



# Transcendental Coalescence in the Age of IoT and Analytics: A Smart City View

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In our previous white paper, "IoT & Big Data - Transforming Green Buildings into Smart Ones," we talked about the following:

- How the Internet of Things (IoT), combined with ubiquitous computing, provides enormous data and information.
- Data now is used to forecast, predict, and optimize operations and needs.
- The concept of device autonomy (i.e. self-aware, self-regulated and optimized transformations).

In this white paper, we would like to introduce this concept to a more generic business environment (a smart city) and reflect on the following:

- A use case (value creation and capture) based approach for a complex business landscape.
- User-centric needs and interactions.

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## Before we start deliberating on this topic, let's first qualify some definitions:

### Transcendental:

As per the Oxford dictionary, mathematically it is something that is "...not capable of being produced by the mathematical operations...." In philosophical terms, it is something beyond the physical realm.

### Coalescence:

A process of "joining or merging of elements to form one mass or whole" (also from the Oxford Dictionary).

### Transcendental Coalescence:

This is more than the mashing-up of technologies and use cases owned by separate business/industry verticals. It is the fusion of people, processes and technology to provide the most intuitive and optimal business outcome.

### Smart City:

A city comprises multiple complex, interdependent systems. The word smart by itself is subject to interpretation and there are multiple definitions of smart cities. For our purposes, we will rely on the definition by the Smart Cities Council: "A smart city uses information and communication technology to enhance its livability, workability, and sustainability."



## Transcendental Coalescence: A Smart City Use Case

The United Nations estimates that between 2015 and 2050, the world population will increase by 32% (from 7.2 to 9.7 billion inhabitants), while the urban population will increase by 63% (from 3.9 to 6.3 billion inhabitants).<sup>1</sup> This extraordinary growth in urban areas is already putting, and will continue to put, a great amount of stress on cities to provide basic services to citizens. We will need more cities and megacities, thus spurring the need for more housing, offices, hospitals, and schools, along with connected and efficient public infrastructure and amenities.

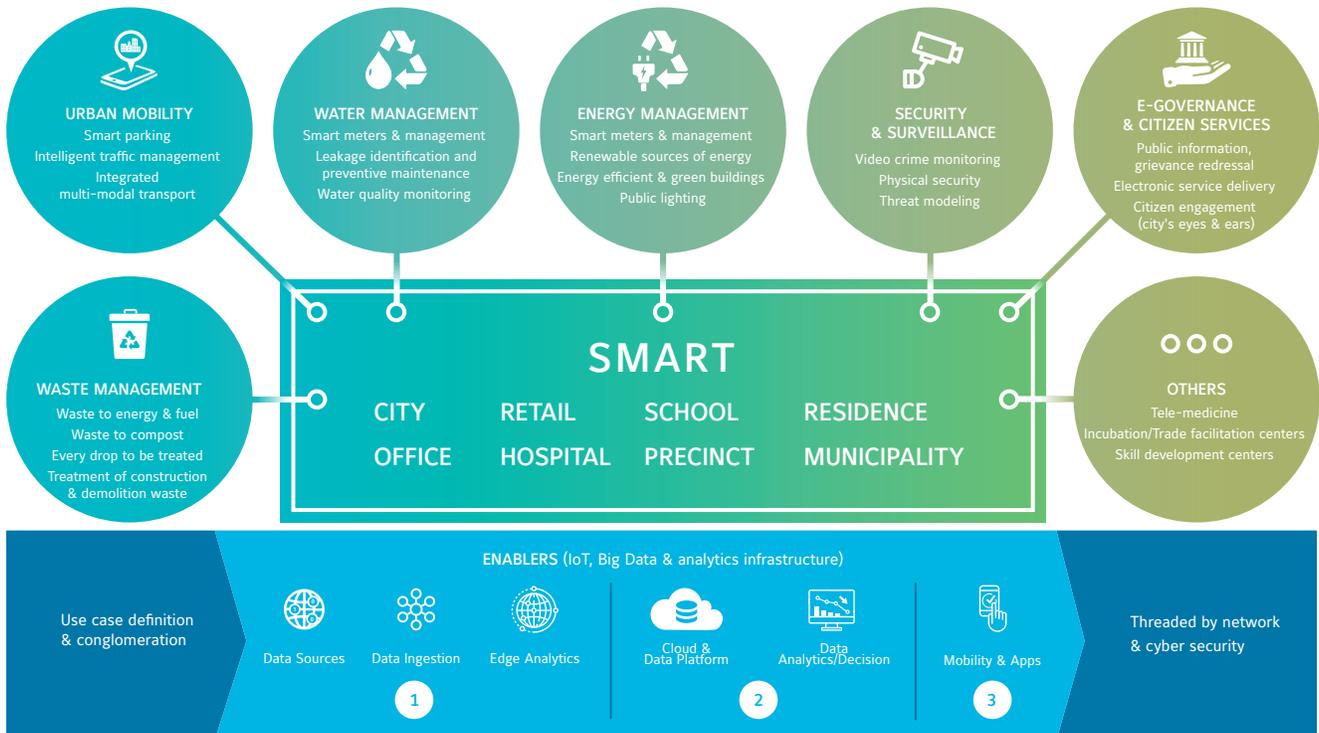
**This extraordinary growth in urban areas is already putting, and will continue to put, a great amount of stress on cities to provide basic services to citizens.**

Both rapid urbanization and unplanned growth pose significant challenges for cities by the way of increased demand for natural resources. The United Nations also found that, currently, even though cities occupy just 2% of the Earth's land, they use up to 80% of the total energy expended and 75% of carbon dioxide emissions. Hence, we need to find intelligent ways to better use our natural resources and better serve the aspirations of the urban population so that cities grow sustainably.

A smart city transcends an aggregation of smart buildings. The aim of a smart city is to unify all the elements and make them work together towards the betterment of its citizens via transcendental coalescence. We can achieve this with a conglomeration of multiple use cases in action across its citizen diaspora, in a bid to increase productivity, safety, and security while creating an experience of sustainable urban living.

<sup>1</sup> <http://www.un.org.za/sustainable-development-goals/>

## Smart City Ecosystem



As shown, there are multiple systems and subsystems in a smart city eco-system, including but not limited to the following:

- Waste disposal and management
- Traffic management, transport systems, and clean vehicle with associated infrastructure
- Water management
- Clean power and energy management
- Physical security, cybersecurity, and surveillance and an overall threat modeling of a city
- E-governance (transport, utilities, healthcare, safety and security, etc.)

Each aspect is an area of specialization applied to the building, precincts, municipality and, finally, the city level. Thanks to the continuous evolution of technology, there is a set of the common underlying themes from a design perspective that transforms the smart city from concept to reality.

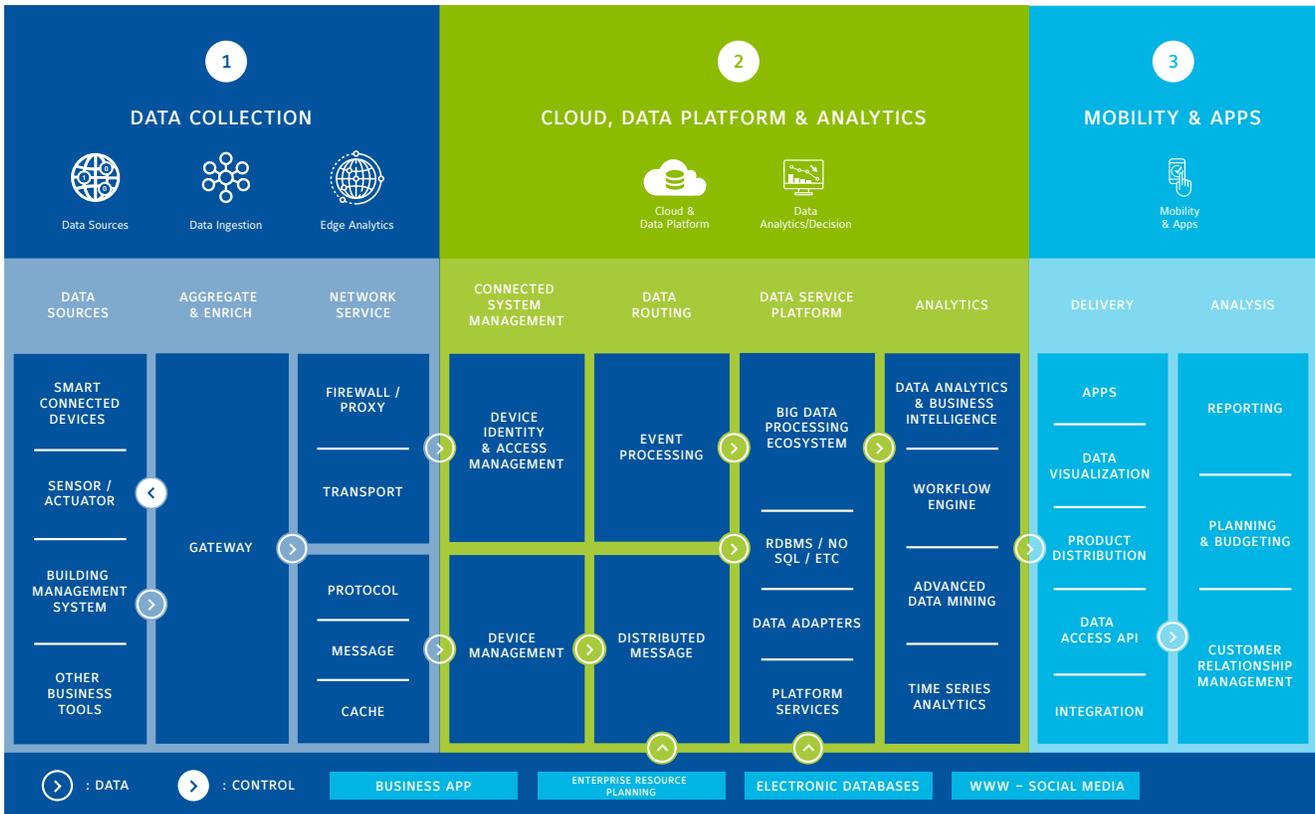
The first design step is the rigorous and meticulous definition of personas and their use cases. The problem statement and/or use cases need to be identified and solutions need to be crafted accordingly – keeping scalability in mind. Technology helps to bring the solutions together, but not all solutions work for similar problems. For example, when it comes to energy optimization, design considerations for Singapore as a smart city vis-à-vis Jaipur (a proposed smart city in India) are very different. Singapore, being an energy surplus economy, energy management will need optimization on the production side, whereas in the case of Jaipur, which is energy deficit, the aim will be to manage demand side optimization.

When building a smart city ecosystem and/or its components, technology selection is critical. A smart city will be dealing with a very large amount of data (in petabytes) that could be structured or unstructured, such as text records, video surveillance feeds, or even social media feeds. **All this data is interdependent and needs to be connected and interpreted in the right context for proactive and meaningful action.** Knowledge of technology components, data flow across systems and subsystems, and allied analytics must overlap to become the foundation stones for those systems and subsystems. Further appreciation for obsolescence (be it electronic hardware or software components in the ever-demanding need of citizens) is necessary to ensure there is a right correct trade-off between future proofing and implementation success.

# Technology Components for Transcendental Coalescence

Complete transcendental coalescence will require an ecosystem consisting of three main technology components. Let's look at them.

## Unified Reference Architecture for Transcendental Coalescence



## Transcendental coalescence enablers in detail

### 1. DATA COLLECTION

#### Data Sources



#### Legacy

(sensors, controllers, building management system)



#### Social Media



#### World Wide Web



#### Electronic Databases



## Data Ingestion

In today's era, where everything is claimed to be an IoT device or IoT enabled, determining the data collection and ingestion strategy is a critical step in designing for a legacy/retrofit environment. (Until all devices are IoT compatible, we have to rely on transition systems acting as a connecting layer between the legacy devices and the IoT system.) This will define the ease or difficulty faced by cloud-based software applications when processing data from the ingestion point. When it comes to real time applications, the absence of clearly defined and widely accepted industry data transfer protocols/mechanisms, a broken value chain, and unclear data ownership and use issues make this job even more difficult.

Optimized data transfer protocols like RESTful API, CoAP, HTTP(s), AMQP, MQTT play a major role here. While the smart edge devices in the network are expected to use these, in most cases, gateways play an important role in converting data into IoT defined protocols. A gateway works as a bridge between the non-IP legacy systems (or non-IoT traditional systems) and protocols with lightweight cloud services protocols for onward processing/analysis of data.

Further, the data is not necessarily in real-time or time-series in nature. There are and could be contextual or unstructured data feeds, as well as, for example, asset maintenance history records or social media content, that are to be used as part of the system.



## Edge Computing (Edge Gateway)

Edge computing (or edge gateway) is a method of optimizing cloud computing systems by performing data processing at the edge of the network near the source of the data. This reduces the communications bandwidth needed between end devices and the central data processing units (either in servers or in the Cloud) by performing analytics and knowledge generation at or near the source of the data. Edge devices are classical 'things' in an IoT world that are defined as computing devices having embedded intelligence to perform a pre-defined action based on input condition or input from other connected smart things or from remote services.

Edge computing ensures dependable operation of the IoT ecosystem even when the connectivity is intermittent. Edge application services significantly decrease the volumes of data that must be moved, the consequent traffic, and the distance the data must travel. This reduces transmission costs, shrinks latency, and improves quality of service. When designing a smart city subsystem and its components, it is best to implement as many edge devices as possible.

## 2. CLOUD, DATA PLATFORM & ANALYTICS

The success of a data strategy and the interconnectivity/ interoperability of various systems depends on the data platform. While there is a generic guideline, it primarily depends on the provider's data platform and associated software architecture. The following generic checkpoints remain:

- Data type compatibility (data ingestion methodology and support): Time series events, unstructured text, image, video streams, PDF, or scanned documents
- Distributed architecture having microservices implementation for autonomously distributed computing at the edge level
- Big Data storage and processing system (e.g. a Hadoop file system)

On the analytics side, the data platform should have the capability to do the following:

- Rule (mathematical expressions based on if, then, else, and simple equations) based on an analytic decision approach
- Ability to carry out statistical analysis
- Perform reinforced/deep learning. Based on statistical data, the system by itself recognizes the pattern based on historical data and takes appropriate action automatically
- Manage complicated workflows

## 3. MOBILITY, APPS AND VISUALIZATION

Until recently, most business problems pertained to technology, optimization, compliance/security, and cost savings. End user needs and experience was mostly neglected as a result. Technologies and use case approaches need to factor in the experience for the personas in the ecosystem. The user interface for the citizen living in a smart city needs to be:



**Engaging:**  
Social, creative  
& collaborative

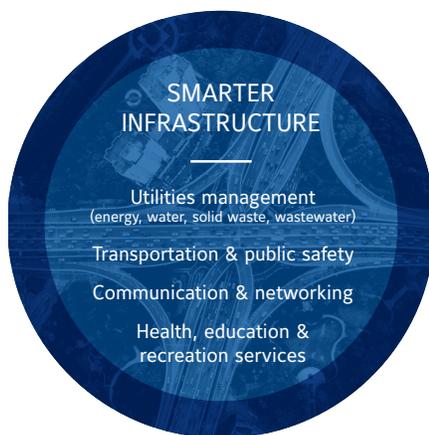


**Fulfilling:**  
Directly related to a happy  
citizen & hence a happy city



**Empowering:**  
Provide a choice & flexibility;  
sense of control

### Three Typical Categories of Mobility & Apps



# Challenges in Developing Transcendental Coalescence: A Smart City Use Case

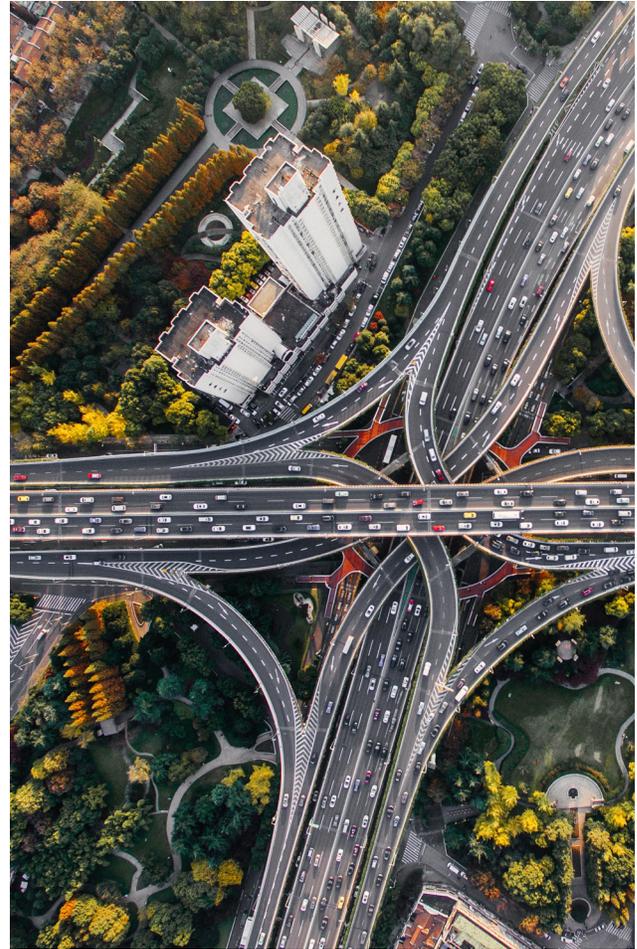
## 1. THE NEED FOR AN INTEGRATED APPROACH

A city is made up of different infrastructure verticals forming a maze of systems. However, these city infrastructure elements typically operate in silos. Smart cities need an integrated approach in order to harness the full potential of smart infrastructure. Integrated approaches are effective tools for capturing the dynamic relations between people, policies and environments. Some of the recent examples made in this direction include:<sup>2</sup>

- The Mayor's Office of Data Analytics in New York City, "is developing a formal structure for reporting out cost savings and increased revenue achieved for the city, along with efficiencies that improve service quality and fairness."
- Wellesley, Massachusetts has saved \$132,000 in energy costs using data analytics by managing and reporting regularly on energy use for each town building and benchmarking.
- The city of San Diego in California, with its open data portal, predictive analytics, geospatial analysis, and performance management program, has achieved significant savings. Some of the projects include:
  - Lean Six Sigma methodology streamlined the 911 call answering and dispatch process to offload non-emergency calls, allowing true emergency calls to be answered faster.
  - Sensors on streetlights allow automatic dimming and brightening of the lights, estimated to save \$2.4 million annually in energy costs.

All of the above examples are individually planned projects. Greater insight and increases in overall efficiencies can be obtained by combining them and correlating data. For example:

- Use of 911 data in coordination with closed-circuit television (CCTV) monitoring can increase security and enable infrastructure measures, such as obtaining information on public lights not dimmed in desolate areas, as well as those having higher crime rates.
- Building energy data and benchmarking can be used to develop smart grid strategies for flattening the energy production line, as well as reducing the transmission and distribution losses.



## 2. MONETIZATION STRATEGY: INFRASTRUCTURE OWNERSHIP & USE

With the absence of a universally accepted cloud/data connectivity architecture, an integrated approach leads to other challenges. The pace at which new technologies and protocols are being designed and proposed for connectivity has led to an absence of standardization for diverse system connectivity.

The initial cost of IoT is one hindrance; current business models do not provide mass proliferation of technologies. As the market matures, cost, legal, infrastructure sharing business models will evolve to justify first cost and will create pull through in the market.

<sup>2</sup> <https://datasmart.ash.harvard.edu/news/article/discovering-the-true-value-of-data-experts-who-are-showing-cities-the-money>

### 3. MOBILITY, APPS AND VISUALIZATION

While leveraging technology brings many benefits, it also creates significant exposure to security and privacy vulnerabilities. One needs to be apprised of the challenges so a strategy can be defined for mitigation.

As Sudhi Sinha, vice president, data enabled business at Johnson Controls, Inc., rightly pointed out in his book, "Building an Effective IoT Ecosystem for Your Business," key areas of focus will directly impact the success of becoming a smart city.

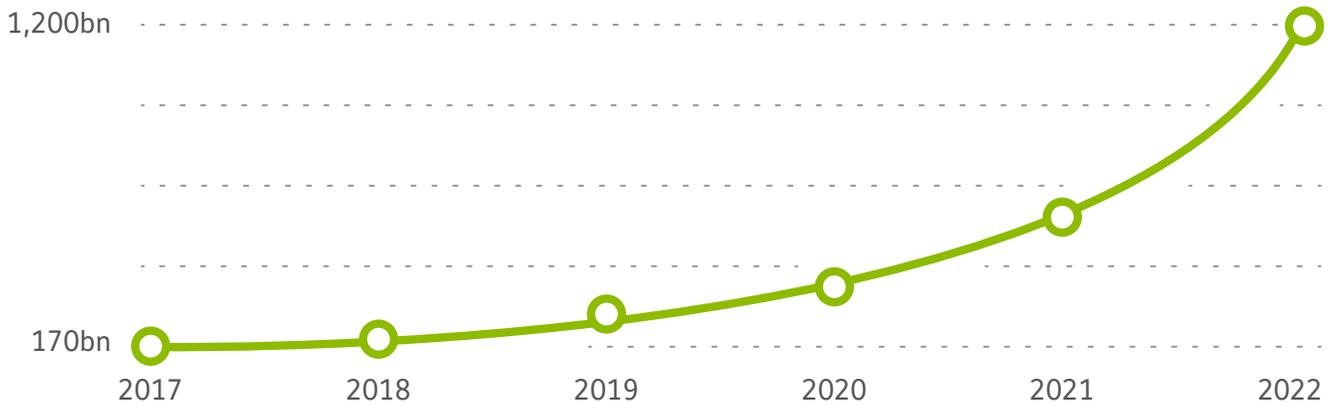
The following are the must-have considerations when creating a cybersecurity strategy:

- Understanding the threat vectors in the world of IoT
- Path taken in the IoT world to penetrate the device
- Recognizing data privacy and ownership concerns
- Learning about the various industry standards and available resources
- Knowing popular and modern technologies and standards
- Designing security policies and practices
- Securing data and insights
- Building a risk management and compliance program
- Determining hacking and auditing security and privacy effectiveness
- Managing attacks and communicating effectively

### 4. LACK OF A SMART CITY VISION AND CITIZEN PARTNERSHIPS

The challenge is to deliver a high quality of life in an urban environment, which brings a huge opportunity for the Cloud, IoT, mobility and apps, and IT and data security industry. To address use cases, businesses need to be proactive in adopting new technologies, driving innovation, creating new products, and acting on these smart city pursuits.

#### Smart city market size



The people who live in the smart cities of tomorrow will continue to demand more, so it is critical that leaders remain committed to delivering evolving technology and smart city solutions.

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