The Future Cities Pilot: Leading the Way for Smart Cities

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According to the Ministry of Urban Development's Smart Cities Mission Statement & Guidelines [1], urban areas in India are expected to house 40% of India's population and contribute 75% of India's GDP by 2030. This is part of a global trend, with the growth of cities outpacing growth in rural areas [2]. With cities playing home to so many people, and with them playing such an important economic role, is imperative that we use the best technology and tools available to efficiently manage their development and operation.

This, of course, is not news: leaders in urban planning and the IT industry alike, including the Open Geospatial Consortium (OGC), have been promoting the concepts of 'connected cities,' 'smart cities,' and 'resilient cities,' as solutions to growing urbanisation for years. Indeed, all cities, with varying degrees of planning, are increasingly using digital technologies to enhance the quality and performance of urban services, reduce costs, use resources more efficiently, and generally plan and run cities 'smarter.'

The Government of India's Ministry of Urban Development's Smart Cities Mission recognises that 'smart cities' is a beneficial concept, but one that means different things to citizens with different relationships to technology and different aspirations. The mission therefore aims to generally "promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment, and application of 'Smart' Solutions." This is a wise direction for policy, and all cities - whether they're involved with the Smart Cities Mission or not - would do well to treat these as priorities for the future of city management.

'Smart solutions' can be viewed as ones that aid in, or are based upon, the integration of the dynamic human, social, and physical environments with the digital system(s) that represent them - the ultimate representation being an accurate 4D city model. Smart solutions can take the form of, say, sensor networks that collect data about the urban environment and feed it into the city model, or they could be tools that use the data in the model to create useful information, knowledge, and insight for the city's residents and stakeholders, or myriad other forms not yet explored.

The common feature of these smart solutions is that they empower stakeholders to make better informed decisions in their daily lives. Collectively, better informed decision making - by citizens and planners alike - improves financial, environmental, and social outcomes for citizens, and helps make urban areas more prosperous, inclusive, sustainable, and resilient.

The Smartest Cities Are Open

The key to making this vision of integrated, yet disparate, systems work together is in the widespread adoption and use of open standards.

City models are, by necessity, built from and include diverse data types - including cadastre, as-built plans, LiDAR scans, aerial/satellite imagery, utility data, real-time air quality, traffic, etc - and are populated from equally diverse sources, including from construction firms, government bodies, 3D/data providers, commercial and public/citizen sensors, utility companies, social media, etc. This diversity makes data/service integration difficult because different vendors have, quite naturally, taken different approaches to implementing technical solutions.

An effective way to guarantee the seamless integration of such diverse data is through a governmental requirement for, and the widespread use of, software that complies with open standards. OGC wants to help cities understand the benefits of using free and open standards for describing things in space and time, as well as the best way to use them. This approach is outlined in its white paper, OGC Smart Cities Spatial Information Framework [3].

Open spatial standards maximize spatial interoperability; that is, they support the communication and integration of spatial information, which is not only critical for 'smart solutions' to work properly, but also provides several other benefits, too:

- Through leadership-oriented policy decisions that mandate the use of standards, cities can pave the way for less risky, less expensive, and more effective public and private sector urban technology initiatives in the coming years and decades.
- When cities endorse or prescribe the use of standards, ad hoc initiatives tend to fit together, providing a 'plug n play' experience for developers and authorities alike.
- Major programs tend to be more easily integrated with existing, concurrently developed, and unforeseen future initiatives.
- Standards open up opportunities for local developers to innovate, building on the data & service offerings that their cities have provided.
- Citizens are empowered through great awareness of their urban environments leading to better collective decisions and participative governance.

Recognising this value, OGC has, over time, created a stack of interoperability standards, such as CityGML, IndoorGML, InfraGML, SensorThings API, and others that support smart cities, and has cultivated their evolution and application through a series of initiatives, including testbeds, pilots, and plugfests. One such initiative recently completed its first phase in Europe: OGC's Future Cities Pilot.

OGC's Future Cities Pilot

The OGC Future Cities Pilot aims to demonstrate ways to improve financial, environmental, health, and social outcomes for citizens of cities that use open standards to improve access to information, knowledge, and insight.

Phase 1 of the pilot achieved this through a series of practical demonstrations - scenarios - that can serve as blueprints for other cities to modify and apply in their own context. The four scenarios focused on the following areas: Urban Planning, Urban Flood Mapping, Adult Social Care, and Dynamic Resource Modeling.

Phase 1 was sponsored by: Ordnance Survey Great Britain; Sant Cugat del Vallès (Barcelona), Spain; Institut National de l'Information Géographique et Forestière (IGN), France, and; virtualcitySYSTEMS GmbH, Berlin.

To aid in the adoption of the technologies demonstrated, OGC will release a number of free Engineering Reports, guides for best practices, and modified and updated geospatial standards that resulted from, and document, the Pilot. An overview video is available now at *www.opengeospatial.org/projects/initiatives/fcp1*.

Scenario 1: Urban Planning

This scenario demonstrated how a CityGML-based 3D city model can accept plans from architects and developers - even when delivered in Industry Foundation Class (IFC) format - in order to check conformance with city rules (during the design stage) and to keep the 3D city model current (at the as-built stage).

The city of Rennes, France, mandates the use of BIM models encoded in IFCs for important building projects. During the pilot, a web-based validation tool

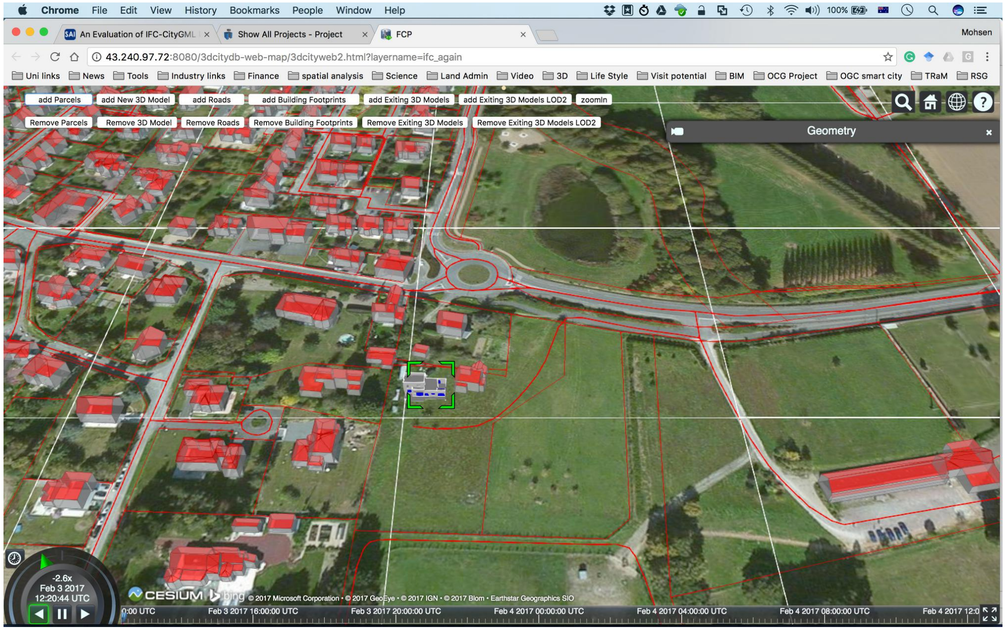

Figure (1). CityGML after conversion from IFC as seen with its surroundings in the 3D-DB-Web-Map-Client

was created and demonstrated that extracts the building information from the submitted IFC files and places it in the city's 3D city model for automated validation against city planning rules, such as restrictions on the building's height, depth, overhang etc. If the design breaches any of these rules, the submitter is immediately notified.

For final verification, an analyst views the building project within the existing 3D city model of the city. Conformant buildings are then added to the 3D city model, using the submitted IFC files to keep the city's 3D city model up-to-date. The original IFC is stored separately for future reference.

Scenario 2: Urban Flood Mapping

A novel use of a 3D city model, as demonstrated in Phase 1, was to use it for more accurate urban flooding maps. Using 3D city models of the Royal Borough of Greenwich, London and Rennes Métropole, France, the Pilot demonstrated how simple it is to create more accurate flood maps than methods based on Digital Terrain Models (DTMs). While not demonstrated by the pilot, it would be possible to also use the semantic information in the 3D city model to identify more 'at-risk' residents and areas, such as nursing homes or hospitals. The pilot demonstrated a new level of interoperability between hydrological flood models and 3D city models. The pilot builds on the previous OGC Testbed 12 results that increased the fidelity of urban flood predictions due to sea level rise and aiding in increased urban resilience.

Scenario 3: Adult Social Care

This scenario demonstrated how OGC's Dynamizer can feed dynamic information from sensors into a CityGML-based 3D city model in order to assess and reduce the risk to residents of social housing during periods of extreme weather.

Prior to the pilot, the Royal Borough of Greenwich, London sought to increase the quality of adult social care by reducing the humidity-a potentially dangerous factor over winter months - in the Borough's social housing.

The scenario demonstrated how the city could use sensors inside public housing to monitor humidity. Properties that display high humidity during the more temperate months could have maintenance tasks assigned to them to reduce the humidity before the winter months put the residents at risk.

At the heart of this scenario is OGC's 'Dynamizer' - a CityGML Application Domain Extension slated to be approved in the CityGML version 3 standard - which allowed previously static properties of objects in the CityGML 3D city model to be overwritten with dynamic information, in this case humidity data coming in via a Sensor Observation Service (SOS).

Scenario 4: Dynamic Resource Modelling

Demonstrating further capabilities of OGC's dynamizer was a scenario based in the commune of Bruzlocated 11 km southwest from Rennes in Brittany,

Figure (2). Visualization of flooding in Rennes using the proposed CityGML encoding draped over 3D terrain and building data (provided by Rennes Métropole/IGN)

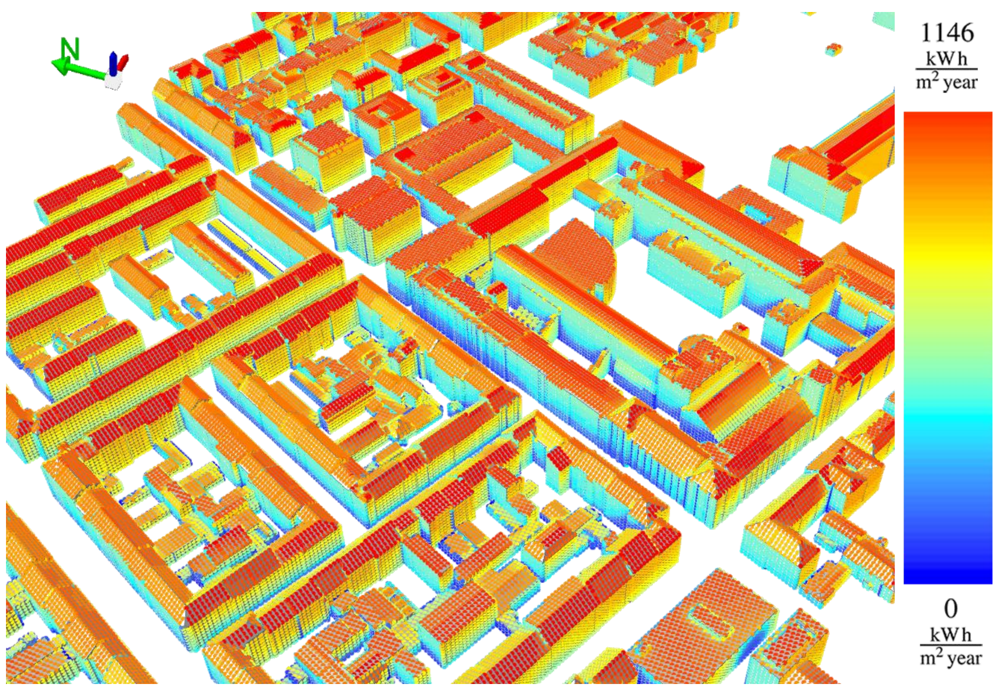

Figure (3). Illustration of yearly global irradiation sum for the building facades, as seen in the web mapping application (image taken from https://mediatum.ub.tum.de/node?id=1348882)

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France (part of Rennes Métropole), that integrated time-dependent properties with a semantic 3D city model - in this case the values of a solar potential analysis for the period of a year.

The CityGML dataset was enriched by solar irradiation values computed by a Solar Potential Analysis tool. The simulation tool estimated the solar power from direct, diffuse, and global sunlight irradiation for individual months of the year. The Dynamizers then allowed the monthly solar irradiation values to be represented within the CityGML dataset, which readying it for visualizations and simulations. For visualization, a web mapping application was developed that allowed interactive exploration of the 3D buildings and solar irradiation values (see figure 3).

Dynamizer: Enhancing City Models With Dynamic Data

Scenarios 3 & 4 both made use of OGC's 'Dynamizer' CityGML Application Domain Extension, which allows the modeling and integration of dynamic properties within semantic 3D city models. As shown in figure 4, the dynamizer serves three main purposes:

1. Dynamizer is a data structure to represent dynamic values in different and generic ways. Such dynamic values may be given by tabulation of time/value pairs; patterns of time/value pairs; by referencing an external file. These values can be obtained from sensors, simulation specific databases, and also external files such as CSV or Excel sheets.

2. Dynamizer delivers a method to enhance static city models by dynamic property values. It references a specific property (e.g. spatial, thematic, or appearance properties) of an object within a 3D city model and provides dynamic values that override the static value of the referenced object attribute.

3. Dynamizer objects establish explicit links between sensor/observation data and the respective properties of city model objects that are measured by them. By making such explicit links with city object properties, the semantics of sensor data become implicitly defined by the city model.

In this way, dynamizers can be used to inject dynamic variations of city object properties into an otherwise static representation. The advantage in using such approach is that it allows only selected properties of city models to be made dynamic. If an application does not support dynamic data, it simply does not allow/include these special types of features.

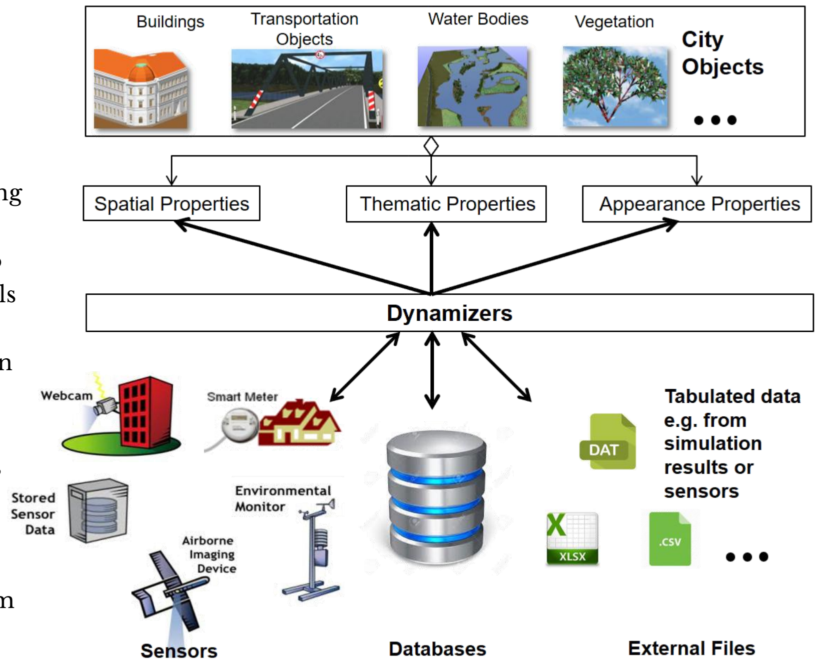

Figure (4). Conceptual representation of Dynamizers (image created by Thomas H. Kolbe, Technische Universität München - Runder Tisch GIS e.V.)

Dynamizers therefore pave the way for existing 3D city models to move from representing static built environments to becoming models of 'living cities,' enabling decision makers to view their city model not just in space, but also time. This is the continuation of GIS moving from 2D maps, to 3D models, to 4D models, and paving the way for the next step in the evolution of city management: 4D predictive city models.

Applying the Outcomes

The Future City Pilot Phase 1 successfully demonstrated how the use of open data standards can provide stakeholders with information, knowledge, and insight that improves financial, environmental, and social outcomes for citizens living in cities, in turn making urban areas more prosperous, inclusive, sustainable, and resilient.

OGC firmly believes that open standards will play a crucial part in the adoption and success of smart applications in the cities of the future, and hopes that the demonstrations that formed Phase 1 of the Future Cities Pilot will serve as a 'blueprint' for other cities around the world to base their own 'smart solutions' on.

Phase 2 of the Future Cities Pilot will continue to focus on the convergence of Geospatial, Civil Engineering, and BIM, and will additionally demonstrate applications for facility management and indoor mapping. Phase 2 will continue to improve the interoperability between IFC and CityGML. If you have a spatial problem that you would like Phase 2 to examine, or if you're interested in learning more about how 3D city models, CityGML, or any of OGC's standards can benefit your city or organisation, contact the OGC at www.opengeospatial.org/contact.

The outcomes of the Future City Pilot, including a summary video, engineering reports, examples of best practice implementations, and more will soon be available for free at www.opengeospatial.org/projects/initiatives/fcp1.

Reference

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