Summary Report on

Project Title: Study of India Appropriate Technology (IoT) Solutions for Smart Cities

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Executive Summary

The main objectives of our project are:

- Recommendation and Guidelines for Smart City RFPs related to IOT Specific technologies, driven by India Specific Use case analysis and Emerging Technology adoption methodology
- India appropriate reference architecture for IOT enabled Smart cities through a collaborative platform of domain experts from industry, academia, government, start-ups, professional bodies and user agencies.

We conducted two workshops with City administrators: one in Chandigarh and another in Electronics City, to understand the City's requirements. A series of telecons/webcons were held with technical presentations from a diverse set of domain experts from Industry, Academic, Govt. Bodies, startups etc. Further deliberations and discussions were done to synthesize the view points in this report which are summarised below.

Inputs from the City Administrators:

1. Citizens must be the key beneficiaries of any smart city solution. It should benefit all strata of society.
2. Unified Command and Control centre is needed to be able to oversee all the city operations by the administrators.
3. Need low cost, sustainable, interoperable solutions with smartness built in to help with maintenance and operations.
4. Solutions should be vendor technology (s/w or hardware) agnostic – every component should be replaceable.
5. Solutions should enable development of future smarter/intelligent solutions.

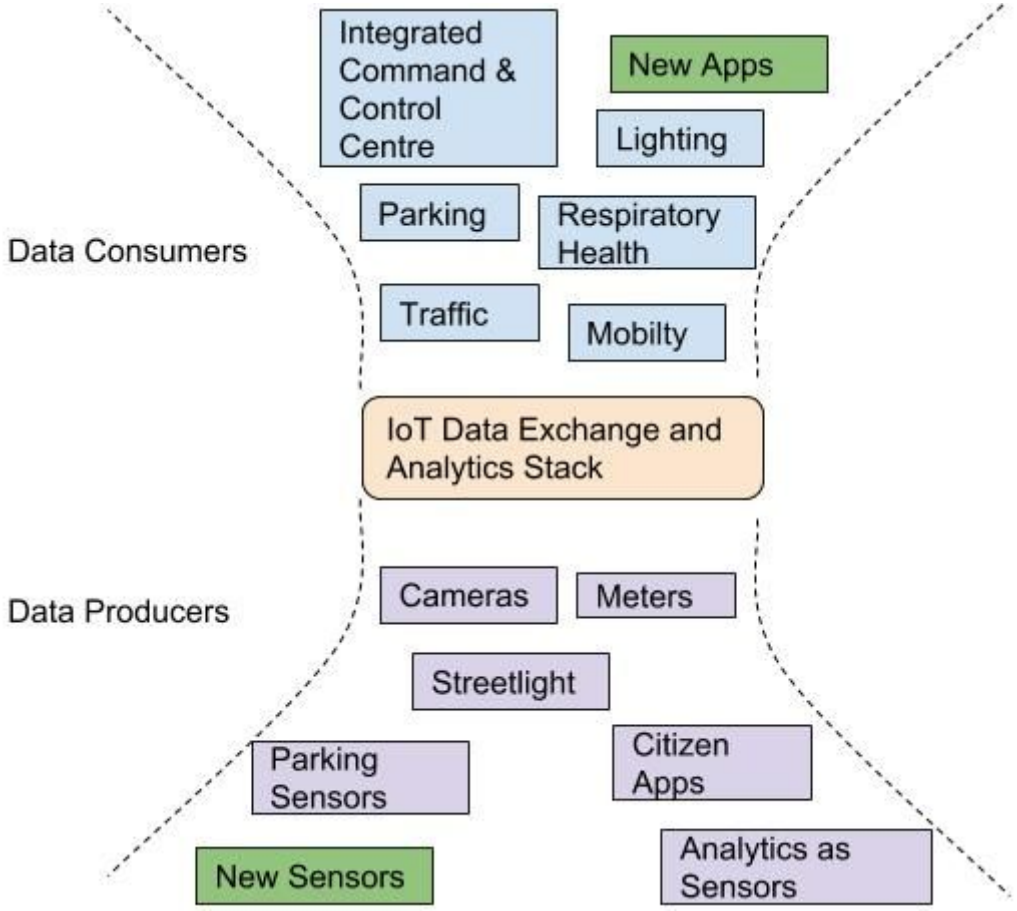
RFP Guidelines

6. Should explore use of non-licensed sub-gigahertz spectrum for LPWAN, including non-IP based last mile solutions (BLE, Zigbee, LoRA, VLC etc).
7. Since smart city solutions will take years to deploy and operationalize, and with rapid technology advancements, costs come down, RFP should incentivize providers to reduce their price over time via rebasing their technology and enable phased additions of technology over time.
8. Since light poles are ubiquitous in cities – they should be used as key anchor points for smart city solutions
9. MoUD's guidelines on Cyber Security Model Framework for Smart Cities provides best practices framework. In addition, a central cell under NCIIPC (National Critical Information Infrastructure Protection Centre) to develop methods to test Smart infrastructure (whitelist hackers) and arrange emergency response in situations of attack can be set up.

10. Open data will be critical for further empowerment of citizens as well as emergence of new services. The RFP should clearly ask for data in open formats to be made available to the city by the vendors of various solutions.
11. RFPs can give an opportunity to MSMEs and startups – to spur the local ecosystem. These can play a major role in training/maintenance as well as offer novel low cost solutions in the case of start-ups.
12. Incorporate crowd sourced data to enhance citizen participation via enabling them to report issues etc.
13. RFPs should promote interoperability of solutions from different vendors.
14. Device management will be critical and a Standards based approach will be essential for this.
15. Quality cum Cost based system can be adopted to ensure high quality smart city solutions.

India Appropriate Reference Architecture for IoT Enabled Smart Cities

16. **Enabling easy collection and exchange of data is a key enabler for future smart city applications**. We advocate an hourglass architecture like in AADHAR, with the neck of the hourglass being the middleware that mediates between Data producers (IoT devices, Sensors, existing IT systems etc.) and consumers (applications like the unified command and control centre, city business decision support etc.).



17. **Providing good, well documented, open APIs for the smart city middleware, along with standardising the data schemas** will be key to enable a rich application and device ecosystem to evolve.
18. A data middleware should be implemented, that will decouple sensors/IoT devices from the applications. This will allow 3rd party applications to be developed for existing IoT devices. It will also allow IoT devices from multiple vendors to be plugged in an interoperable manner.
19. **Open data models for all IoT data sources (and actuators) needs to be developed to enable interoperability and vendor neutrality of devices in the IoT system**. In addition, the models should be extensible, allowing for easy enhancement; and operations need to be developed which will seamlessly integrate the enhanced information model with existing applications.
20. **India appropriate City Information Model (ontology) for Indian cities, their structures** and their operations need to be developed which will enable future smart/intelligent solutions.
21. A data/sensor catalogue should be provided which is machine and human searchable via standard REST API. The catalogue will contain information of all available data sources (IoT sensors, their capabilities, owners, access methods etc) in a standard form using open templates like JSON.
22. The data middleware should provide the capability to subscribe to live data as well as access archival data from the IoT devices via standard REST and Streaming APIs.
23. The data middleware should support AAAA (Authentication, Authorization, Accounting and Auditing) capabilities for devices, applications and human users. It will support both real and virtual devices (sensors). It should support complete lifecycle management of devices.
24. The AAAA should implement state of the art security features in compliance with MoUD recommendations and extend it further as required. Security Certificates, API Keys, Authentication Tokens etc., should be managed by the AAA. Support for SLAs and federated authentication should be provided.
25. Authorization capability should enable fine grained access control to resources. Coupled with accounting and interface to digital payments infrastructure, this will enable developing a data marketplace.
26. **The data middleware's interfaces and data formats will be "open" allowing for easy replacement of any component,** migration to new system integrators, migration to new platforms etc. without losing valuable data or incurring too much downtime.
27. A standards based management for devices, equipments and applications, should

be adopted to manage the ICT components of the smart city implementations. This will enable multiple vendors to offer device, ICT and Solution management services. Device management should be decoupled from ICT and Solution management as well as the data services and applications.

Suggestions for the future

28. Since there is not much experience with smart city solutions in India, **we recommend the setting up of sand-boxes/living labs/test-beds in every city to enable experimentation**, learning and teaching of smart city concepts in these spaces. These can be co-located with a local university and involve local MSMEs and other companies, in collaboration with city administration.
29. The smart city test bed will enable exploration of new concepts by researchers, demonstration of new technologies by entrepreneurs, teaching of smart city concepts to city employees and students and spur the development of local solutions to local problems.
30. Every smart city can be encouraged to set aside a small budget (<1%) for the smart city test bed, with additional support from state and central R&D funds.
31. Interoperability and compliance test centres and frameworks for Smart City Solutions should be set up.
32. Extensible, open source technologies and standards should be adopted/developed wherever possible to enable low cost/sustainable/vendor neutral solutions.
33. Common, well documented APIs, and Data schemas needs to be developed and adopted across all smart city implementations in India. This activity can emerge from test beds and needs to be embarked upon immediately. A consortium of implementers should be formed to drive this activity.
34. City information model needs to be developed. Such information models need to be distributed and extensible. This will be essential for emergence of smart/intelligent applications of the future. This has to be driven by one of the Indian Standards Bodies.
35. City, region & domain specific guidelines/standards in practically every sphere are needed. For example, smart street lighting standards in terms of minimum lux for safe city and hence the pole heights, LED lumens, installation guidelines, backup procedures etc. are needed for smart street lighting. Similar standards are required for surveillance (camera resolutions, deployment guidelines etc.) and practically every other application area. Indian Standards bodies should take these up one at a time to develop a thorough standard and reference implementation for each domain.

Gaps in IoT technologies for Smart Cities for future R&D

36. Low cost Smart IOT devices for many city applications, customised to each city's requirements, along with open data models are needed. For example, multi-color

LEDs for North India, to effectively deal with fog in winter months.

37. Distributed trust technologies for audits (for e.g. Block-chain) should be explored for use in Smart City services.
38. New analytics for video will be needed to enable more effective use of cameras.
39. Distributed/edge analytics need to be explored, especially for video.
40. High priority data channels for Emergency services for handling critical data and its model, like gas leakage, fire, etc.
41. Indian City specific Information Models/Ontologies are missing and need to be developed.