

# The Intelligent IoT Integrator (I3) Project: Working Together

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This article is adapted from a note I wrote for a newsletter a few weeks ago. It pertains to [the Intelligent IoT Integrator \(I3\) project](#) that we have been leading at USC working with a broad consortium of private companies and public institutions from around the world, to build a real-time IoT data management and marketplace for smart communities.

About three years ago, my colleague Jerry Power, Director of the [USC Marshall Institute for Communication Technology Management \(CTM\)](#), and I started having conversations with each other and others at USC about the Internet of Things (IoT). Our conversations focused on what has inhibited the wide-spread adoption of IoT despite its clear promise to seamlessly bridge the physical and virtual worlds and add value to our lives. We quickly identified that the underlying problems were inherently multi-dimensional,

and required crossing traditional disciplinary and organizational boundaries cutting across government, industry and academia. As we expanded our conversations and proceeded down the path of building the Intelligent IoT Integrator (I3) project with the help of many partners and members, we have continued to grow our understanding of challenges and questions arising from multiple perspectives.

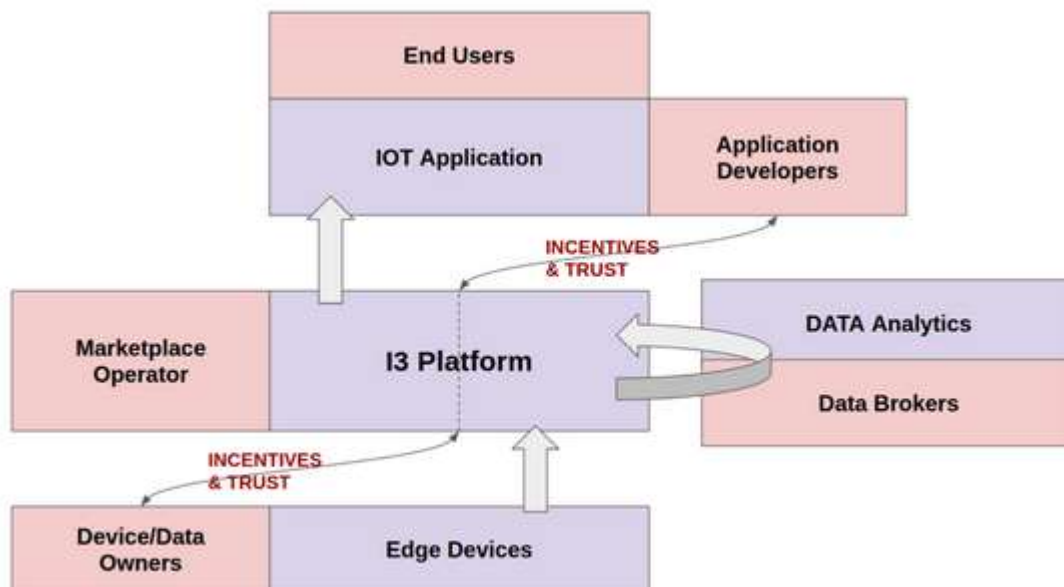
From a pure technology perspective, IoT applications are still being developed largely under an assumption that was characterized by Peter Deutsch and others at Sun Microsystems as one of the [eight classic fallacies of distributed systems](#): “there is a single administrator.” Scaling IoT systems beyond siloed applications that can be handled by a single administrator requires revising the fundamental architecture of IoT systems, identifying the ways in which applications and devices tend to be tightly coupled together and working to decouple them so that different data sources can be fed to different applications in a more flexible manner. It also requires incorporating into the very foundations of the architecture economic, game-theoretic, thinking — a scalable IoT system must allow the different participants to have an incentive to interact with each other, to buy and sell “goods” and “services” pertaining to real-time data.

From a business perspective, what is the value to companies to collaborate with each other in the IoT space and how should they do so? While there has been no shortage of new networking and technical interoperability standards in the IoT space over the past decade (BLE, LoRAWAN, NB-IoT, Iotivity, Alljoin, to name a few), they have not addressed the underlying challenges of how companies can help develop, operate and participate in a shared B2X (spanning business to business, business to citizen, business to government) real-time data ecosystem in a way that benefits all parties. What are the frictions and pain-points in enabling such collaboration? How could the necessary business agreements and transactions needed for such participation be simplified to reduce such frictions? What does the new “data value chain,” analogous to the traditional supply chain for physical goods, look like?

From a government perspective, what is the right approach to building smart cities enabled by IoT data that balances a number of concerns, including a) how to build an open multi-vendor ecosystem that avoids concerns about single-vendor lock-in, b) how to create a self-sustainable

market economy to drive innovation and meaningful deployment of technology rather than depending on pure government funding alone, and c) how to empower citizens with useful data-driven services to enhance the quality of their lives in their communities, while also providing them meaningful data privacy guarantees and user-friendly data ownership and management tools? Such tools are needed so that citizens can decide what data is shared, with whom, when, how long, under what conditions, and for what incentives.

From an operational perspective, what are the real problems in serving a community like a campus or city or an airport that an IoT data sharing technology can help to address? How can the operation and maintenance of the software be made financially sustainable?



The Intelligent IoT Integrator Ecosystem: device owners make data from their devices available on a community's I3 marketplace, where application developers can find relevant data streams for their applications to benefit end users that are members of the community. The marketplace allows device owners to specify who they will share their data with, when, for how long, under what conditions, and at what price. Besides device/data owners, marketplace operators, application developers and end users (community members), the I3 ecosystem also include data brokers that may buy raw data streams and analyze them using machine learning or other tools to create meaningful processed data streams and sell them back on the marketplace.

These and other such questions pointed us in the I3 project towards building a multi-stakeholder market-based data-management ecosystem for IoT for smart communities that is open and allows the scalable integration

of new data sources, applications, and services over time. The crux of the I3 system is to decouple devices from applications and provide low-friction mechanisms in the form of an online marketplace whereby device owners can describe and make the data from their devices available to multiple application developers on their own terms, and at the same time allow application developers to have a one-stop-shop to find useful real-time data sources that they can leverage to build valuable services for community members. Thus real-time IoT data providers, data consumers, and also data brokers that can consume raw data and analyze them to provide insights can together form an ecosystem that mutually benefit each other and the wider community.





Parking at the US Open (from <https://www.flickr.com/photos/alex92287/3379625639>)

To understand the benefits of thinking of IoT in this way, consider the following two concrete examples:

- Building a parking app in a big city is hard today because there are many different sources of relevant information — from city metered parking to private garage owners to street cameras that can be analyzed using computer vision to determine parking availability. With I3, each such provider can contribute their data to the marketplace and then an app developer has a single place where they can acquire (for the right price, and agreeing to the data owner's usage conditions) all these streams of data.
- One street-facing camera can be used for many different applications — from security to traffic monitoring to detecting parking availability to monitoring road conditions to determining if there is garbage that needs to be picked up. With

I3, instead of each of these use cases being implemented as different apps each with their own corresponding IoT devices, they can all connect to and process the same camera feed. To comply with privacy regulations such as San Francisco's recent [ban on facial recognition technology](#), the data feed from the camera could be first processed at the seller's end (or, alternatively, via a trusted data broker) to "fuzzify" any human faces.

The competition implicit in a marketplace benefits many members of the ecosystem. Citizens benefit from application developers competing to provide them valuable data-driven services. Application developers benefit from device owners having an incentive to compete to provide useful data streams at sufficient scale and density, as well as from being able to discover complementary data sources from multiple providers. Device owners benefit from having a marketplace where they can monetize their data offerings. And these benefits can scale when the same I3 system is adopted by more than one community over time.



Grand Central Market in downtown LA ([from Wikimedia](#))

Another way to think about this is that cities have always been sites for thriving marketplaces where citizens can gather to buy and sell goods and services with each other. What we are doing with I3 is extending this concept from the physical to the virtual world, where what are being are bought and sold are data goods and data-driven services.

As we started down the path of realizing this vision, we found that the process of building such an ecosystem itself requires a thriving ecosystem of diverse partners representing the various perspectives, having a voice and being engaged actively in every stage of design, development and testing. Therefore, we created and [launched the I3 consortium at USC](#) in the November of 2017, with the backing of many public and private organizations.

We feel truly fortunate to be supported by a number of enthusiastic, passionate individuals from a wide range of organizations in the I3 community — faculty and researchers from research institutes and university centers to officials from city and county governments to entrepreneurs and business leaders from private companies both big and small, from across the world. To give a concrete picture, the recently concluded second I3 conference included representatives and speakers from the following organizations: City of Los Angeles, Long Beach, County of Los Angeles, City of Pasadena, Verizon, Amazon, Microsoft, Ericsson, Western Digital, Cradlepoint, Wizr, IOTA, Kiana, USDG, EnOcean, Traction Labs, Insight, Aurigon, Zetta Advisory, Inria, Korea University, and USC. These stakeholders have contributed very substantially to the I3 project in many forms including ideas, feedback, time, software and other resources.

I welcome you to visit the [I3 Consortium website](#), [join the I3 mailing list](#), and learn more about the I3 consortium, which we view as a forum where diverse interests are presented, not with a naive intent to align everyone to the exact same goal but rather to create a common framework that can support a diversity of needs. We believe it will help us continue to grow our community so we can continue to make progress towards addressing the multi-dimensional questions and challenges facing us.