolate, or allocate values to fix mismatches in time interpretations between models, as well as space-alignment functions to handle geospatial mismatches. (For more detail on Splash, see Haas et al., 2011, and Tan et al., 2012.)

To show how to use the platform to examine complex systems, we next apply our composite modeling method to a public policy problem related to transportation. We then discuss limitations of and potential issues with our approach.

Example: transportation safety scenario

Consider a hypothetical scenario. Suppose a city is experiencing an unexpected increase in traffic fatalities that is influencing quality-of-life ratings by the citizens and independent ranking agencies, and is also having a substantial impact on the city budget. City stakeholders — such as offices of the mayor, police, public works, transportation, fire, emergency services, environmental services, and so forth — know that changes in population growth, socio-economic movement, business locations/zoning, and city/roadway design might all be influencing this increase in traffic fatalities. In addition, the city is located in a region that has severe weather and micro-climates throughout the year, and seasonal changes in demographics.

Normally, each city stakeholder uses data and information to make near-term and longer range planning decisions individually. These stakeholders then come together to determine what the decisions identified for the individual pieces mean for the whole (Figure 3). This approach may be effective when examining a component or subset of a larger ecosystem. However, it is difficult to come to informed conclusions about the impact of decisions being made by one stakeholder agency on other stakeholder agencies, that is, the unintended consequences of making a local (component) decision that may have an impact on the entire ecosystem. For example, it may be difficult to compare (a) the safety and financial impact of roadway redesign, with (b) installations of variable speed limits and ticketing systems, with (c) reallocation of enforcement and emergency services. The unintended consequences might be either positive or negative, leading to interactions that are either value-creating or value-diminishing, and it would certainly be best to understand the likely consequences before making actual changes.

To gain a more complete understanding of the consequences of particular safety investment decisions, it would be preferable to look at the problem of unexpected increase in traffic fatalities by coupling individual components of the city ecosystem into a kind of running simulation model of the city (Figure 4). In bringing information together by coupling multiple relevant models, city stakeholders can start to examine the challenges more holistically, with greater potential of identifying solutions which encourage relationships and interactions that create or maintain, rather than diminish, value. Specifically in this case, weather and geography influence both traffic and emergency response, which together influence outcomes. Simulating the conditions and the effects of proposed changes within a whole system model will likely lead to better insights than simulations run on

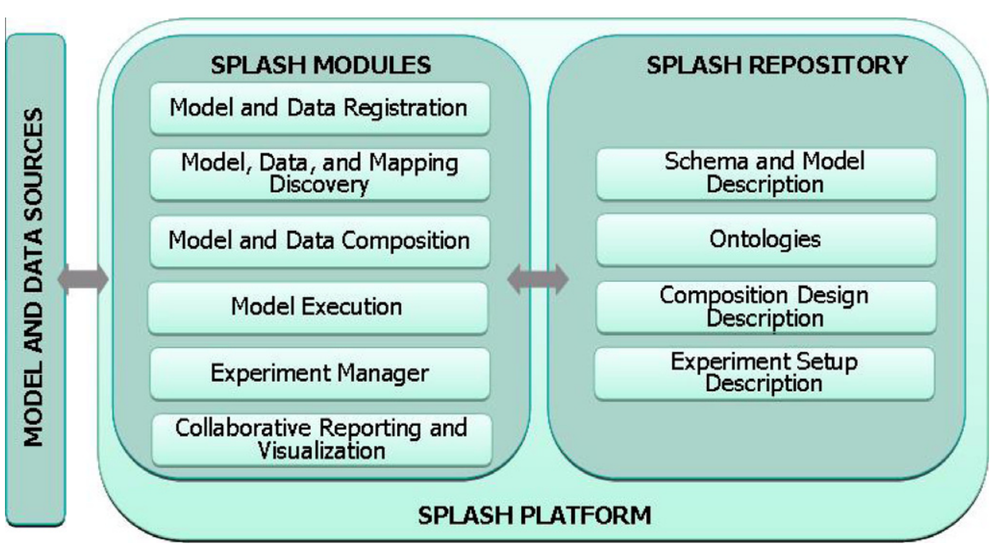

Figure 2 Basic architecture of Splash.

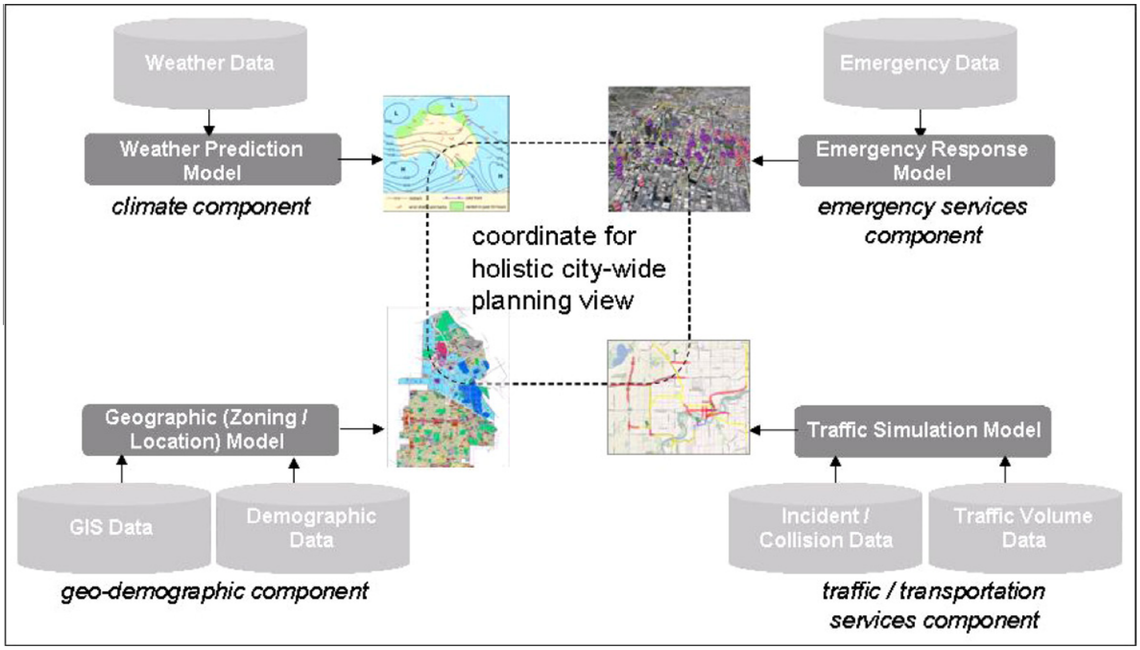

Figure 3 Dependencies in the transportation safety ecosystem.

individual parts of the system. Splash can help analysts bring together multiple models and data to design comprehensive composite models like this one. It is a tool for helping to understand complex value constellations from simpler models of their parts.

Limitations and open problems

Despite the promise of the Splash approach, there are many challenges to composing large-scale models for a complex ecosystem on both technical and social sides (Maglio, Cefkin, et al., 2010). Technical challenges include how to determine and ensure models are compatible with one another; developing mechanisms to integrate models and data into larger, more complex models of larger, more complex systems; and designing an execution environment for the models to run in. Social challenges include understanding and supporting underlying assumptions, methods, and goals of varying communities of experts and decision makers, enabling diverse partners and stakeholders to take advantage of the modeling and simulation environment, and exposing possible consequences of change to support decision making. Importantly, we recognize that models are themselves abstractions and should not be confused as the site where value cocreating

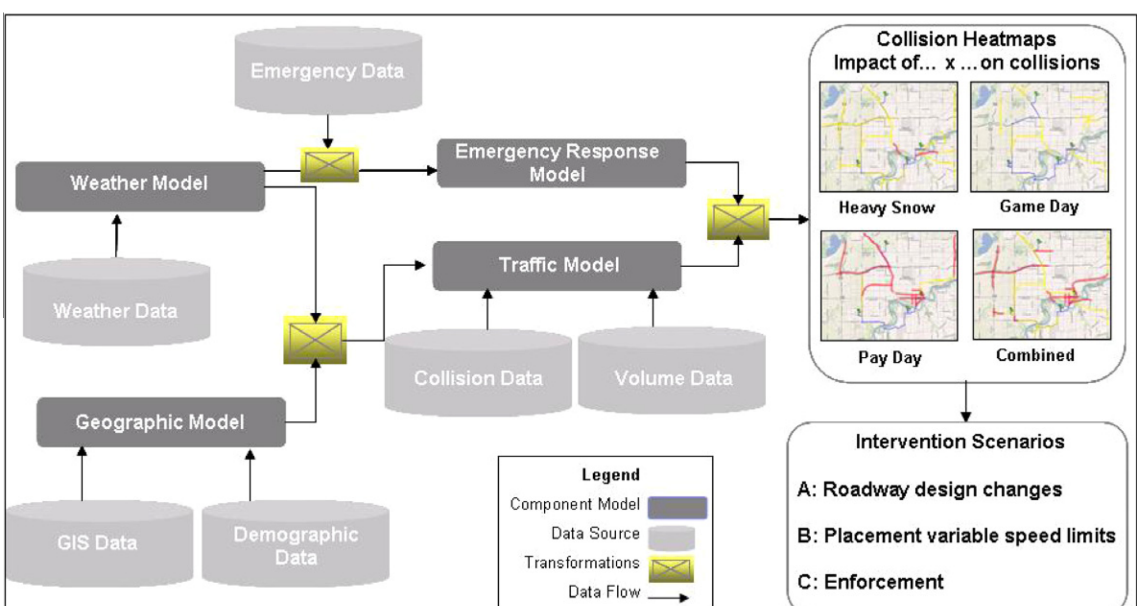

Figure 4 Composite model of transportation safety.

interactions occur, which is in the complex realm of everyday practice. In addition, there are some fundamental research challenges yet to be met. These include aspects of vetted models and data identification and collection; model and data compatibility methods to identify and reconcile mismatches; and simulation experiment validity and optimization (Haas et al., 2011). Even with these limitations, the prospect of composite modeling to simulate and examine an ecosystem is a step forward in helping decision makers understand the full complexity of real service systems.

Case scenario: London Borough of Sutton

How can we apply our approach of modeling complex service systems to the case of the London Borough of Sutton, investigating factors that influence the perception of crime and the relationships that effectively co-create value in the system? In this section, we sketch one potential way to do this.

The challenge: level of crime

The London Borough of Sutton has one of the lowest crime rates and is one of the safest boroughs in London (with a victimization rate for all crime of 0.07 per resident per annum). Yet the level of crime is rated by residents as the most important issue compared to other top priorities, such as public transportation, education, health services, housing, and job prospects (Andreu et al., 2010). The challenge for the borough lies in reducing the fear of crime. The objective of the Safer Sutton Partnership Service (SSPS), an organization of council staff and police officers, is to work with residents and partner organizations to provide community safety services to make LBS the safest borough and the safest-seeming borough at the same time. Here, we examine how to reduce the fear of crime by taking a complex service system or a value constellation modeling approach, by considering the constellation of elements that compose and influence crime and the community. Specifically, our approach is to (a) identify the elements influencing fear of crime, (b) establish the level of abstraction to be modeled, and (c) identify the relevant component models to simulate the ecosystem to consider the impact of specific changes on the overall system.

Influences: London Borough of Sutton 2020 vision

The Sutton Plan (LBS, 2009) provides background about the borough and a three-year Medium Term Service and Financial Plan for key improvement priorities established by the Council. There are elements of the plan that illustrate not only priorities, but also aims with objectives, longer term vision, and partnerships. Each of these components is summarized in this section. These are also elements assumed to be influential to the definition of an LBS service constellation for evaluating and examining how and where value is created or diminished in interactions.

Vision. The LBS 2020 vision (LBS, 2009) outlines the borough's values (partnership, respect, innovative, diversity, and empowering) and acts as the foundation for three-year operational planning. The core of the vision statement is (p. 8):

Our vision in the Sutton Strategy is of a borough in 2020 where the suburban quality of life is better than any other part of London; town and district centres that are vibrant with increased choices of decent housing for people who want to live in the borough; the best educational system in England bar none; parks, gardens and public spaces that, like the rest of the borough, are safe and feel safe; support for vulnerable people that means almost everyone lives in their own home, with choice about how their care is provided; reduced dependency on private care ownership and better choices to travel by public transport, cycling or as a pedestrian; and clean, safer and green suburban neighbourhoods in which people are proud to live.

To achieve the vision, the LBS Council has established partnerships with health service agencies, Sutton and neighboring police agencies, sustainability groups, educational agencies, volunteer organizations, and residents. The goal is not only to support the residents of the LBS, but to also encourage and engage resident involvement and to leverage auxiliary agencies to create a ''sustainable suburb of London'' (p. 8). With the vision, the Council has created priorities with aims and objectives to measure progress that unfold as an incremental three-year plan to reach the 2020 goal.

Priorities. In general, the LBS Council has communicated and committed to nine priorities. The priorities are focused on quality of life for all residents (children to elderly), environment, safety, and housing (Figure 5). The priority of particular interest for this scenario is ''create safer communities'', which is measured by the performance of the SSPS (Safer Sutton Partnership Service) to meet or exceed local and 2009 Home Office Public Service Agreement (PSA) targets. The priority itself is focused on reducing actual crime (e.g., theft, vandalism, violence) and anti-social behavior (ASB, e.g., disorderly conduct, drugs and alcohol abuse), along with reducing the fear of crime and building confidence in the criminal justice system. A communications strategy and additional activities by the Safer Neighbourhood Teams program have been proposed as interventions and plans to improve residents' perceptions of crime and community safety.

In addition, the Sutton Plan identifies a set of aims, with objectives and targets that correspond to the priorities. The ''safer communities'' priority aligns with two aims to improve handling of ASB and residents' perceptions about community safety. Each of the aims has set objectives that are to be delivered with existing resources.

Partnerships/stakeholders. Although it is important to understand the goals and objectives, we also need to understand the relationships to examine the value constellation. A simple way of understanding the value relationships is as dyads, then linking them to identify the service system with a core exchange, and then include extended relationships beyond the original core. For the London Borough of Sutton, there appears to be a core relationship between the Sutton Police and the LBS Council, as the Safer Sutton Partnership Service (Figure 6) that is guided by goals and directives detailed in the Crime and Disorder, Drug and Alcohol Harm Reduction Strategy.

Formalized relationships that extend the dyad are between the (a) Sutton Police and Safer Neighbourhood

1. Ensure the council is **efficient and effective**
2. Develop a **cleaner greener** environment
3. Create **safer communities**
4. Invest in the borough's **children and young people**
5. Value the borough's **older people**
6. Develop **active and inclusive communities**
7. Encourage **enterprise and employment**
8. Improve **health and wellbeing**
9. Improve **housing**

Figure 5 Sutton Plan nine priorities (LBS, 2009, p. 24).

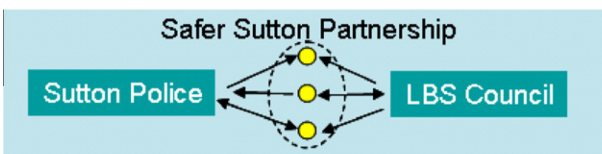

Figure 6 Service system dyad between Sutton Police and LBS Council.

Teams, (b) LBS Council and Safer Parks Teams, and (c) LBS Council and the Safer Transportation Team. More informal, yet important relationships that extend the dyad are with the residents themselves. These extensions create a service system with each organization reporting and coordinating with their primary partner (i.e., Police or Council) and extending relationships to partners of their respective primary partner. In addition, partners such as the Sutton Neighborhood Watch Association interact and coordinate with the Safer Sutton Partnership dyad as the primary partner to create an additional service system (Figure 7). A service constellation becomes apparent when coordination with adjacent service providers (i.e., borough councils and police forces) and their partners (i.e., residents, groups, agencies) to share in responsibilities to create safe neighborhood environments are added to the Sutton Safety Partnership service system (Figure 8).

Importance: safer communities composite model

Let us now assume that the Sutton Safety Partnership service system identified in the previous section is accurate (we can only assume accuracy because the service system has not been validated for this exercise). The level of

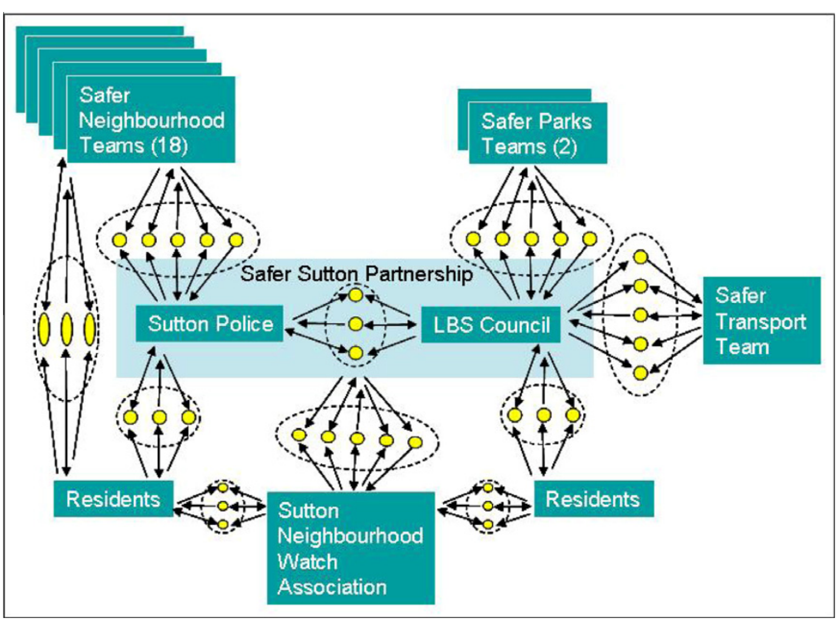

Figure 7 Example Sutton Safety Partnership service system.

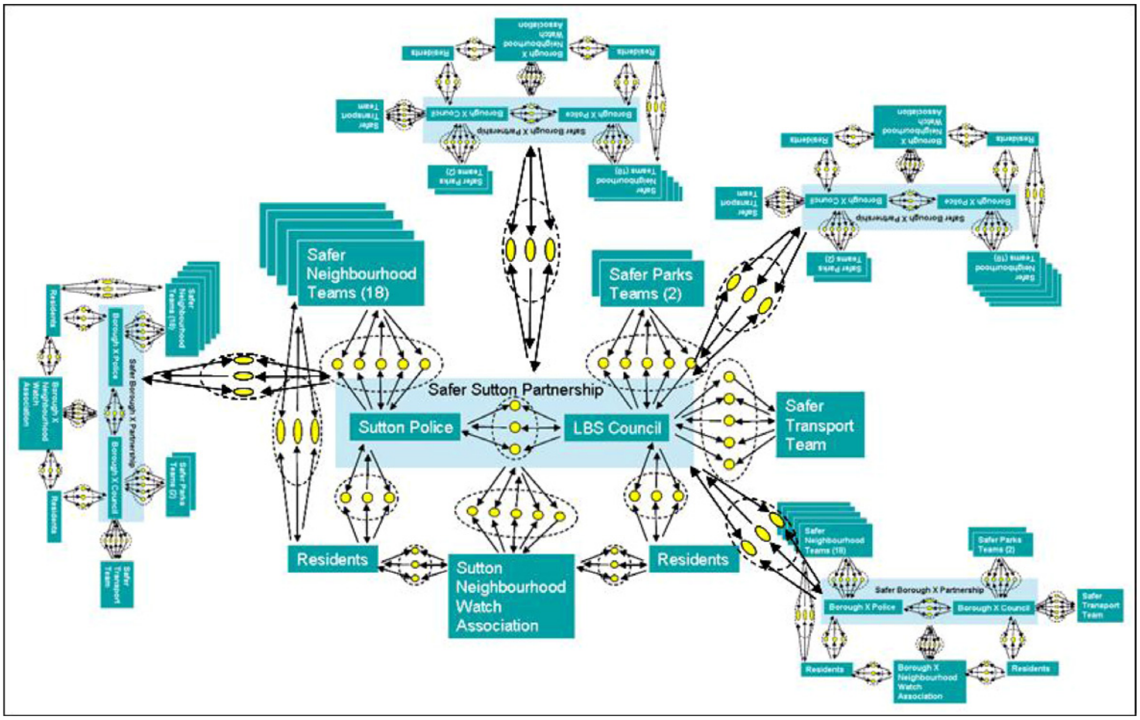

Figure 8 Example service constellation around Sutton Safety Partnership service system.

abstraction to be used for this particular case example is the Sutton Safety Partnership service system illustrated in Figure 7. The service system includes six entities: LBS Council, Sutton Police, LBS Residents, Safer Neighbourhood Teams, Safer Parks Teams, Safer Transport Team, and the Sutton Neighbourhood Watch Association. Note, that if desired, one could narrow the abstraction to examine each of the individual entities as a separate service system (e.g., examine the relationships and interactions within the LBS Council system), or broaden the level of abstraction to examine cross-borough relationships (e.g., examine the service constellation that includes the LBS service system).

For the sake of our example, we will assume that the entities have evaluated their individual costs and benefits of being a part of the Sutton Safety Partnership service system (processes of valuing) to agree to the terms for working with one another (processes of coordinating). Given, each entity has examined the individual value of their involvement in the safety ecosystem (similar to the juxtaposition of individual components in the transportation example in 'Example: transportation safety scenario'), the question that remains is 'are the relationships that define the service system really value co-creating?' The approach we are advocating to investigate this question is through the development of a composite model that couples component system models to examine the service system as a whole versus as the sum of the parts. (One could imagine also creating a system-of-service systems composite model to examine the value of the service constellation.)

Many factors influence safety. We will focus on a few that appear to be particularly relevant to the LBS case — factors with a direct, more obvious impact on safety and perception of safety, along with factors with a less obvious impact, yet may be influential to community safety (Andreu et al., 2010). Obvious factors include types and rates of crime and ASB, policing and enforcement, and physical environment. Influential factors are assumed to be socio-demographic, socio-cultural, and economic. These factors and attributing information and organizations are listed in Table 1.

To build the hypothetical composite model, we will treat the factors impacting actual and perceived crime rates as component parts, for which we want to identify a set of attributes to use as model and data resources. The composite model will then generate a simulation that can be run to create evidence of value, based upon adjustable model parameters, to examine impact of parameter changes as 'what-if' scenarios that are relevant to the challenge being faced. For the LBS example, the creation of the composite model stems from the six factors that appear to be the most relevant to the Safer Communities priority (Table 1). Existing models and the relevant data can be mapped and coupled to generate a services demand simulation (Figure 9).

The models used to generate the simulation are representative of service system components. In this case, six areas of focus were identified to leverage existing models to represent components of the system. These models are Geographic, Demographic, Migration, Response, Transportation, and Services Schedule. The models used for the components may be of different types and origins, that is, the models may be agent-based, differential equations, stochastic, or statistical in design. For example the Geographic model may be a differential equation model, and the Transportation model may be an agent-based model. Regardless of type, the models are selected and used in the composite as a best representation of the component in the simulation. As stated, six areas of focus were identified for the composite model:

- **Geographic Model** to represent the physical environment such as borough delineation, built and natural features, and zoning along with an overlay of crime/ABS hotspots and neighborhood watch zones and activity.
- **Demographic Model** to represent the residential population of LBS.
- **Migration Model** to represent employment types and opportunity, and how that is influenced by geographic and demographic factors.
- **Response Model** to represent coordination of monitoring, policing, enforcement, and crime/ABS abatement.
- **Transportation Model** to represent movement to places of employment and to public and privately provided community services (e.g., health, entertainment, food/dining).
- **Service Schedule Model** to represent public, borough supported community services such as libraries, waste management, and parks and recreation.

Once built and validated, the composite model acts as an engine to simulate the environment it represents. In running the simulation, parameters such as an increase in unemployment or a change to the SSPS configuration (i.e., dependencies and measures of neighborhood watch associations and/or safer neighborhood patrol, transportation, and parks teams) can be modified to understand what the impact would be upon the service system.

Table 1 Factors affecting actual and perceived crime rates crime for LBS (adapted from Andreu et al., 2010).

Factor	Attributes
Crime and ASB	○ Assault with injury
	○ Other violence against person
	○ Criminal damage
	○ Burglary
	○ Theft
Policing and enforcement	○ Sutton Police
	○ Safer Neighbourhood Teams
	○ Safer Parks Teams
	○ Safer Transportation Team
	○ Sutton Neighbourhood Watch Association
	○ Residents
Physical environment	○ Borough geographic delimitation
	○ Zoning and layout
	○ Built and natural features
	○ Waste and recycling
Socio-demographic	○ Population by age
	○ Ethnicity/diversity of residents
	○ Census information
Socio-cultural	○ Community cohesion (MORI resident survey)
	○ Education levels of young people
	○ Education for adults
	○ Learner migration
	○ Learning and library services
	○ Entertainment activities
Economic	○ Employment
	○ Commute
	○ Jobs/industry
	○ Health services
	○ Affordable housing

Examining value: evidence-based decision making

To illustrate this proposal, consider the following challenge to the LBS: having to perform a risk assessment of community needs to simultaneously reduce crime/ASB, reduce the perception of the fear of crime/ASB, and meet or exceed local and 2009 Home Office PSA targets given no additional borough resources. Using the safer communities composite model, the Safer Sutton Partnership and partner entities could evaluate value-driven alternatives as what-if scenarios (value for the community taking into consideration SSPS budget constraints and risk assessment targets). The output of the what-if scenarios could then be used as projections of value being created, shifted, or diminished based on existing baseline assumptions, agreements, calculations, and performance targets or *processes of* value (e.g., type and amount of investment by entities) and *processes of coordination* (e.g., type and amount of return on investment for entities). In this example, the what-if scenarios include focusing efforts to abate crime/ABS in local hotspots, extending activities/greater reliance on Safer Neighbourhood Teams, integrating (existing) services to decrease drug and alcohol abuse of residents, and implementing an information communication technology (ICT) strategy to improve communications with residents and across partner entities.

By modifying parameters to the safer communities composite model, results to alternative interventions could be examined for overall impact to the service system (e.g., increase/decrease in crime/ABS activity or increase/decrease in resident perception of crime/ABS); or impact to components of the service system (e.g., impact increase/decrease burden on particular entities in the system and the effect on the rest of the system). The what-if analysis output could then be used by the Safer Sutton Partnership to communicate ideas and plans to constituents (residents, government, and corporate stakeholders) for approval and or pursuit of improvement grant opportunities (Figure 10).

Discussion

Service system analyses tend to consider individual provider—customer dyads in isolation, as entire value constellations are simply too complex for the emerging methods to handle. As a general method and a specific platform, Splash is intended to help overcome this sort of simplistic thinking by enabling us to model complexity by coupling simple models together, reliably and effectively. Specifically, Splash is a framework that supports integration of multiple models, simulations, and data to gain understanding of complex service systems. It comprises mechanisms for cataloging, describing, connecting, and executing diverse sets of models together. The platform takes models of real-world systems, synthesizing and integrating them into an interoperating complex composite system model that policy makers can use to try out and evaluate alternative intervention scenarios.

For a complex construct such as safety, system parts such as transportation, demographic, education, policing, and regulations may be among the many components that affect community perception. Policy makers need to understand the gaps between current perception and a more ideal, shifted perception and changes in the real-world

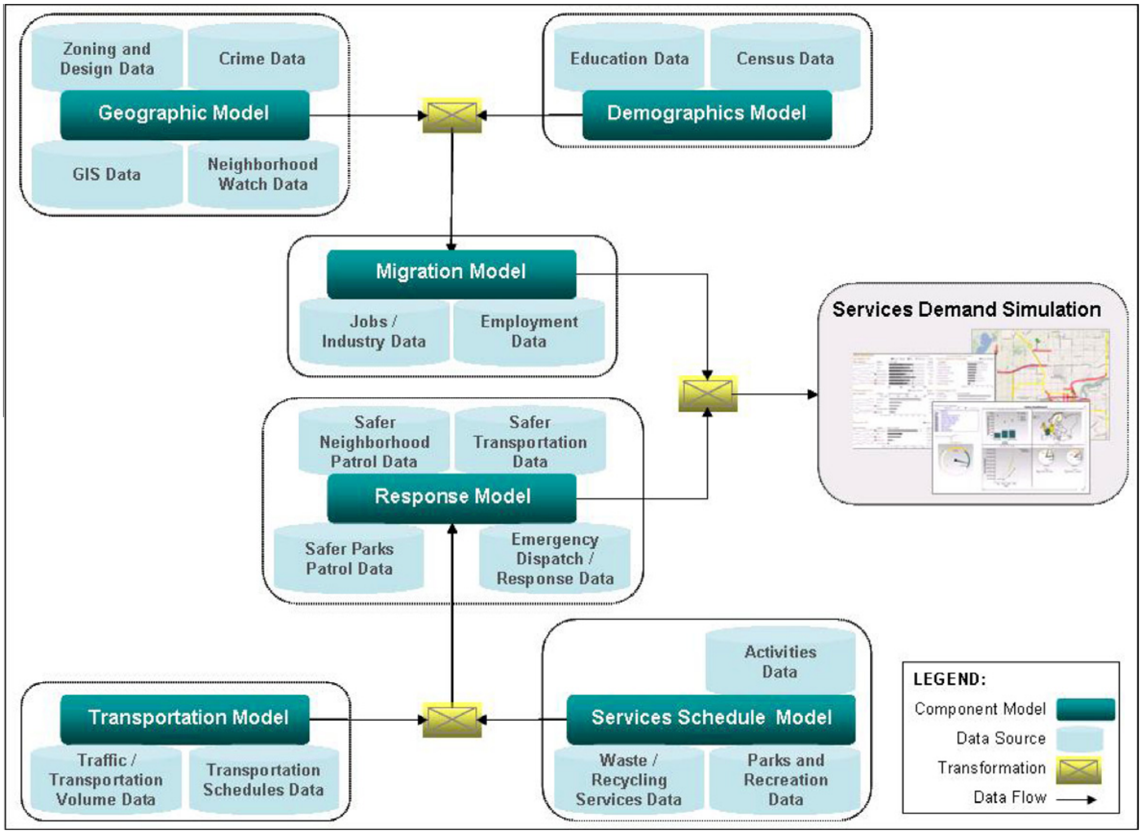

Figure 9 Hypothetical safer communities composite model.

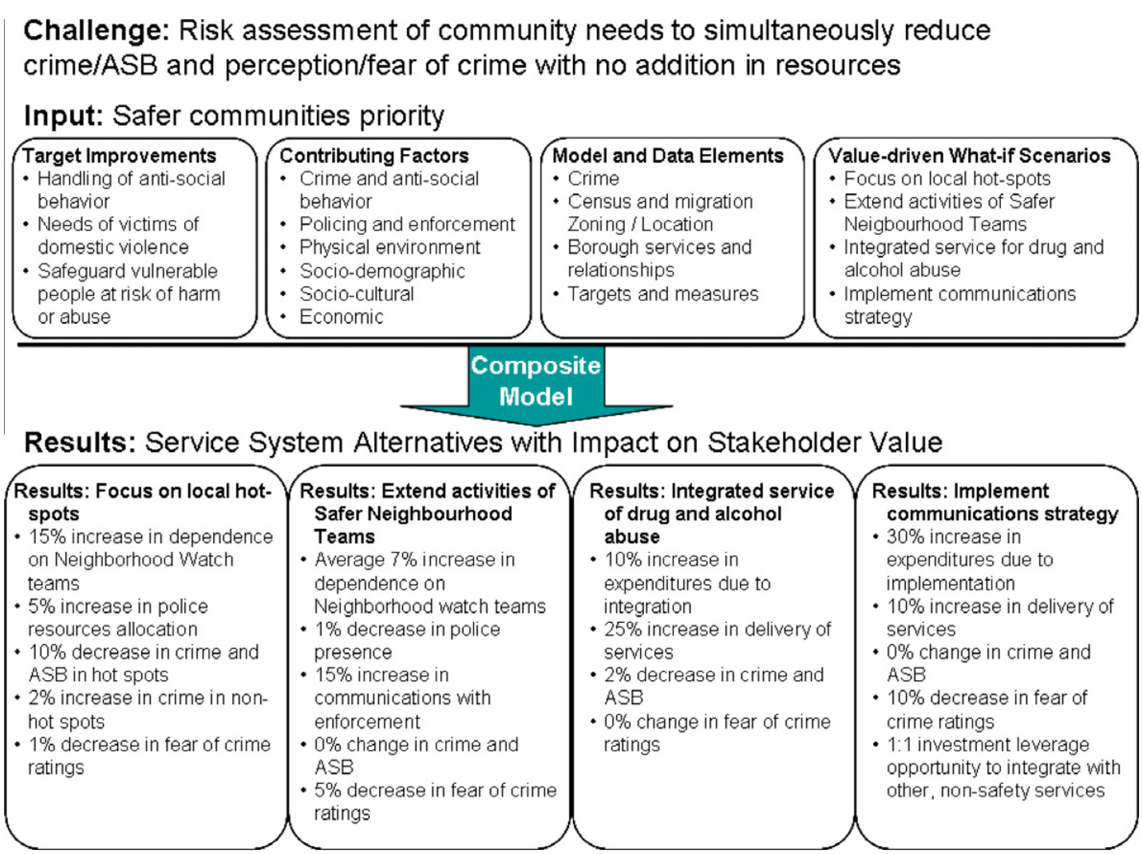

Figure 10 Simulated what-if analysis to evaluate service system value.

system components that can be adjusted to achieve an improved and sustainable reality. The data and models that make up these components are varied in the nature and granularity of both their content and modeling approach, from statistical and queuing models to agent-based and social network models, each designed to best represent the individual questions and content at hand. Splash aims to enable composition of models across a wide range of types.

In the hypothetical composite model for the London Borough of Sutton's safer communities priority, we examined and outlined the factors and component modeling and data elements thought to be most representative of the service system. Our proposed composite model would allow for simulation of the service system using models and data that already exist to examine impact of alternative modifications to the system through what-if scenario analysis. This, in turn, can provide evidence to policy makers and constituents of the potential for increasing value co-creation within and across the service system (e.g., investment, ratings, community engagement).

Conclusions

Understanding relationships among stakeholders in a value constellation can help us improve value creation in a complex service system. Here, we suggest a new approach to dealing with the complexity of predicting and managing service system interactions: enabling model composition to design and evaluate stakeholder relationships using what-if scenarios. We show how a service system analysis–analyzing value constellations to find opportunities for reconfiguring roles and relationships that effectively and efficiently create value–can be applied to a sociocultural service system by focusing on the complex relationship among components that can influence complex questions, such as safety and quality-of-community. Modeling and simulating the value constellations of complex service systems, such as those that make up the London Borough of Sutton, can help us discover which interventions and reconfigurations will be effective and which will not.

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CHERYL KIELISZEWSKI is a research scientist at IBM Research — Almaden. She has over 15 years of research and applied human factors engineering experience, been the technical assistant to the Almaden vice president and lab director, managed a team focused on the design and implementation of advanced analytics for business intelligence and, most recently, part of the Splash team. Dr. Kieliszewski received her Ph.D. from Virginia Tech in Industrial and Systems Engineering and is co-editor of the *Handbook of Service Science*.

PAUL P. MAGLIO is a research scientist at IBM Research — Almaden, and a Professor of Technology Management at the University of California, Merced. A founder of the field of service science, he serves on editorial boards for the *Journal of Service Research* and *Service Science*, is co-editor of the *Handbook of Service Science*. Dr. Maglio holds an S.B. in computer science and engineering from MIT and a Ph.D. in cognitive science from UCSD.

MELISSA CEFKIN (Ph.D. Rice University) is a research scientist and manager at IBM Research — Almaden. She is a business anthropologist specializing in workplace ethnography, services research, and solution design. Previously Director of User Experience at Sapient Corporation and a Senior Research Scientist at the Institute for Research on Learning, Dr. Cefkin is the editor of *Ethnography and the Corporate Encounter: Reflections on Research in and of Corporations* (Berghahn Books, 2009) and serves on the Board of the Ethnographic Praxis in Industry Conference (EPIC).