



From Big Data to Big Service

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Big service—the convergence and collaboration of big data systems—presents a solid solution to the challenges brought by big data.

Offering potentially huge value, big data is an increasingly important asset for business enterprises and society in general. Cloud computing, the Internet of Things (IoT), social networks, wireless sensor networks, and intelligent terminals drive and support the acquisition, storage, analysis, and use of big data. Leading IT companies such as Oracle, IBM, Microsoft, SAP, and HP have invested more than \$15 billion buying big data management and analytics software firms and other initiatives to solidify their foothold in this field.¹

Efficiently analyzing and processing big data is imperative and requires implementing various services across

multiple domains, networks, and the cyber-physical world. These services should ideally speed up data processing, scale up with data volume, improve adaptability and extensibility despite data diversity and uncertainty, and turn raw, low-level data into actionable knowledge. Such interoperability across a large number of services, domains, and business processes and rules is, by necessity, a complex service ecosystem. Through this ecosystem of convergence and collaboration, which we'll call *big service*, we can more effectively address big data challenges.

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BIG SERVICE CHARACTERISTICS

Big service has evolved from the collection of collaborating, interrelated services for handling and dealing with big data. Like big data's five key characteristics—volume, variety, velocity, veracity, and value—we believe big service has seven corresponding characteristics:

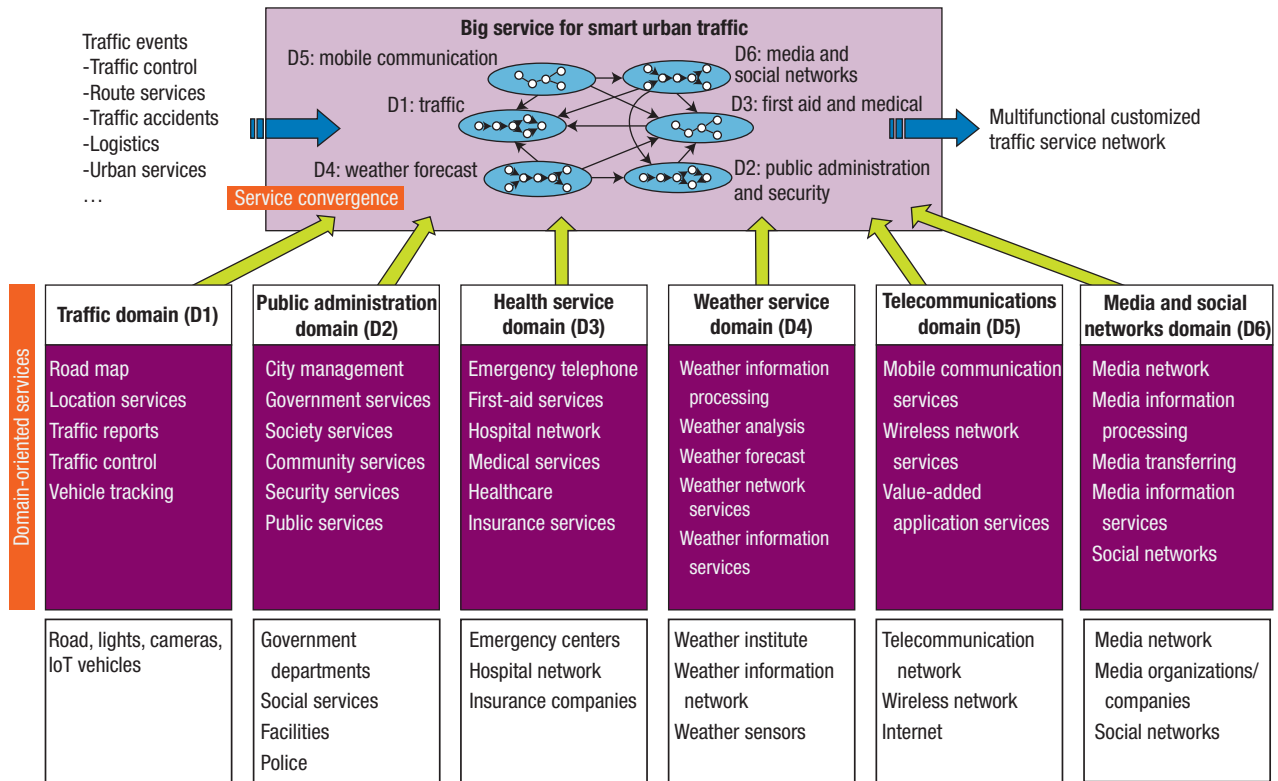


Figure 1. By collecting urban traffic data from a wide range of sources, big service can construct customer-oriented service solutions to quickly respond to traffic events.

massiveness, heterogeneity, complexity, convergence, customer focus, credibility, and value.

Big service brings together both virtual (such as cloud services) and physical (such as public transportation) services; by aggregating these services from various domains it produces composite service solutions to meet customer requirements. Big service is customer focused so that when it receives a customer's requirement, it creates composite services on demand, combining service resources to complete the service tasks. The composite services are also adjustable based on the customer's changing demands—even mid-level service communities are able to establish composite services through small grains of services from

different domains. Service credibility is of course critical for constructing and operating big service, and its value is emphasized through every phase in the services life cycle.

Big service's usefulness in solving business problems is particularly relevant in the cyber-physical world. For example, the European Commission's proposed Internet of Services (IoS) is a vision of the future with a networked form of big service.² The IoS presents a paradigm in which everything is available as a service on the Internet. It can also be viewed as networked services or systems across the real and virtual worlds over the Internet. In the IoS, services—as encapsulated functional entities containing interaction processes by service providers and

customers—are distributed, virtualized, and converged over the Internet to meet the requirements of and create value for customers.

Another example of big service is smart urban traffic ecosystems, as shown in Figure 1. Urban traffic data is gathered from a wide range of resources, such as vehicles, traffic surveillance cameras, weather conditions, and social networks. Various services across different domains collect, store, and analyze such big data. Big service then takes the information and uses it to select services and construct customer-oriented service solutions to respond quickly to traffic events, such as accidents and traffic control issues, according to real-time traffic information.

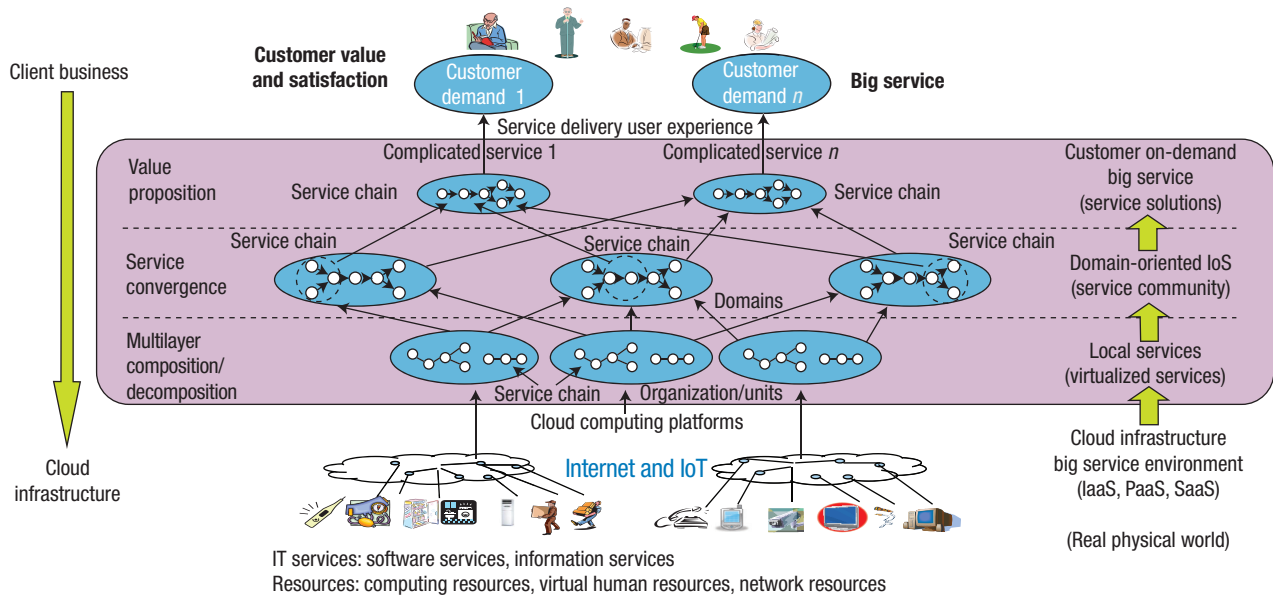


Figure 2. Generic reference architecture for big service. This architecture has three main layers (local services, domain-oriented services, and demand-oriented service solutions) and two additional layers (the cloud infrastructure at the bottom and the client business at the top). IaaS, Internet as a service; PaaS, platform as a service; SaaS, software as a service.

BIG SERVICE REFERENCE ARCHITECTURE

A generic reference architecture for big service is depicted in Figure 2. Such an architecture can be organized into three main layers: local services, domain-oriented services, and demand-oriented services. The reference architecture also contains two additional layers: the cloud infrastructure at the bottom and the client business at the top.

Local services layer

Most services are generated, owned, and shared by individuals and organizations. Some are atomic services (also called elementary services that do not rely on other services) that are virtualized from physical services or the IoT. Others are complex services offered through service composition. In the local services layer, the basic service infrastructure and resources are packaged into services using service encapsulation and virtualization (for example, cloud services). The atomic and composite services can be connected or integrated through

service chains and then run on cloud platforms.

Domain-oriented services layer

In this layer, aggregated local services converge into more powerful composite services according to the domain-oriented business demands and actual businesses relationships. The typical format of this layer can be a big domain-oriented services network (such as the IoS). There are many domain-oriented service communities in which the composite services come from one domain or multiple domains. Composite services and service networks link together through high-level service chains, which are also called service hyperchains. Through service convergence across multiple organizations, domains, networks, and cyber-physical worlds, more complex service communities will exist in the cloud and big data environments.

Demand-oriented services layer

Customer requirements in big service are mass individualized or extremely diverse, and the service solutions are

customer oriented and value driven because of mass individualization. Matching reliable demand-oriented services with the customer requirements is an important factor in this layer, as it's highly tuned to the satisfaction of and value creation for the big service customer.

Other layers

The infrastructure layer at the bottom underpins the big service environment constituted by cloud computing platforms, services, and other basic resources such as computing, human, and physical. The key elements at the client layer are the customers' experiences and requirements. To analyze a customer's functional and nonfunctional requirements, service requirements engineering and service ergonomics need to be developed further by the community.

BIG SERVICE RESEARCH TOPICS

Big service is an emerging, interdisciplinary field that requires the support of many technologies, such as cloud

computing, business process management, big data, the IoT, software engineering, service computing, and data mining. To fully realize the potential of big service, however, further research and development are needed in at least eight challenging areas.

System architecture. Big service is a complicated ecosystem with many diverse services that can cross multiple domains and networks as well as both the physical and virtual worlds. A carefully designed system architecture and reference model is needed to effectively establish the principles, structure, and configuration of a big service ecosystem.

Complex service modeling and representation. Despite extensive research on service modeling and representation, it's still a challenge for big service due to its unique characteristics. Models for complex services, service requirements, service behaviors, and service semantics should be adapted to the integration, interoperability, convergence, and coordination of service communities. Furthermore, since big service is a complex and evolving service ecosystem, modeling and quantifying its evolution patterns can help us to better understand it.

New service engineering and methodology paradigm. A new paradigm of software service engineering and methodology, which is different from traditional software engineering approaches, is needed for big service. In this new paradigm, service-oriented requirements engineering and domain-related service engineering can be simultaneously developed. Accumulating well-prepared, reusable service resources for service convergence therefore becomes a meaningful task. Matching converged service solutions with customer requirement propositions is a key issue that needs active research.

Service convergence and collaboration. In big service, models and approaches for how services are being composed across different domains, various networks, and the cyber-physical world should be developed.


The domain-oriented services community is an important layer for service convergence, and the service chain is an important approach for composing the smaller-grained services from multiple sources into composite services.

Service value model and transformation. Service value models, value networks, and service value annotation should be extensively researched and developed. To transfer value factors into the services life cycle, the value-oriented or value-aware service engineering methodologies need to be applied.

Context-aware service constitution and delivery. Future service systems will offer more customized service solutions to meet individual customer requirements. To eliminate the gap between diverse individual customer requirements and the massive number of services in big service, context-aware service models will play a critical role. The semantic information of context should deal with not only the environment-related information but also the user-oriented knowledge.

Service intelligence and recommendation. Service intelligence in big service is similar to business intelligence in e-business, and it will become an important research area as big service grows. However, service intelligence is much more complicated due to the dynamics and complexities of the services themselves and the relationships among them.

Dependability, credibility, and trustworthiness. Services are increasingly being used in complicated mission-critical and business applications. Consequently, the dependability, reliability, credibility, trustworthiness, safety, security, and quality of big service will become critical issues and need extensive research and development.

Through integration of the virtual and physical worlds and linking services across multiple domains and networks, big service will greatly influence service science, information technology, industrial business, and other fields as it yields tremendous benefits to society. 

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Big service reflects a natural evolution from the merging of cloud computing, the IoT, the IoS, and social networks.



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