The spatial brain – a GIS approach

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Abstract

The human brain is a remarkable organ and can, for instance, process large volumes of information in a short time span. As an example, when reading a book without illustrations, the brain has the ability to visualise what is described and create a picture. In much the same way, it can interpret maps and produce directions from point A to point B, effectively transforming the picture into words.

The use of maps with a navigation tool (GPS) to assist with decisions for the best route to follow is a familiar concept in today's time. For this, a road network is applied. Within engineering infrastructure (e.g. telecommunication and electricity networks), a map is required to visualise where all network assets are located, as well as to understand how to perform relevant operations without being physically next to the asset. A spatial resource planning tool, which in this context can be called the spatial brain, will enable the average person to visualise and interpret such networks. This visualisation includes not only a map of the network, but also adds the capability to inspect the real world object and its behaviour over a required timespan.

The spatial representation of data becomes a powerful tool in this context. Different roles within a company have different needs to visualise the same picture from different angles. This paper will explore these different angles, and explain how the spatial brain can evolve by doing spatial harvesting on the company's data. This harvesting will lead to the expansion of information, and improved decision making on many business levels.

Keywords

spatial, geographical, context, effective, supportive, Smallworld, GIS, benefits, mannerisms, simulation, translation, intelligence, harvesting, behaviour.

Introduction

The human brain is powerful as the evolution of human beings already attests. Considering that the physical brain can evolve in this way, the evolution of human behaviour and consequently how human behaviour can develop from spatial systems follows. This closed-loop process creates new ways of thinking and spatial patterns, which then evolves into new thinking mannerisms. These developments trigger new business enactment and benefits out of these new patterns. These ultimately lead to better decisions based on well-established information.

What if the world was a complex setting where there was always only a single solution to a specific problem? In the past, this question wouldn't have been possible to ask, for there was only one solution to a problem. Consider the example of how to travel from point A to point B. The answer was simple – just take a walk. Today, the options are much more varied. There is a myriad of solutions to the same problem. Man can now travel from point A to point B by car, train, and plane. Or one can still put on your walking shoes.

How then should companies apply spatial mannerisms in such a way that there can be more than one solution to a specific problem, and yield more positive results from the problem than just a final solution? Continuously applying what was learnt from mannerisms and trades, or measured from the previous round of obstacles, is essential.

The need for evolutionary thinking and behaviour grows more important than in the past. Consistency of systems, such as telecommunication and electricity systems, is an essential need in modern life. Without these systems, the human race is severely restricted. A few decades ago, the only channel of communication was the telephone handset. Today, solutions for telecommunications are legion. Wireless facilities serve the needs of a broader market. When will the full potential of the telecommunication industry be reached? Currently this question is rhetorical, but perhaps in the future, communication needs will grow to such an extent that entirely new solutions will be created, so that the human race will have the ability to communicate with brand new technology. The human mind should gather data and form information patterns so that the skill exists to enable systems, such as a telecommunication system, to evolve beyond expectations.

To have the ability to expand beyond expectations, new tools are needed to assist the mind, to not only gather data, but to store such gathered information in a manner in which additional information can be harvested from the existing and co-existing systems in the same space.

Spatial behaviour and human behaviour – geographical information (GIS) approach

Why is a spatial brain needed in today's life? Fig. 1 below illustrates the components that are required to understand the relationship between the human and spatial behaviour, leading to the need for a spatial brain. This succession should be viewed as an infinite loop of evolution within the spatial brain and human mind. There will always be new needs, new mannerisms, and new behaviour that develop for spatial dependencies. The illustration will be discussed in the section below.

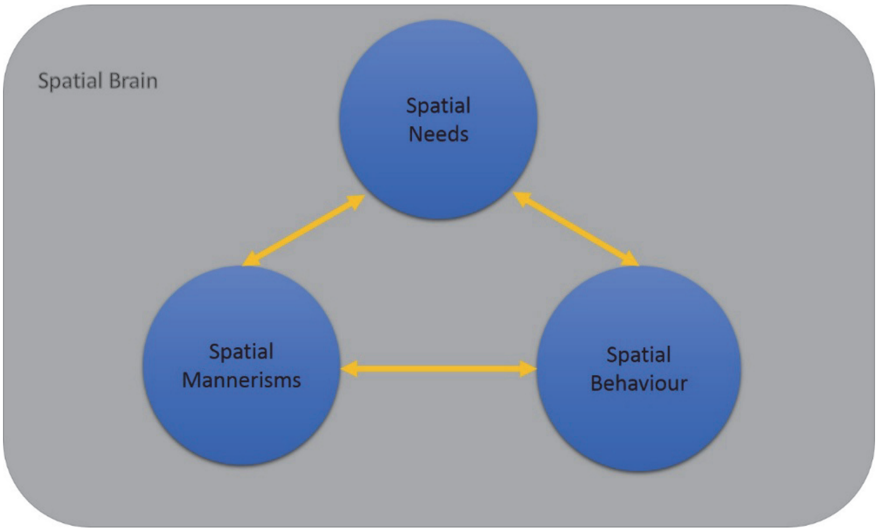

Fig. 1: Cycle of spatial/human behaviour.

Spatial needs in the business environment

Most people associate the term "GIS" with street map networks. Most people are familiar with street data displayed on Google Maps and GPS navigation devices, therefore the road network and the space which surrounds the street objects are known to most.

If one changes the space of familiarity for a moment, to make the space more business-like, and one enters the telecommunication environment, new object types appear and new network infrastructures co-exist. Objects such as underground utility boxes, conduits, buildings, and cabinets are all telecommunication objects. One of the needs within the telecommunication milieu is to have the ability to simulate the telecommunications network in a dimensional manner. This co-operative telecommunications network will interact with other co-existing networks, such as the previously mentioned road network. Direct visualisation of where certain telecommunications objects are situated will become vivid. The cables which run below and/or cross the road will have a clear identity. This is powerful data, especially for planning purposes within the business. One can now notice a manhole position on the road, requiring business processes to be activated, permission to be granted and safety process policies to be executed, should a worker need to enter the manhole for maintenance purposes.

The spatial brain, which is supporting the human brain, should not only have the ability to read spatial data as a two-dimensional representation of the real world, but also have the ability to present a simulation of real world objects, including their behaviour. Within infrastructural networks, the state of an object, including the object's characteristics, makes an object behave in a certain manner. The ability to do this allows the network to be effectively controlled and enables '*what-if*' scenario analysis to be done. The results of such analyses will influence business decisions dramatically.

Spatial mannerisms/behaviour

Discussing spatial objects, we can immediately identify and say that these objects take up space. They have both content and position. With this concept in mind, the human brain can define what the object consists of and what purposes it serves. If it is not the first occurrence for the object to represent itself, we can describe it and analyse what the purpose is. For example, a world map is a two-dimensional object which contains points, lines, and polygons, representing real-world objects such as cities, roads and continents, and preserves the relation to space with other real-world objects.

The way in which certain objects behave within their environment forms an essential part of the perception of the object – how spatial data behaves within the space, and all the components that surround the object. From this, we can directly grasp the benefit of spatial information. The mind has the ability to simulate and attend to the behaviour of a real-world object on a computer system and can manipulate the data with the click of a button.

Spatial data and controlling of information requires data to be presented and maintained in an effective manner. It should always contain reliable information, otherwise the spatial brain will adapt erroneous behaviour.

The human brain is dependent on receiving accurate information to process in order to reach a correct result or output of a process, and the same dependency is valid for the spatial brain. The spatial brain needs correct, adequate information to have the ability to transform information into a result which is accurate and sustainable.

Mannerisms and behaviours are dependent on information processing. If the data is entered incorrectly, then poor information is the result.

The spatial brain

The average human brain does not have the ability to recall spatial networks and make decisions based on what has been recalled. It depends on what type of spatial context is needed to be recalled. Identical information can have diverse results, depending on the need and reason of stored information. The user of the spatial tool should decide what the reason is for interrogating the spatial data. Certain behaviour can be executed on spatial information by calling functionality of the spatial tool, and analysis of the network should return results that are needed as output.

Fig. 2 illustrates the ability to analyse and manipulate data in different protocols. The tool is GE Smallworld Network Viewer, and data used in the illustration is based on a telecommunication environment.

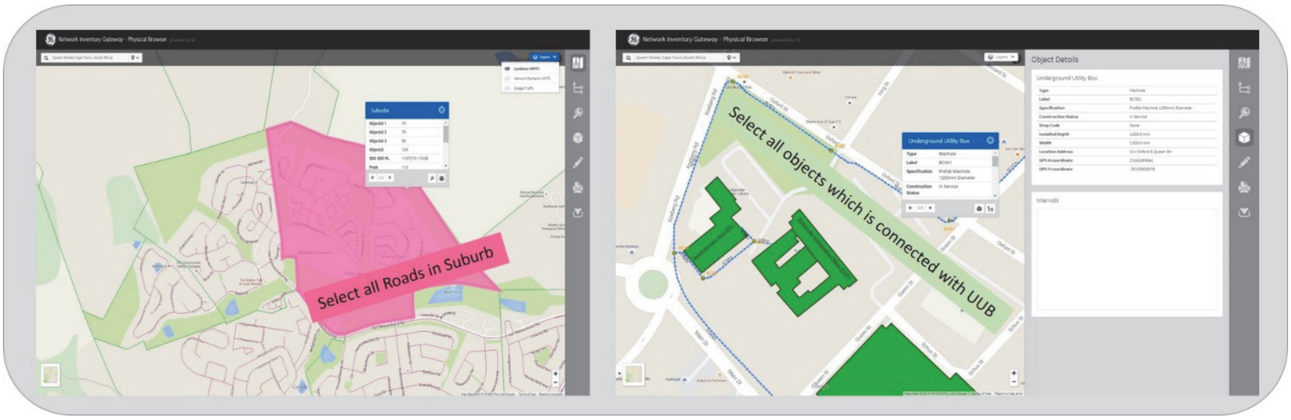

Fig. 2: Spatial queries and connectivity queries.

Selecting all roads within a suburb is a typical GIS query, which will search for all the roads within the selected suburb. This query output is spatially based, meaning that the result is purely dependent on the objects' location.

Selecting all objects which are connected to underground utility boxes (UUB) is a more advanced query which uses connectivity rules, which implies that a spatial tool is not only about location. It also has the ability to manipulate data in ways of mannerisms, behaviour and rules of how certain objects interact with others.

By understanding spatial mannerisms and the behaviour of objects of the real world, the need for a spatial tool within the business become clearer and can therefore be defined. The spatial tool is there to support decision-making and can give results to support a decision.

Evolution of the spatial brain – spatial elements

The spatial brain approach has a huge significance in the evolution of GIS. Although we recognise it as a tool, we need to see the influence it has on human behaviour, and the support it gives for new needs and new mannerisms in the human mind. Fig. 3 shows some aspects of spatial mannerism which can be derived from human and spatial behaviour. The pyramid illustrates the importance of elements that are part of the spatial evolution – working with a bottom-up approach to develop spatial mannerisms for simulating the differences between spatial patterns and the spatial mind inside a GIS environment.

The spatial elements will be discussed and analysed in how the spatial components are intertwined and used, so that optimal results can be delivered, and re-used to produce new spatial information.

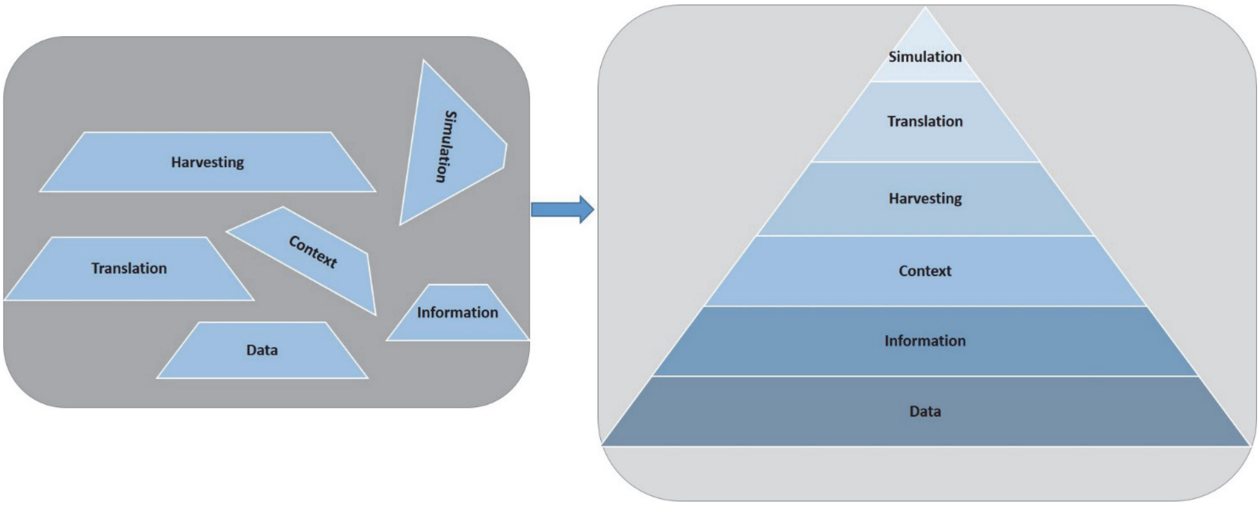

Fig. 3: Spatial elements.

Spatial data and information

Gathering of spatial data is an on-going process, together with generating information from the gathered data. The difference between spatial data and information lies in the uncertainty over which data will be useful for the specific business milieu. As soon as data contributes positively to the business and its needs, we can refer to it as information.

Spatial data is data with direct or indirect reference to a specific location or geographic data. To have the ability to analyse spatial data is to make use of a spatial resource system, better known as GIS. GIS can be seen as the translator of spatial data into spatial information. Whatever data can be input into the GIS can be processed to give a result to the required resource.

Spatial information which is supportive of business decisions is expensive, in the sense that it needs to be maintained and updated in a frequent manner. Fig. 4 illustrates a number of datasets that can be used within the spatial environment.

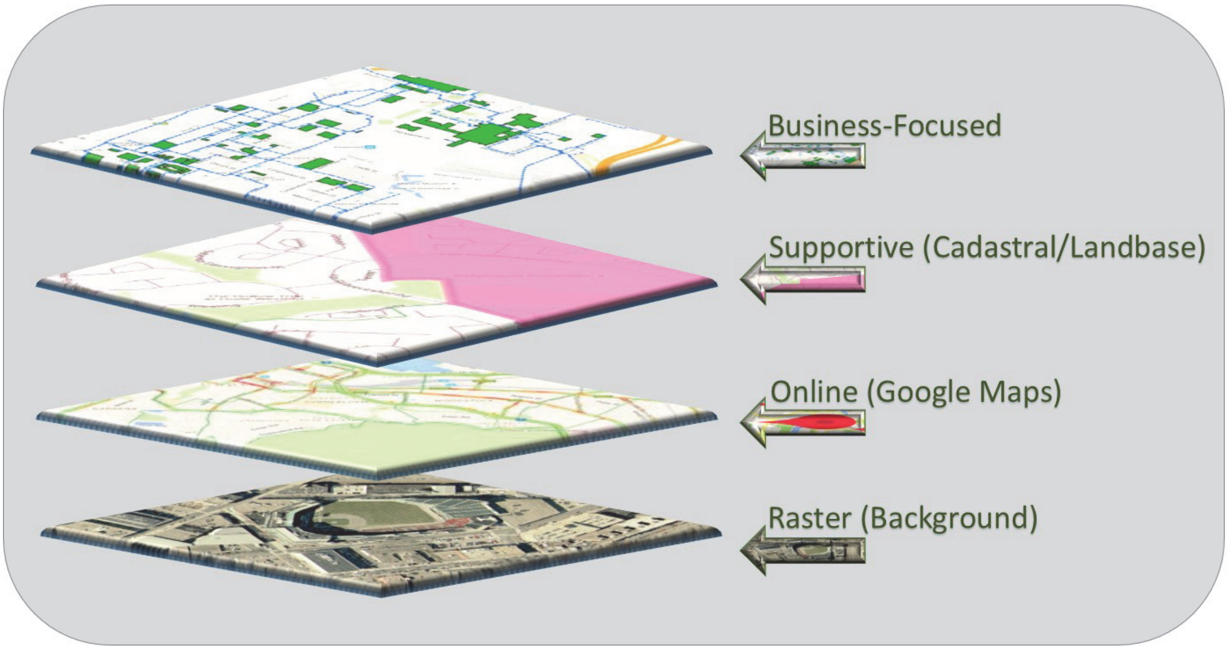

Fig. 4: Spatial data layers.

Explanation of these data layers are as follows:

- *Raster data*: Imagery from satellites, digital pictures, scanned maps or digital aerial photographs, for viewing and referencing only. This is mostly purchased from a third party, e.g. SPOT 5 imagery. A raster layer also exists in Google Maps, although a problem here is that these can only be viewed online.
- *Online supportive data (Google Maps)*: Provides directions and interactive roadmaps of certain areas of interest, such as cities in South Africa. Additional information is also available, e.g. traffic flow. It is dependent on an internet connection for use. Some business cases require additional offline supportive data, and should be provided as such.
- *Supportive* (*e.g. cadastral/landbase data*): This is a vectorised set of data, which is focused on showing boundaries for properties, roads, rivers etc. This dataset is available from external companies and is usually purchased and not captured by companies themselves.
- *Business-focused data*: This is business specific vectorised data to be captured. For example, telecommunication-specific data should be captured in a telecommunication-specific data model.

If the above-mentioned types of data sources (there may be more), are well maintained and implemented in a standardised manner, then information retrieved from these data sources will add even more value, and will result in a reliable GIS for all day-to-day use by all users. There will then be more aspects in the business which will turn to GIS for business planning and decision making. Data and information is the most crucial component within a spatial solution product. Without data, there is nothing to manipulate or view.

Spatial context in the business environment

Spatial context refers to how spatial data should be represented in a definite space. Spatial thinking plays a major role when observing how to represent spatial information. Spatial needs have to be taken into consideration. As the environment evolves, the context of spatial information should expand, subject to the needs of new representation of the data.

Behavioural, physical and cognitive space needs should be considered and understood when context and data angles are defined. It is essential that the information is understood and the benefits known for the setting to be efficient in the business environment. Data consumption can be a costly process, and great consideration needs to be taken.

The benefit of spatial context is that the representation of data may contain different angles/dimensions for the same information. The spatial user can now have alternative ways of looking at the data and obtain information to support decision making. Fig. 5 shows an example within the telecommunication setting.

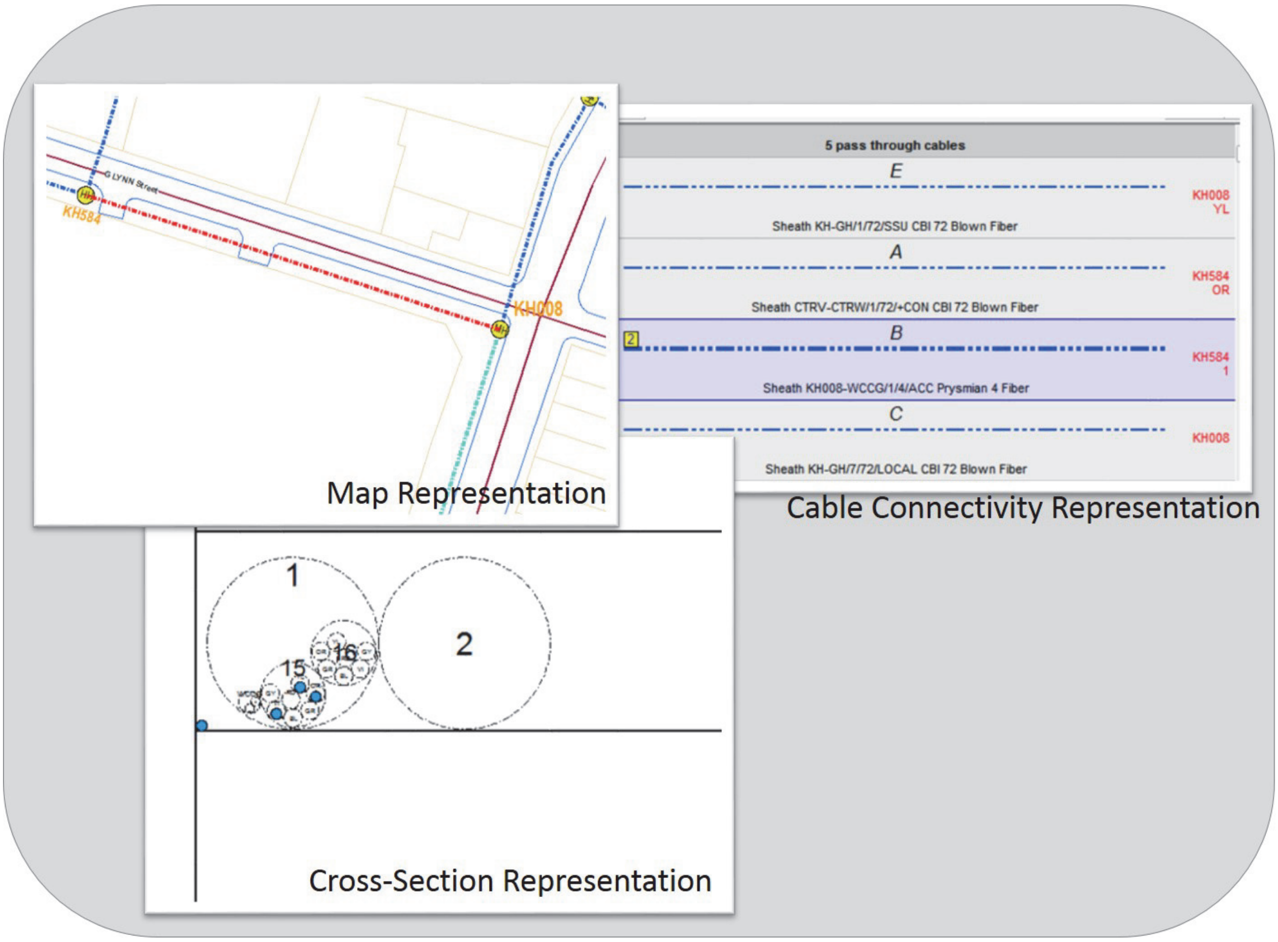

Fig. 5: Spatial context (cables).

A *map representation* is typically seen on a map-based view. This view may contain supporting layers of data, e.g. Landbase data, including the following examples:

- *Cable connectivity representation*: shows a schematic representation of a cable connectivity a structure.
- *Cross-section representation*: shows placement of cables within conduits and the trenches.

Different angles of the same data are therefore represented, allowing for decision making on different levels. For a user that needs to do route planning for a conduit, there is no direct need to see the cable connectivity or cross-section, but this information can assist in making decisions regarding which type of conduit should be used.

To be able to view spatial context in this manner, a well-defined data model as well as a spatial tool is needed. Smallworld, a GE spatial tool, has well-defined products which support the telecommunication-driven environment as well as other infrastructure utilities, including most engineering infrastructures. To keep things simplistic, only the telecommunication products will be described.

Examples of products within the telecommunication market are as follows:

- *Physical network inventory (PNI), logical network inventory (LNI)*: These two products give the telecommunication business the power to capture data in a well-defined telecommunication data model. They are "off-the-shelf" products, but customer development can be done on these products as well.
- *Network Viewer* is a web-based application which has the ability to view PNI-data model through the web. The application supports field engineers, who have to perform inspections on-site, and can also send updates directly to the PNI-data model via red-lining etc.

Spatial context abilities are influential. Different angles on the same data, and the relationship of these angles with the surrounding data can be viewed. A powerful spatial tool can translate spatial context resulting in outputs for managerial purposes. Reports and workflows can then be activated within the application.

Spatial data harvesting for GIS

The concept of spatial data harvesting is to derive other data from already existing data, and the ability to use this data, especially for data visualisation. Spatial data harvesting offers great benefits for GIS-based applied decision making. New spatial patterns (organising and placement of people and objects in the human world) can be visualised and these new patterns can lead to a new dimension of the already existing data.

The most important aspect of information is that it needs to be understood and analysed as to how it fits within the existing business patterns. Failing this, it will never turn into business information, nor will it be able to support other types of data. Spatial databases tend to be very large and expensive to maintain. Data which overflows must be removed, for the mere reason that it does not support the business. As soon as irrelevant data in the existing database is harvested, it generates more garbage data. The term, "garbage-in, garbage-out" *(GIGO)* comes into play. An example of data harvesting in the engineering environment, is where schematic diagrams are needed for reviewing layouts and connections within buildings/substation.

A schematic diagram is a representation of the elements in a system using abstract, graphic symbols rather than realistic pictures. A schematic usually omits all details that are not relevant to the information it is intended to convey. Within the GIS all information already exists, but in more detail. The GIS map in Fig. 6 shows the view of the real world, coordinates and curves in the cable, from point A to point B. The schematic representation has been generated from the GIS data, and because of the application-based functionality, the behaviour and patterns of objects can be simulated and a schematic representation can be visualised and stored for future use.

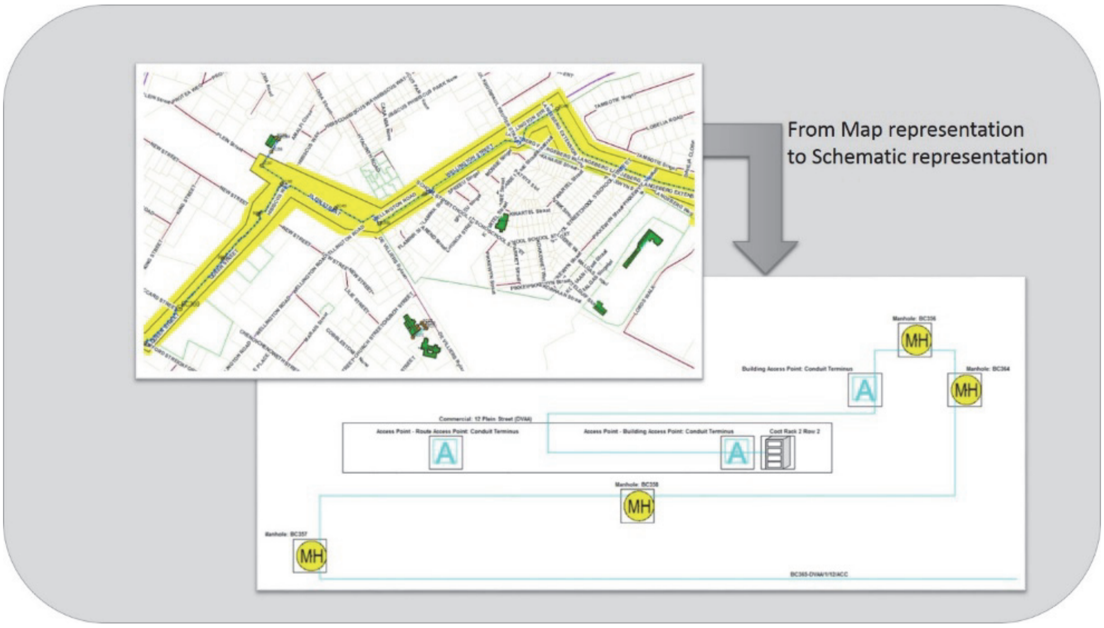

Fig. 6: Spatial harvesting (schematic generation).

Spatial translation and spatial simulation in GIS

Spatial simulation can occur when the behaviour of objects can be understood and translated into functionality within the GIS system. The concept of spatial translation is how the spatial data behaves when certain spatial rules are applied. These include business rules, connectivity rules and attribute values.

Engineering applications can effectively use the pre-process phase to filter out the data types to be translated, thereby optimising the performance of the entire translation process.

Smallworld has a product designed to support the fault management process by helping field engineers to find faults quickly and accurately. The Fault Locator tool accesses the telecommunication-based data model (Physical Network Inventory or PNI), and has the ability to simulate how the current state of the network should work. In the example illustrated in Fig. 7, it queries (translates) results of an optical measurement device to pinpoint an accurate geographic location of fibre breaks. This will not be possible if the rules and attribute values are ignored. It can then simulate what should be, against what is.

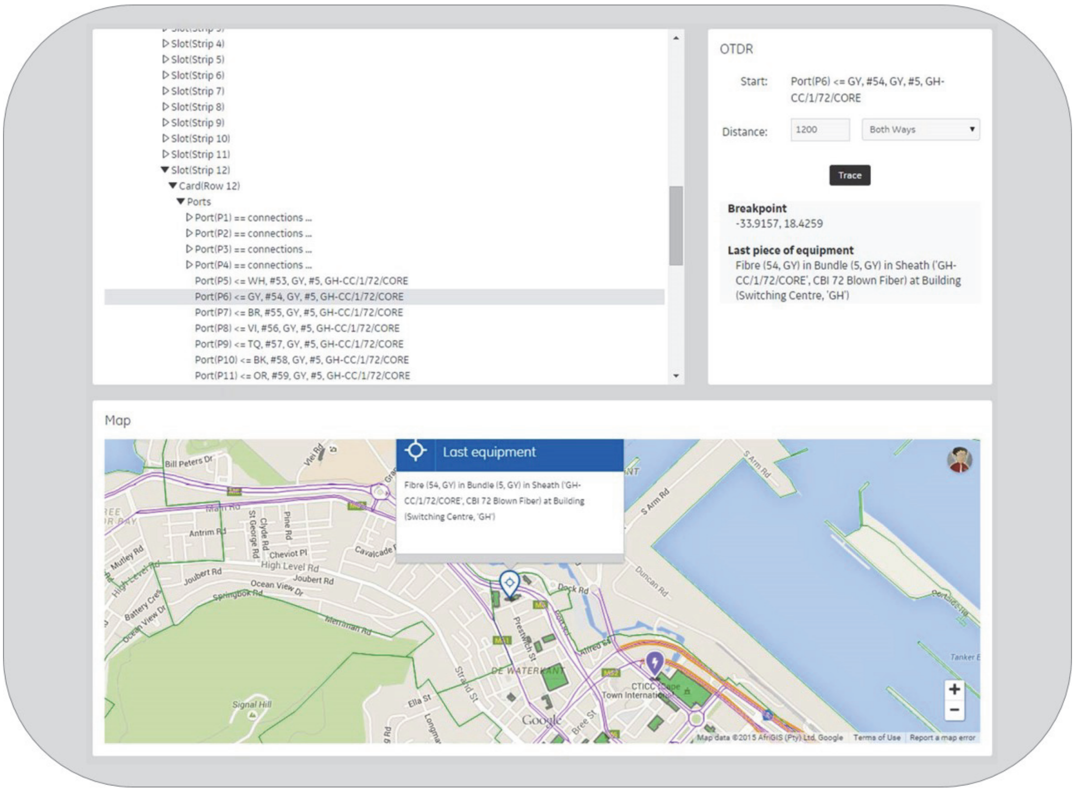

Fig. 7: Simulation effect.

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