How to assure the quality of services of an SDI

Methodologies and tools to assure the quality and reliability of spatial web services in a Spatial Data Infrastructure

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Summary:
The volume of data devoted to Spatial Data Infrastructures in many countries around the world is certainly following the macro trends of the increasing use of geo-localization services and its applications. Since the information accessed quite often is crossing borders, be for climate forecasts, transportation routes or even for emergency response to natural disasters' reasons, the interoperability of those systems is a key factor in their creation, applicability and maintenance. In the level of the European Community, the INSPIRE Directive is a good example to ensure that spatial data services and data sets are created/converted to interoperable.

Spatial information is not only part of national SDIs, but it is also present in many other living aspects of a regular citizen day. The fact that hardware and software components of an SDI is usually manufactured by various vendors, brings an extra technical concern to the table, once these components mostly need to communicate smoothly, helping the overall service health be kept up. However, powerful technical capabilities of components alone is not enough to guarantee a high quality and reliable SDI.

To establish a reliable SDI, measuring, improving and communicating information about the Quality of Service level is a key success factor. The criteria should include availability, performance and capacity of the SDI components. Having said that, the big challenge has been to develop a standardised way of communicating the expected Quality of Service level to the end users.

Methodologies and tools discussed here aim to solve the issues above by:

- Testing the capacity of services to meet requirements (like INSPIRE View and Download Services);
- Keeping track of uptime and performance;
- Identifying trends affecting service level and availability;
- Validating the service through the check of the capabilities document against INSPIRE and OGC Standards;
- Establishing thresholds for indicators and setting up alerts and warnings;
- Measuring the impact of implemented improvements to end users and;

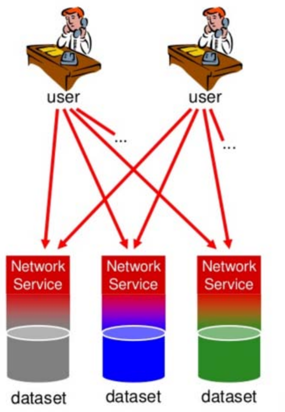
Concluding, by doing fine-tune adjustments to the infrastructure according to the findings discussed above, will lead to an effective optimization of investments in the SDI, which ultimately brings more development to the related region.

PALAVRAS-CHAVE

SDI, spatial web services, interoperability, quality of service, reliability of service, performance of service, web map service, web feature service, ArcGIS MapServer REST, OGC, INSPIRE

INTRODUÇÃO

The volume of spatial data collected keeps increasing rapidly with ever more powerful and more detailed ways for observing and simulating our environment and the human behaviour. Continuously available Spatial Data Infrastructures (SDIs) are required to create usable information from the vast amount of data by effectively querying and using it from a site possibly located on the other side of the world. A good SDI makes it possible to discover, filter, acquire and interact with spatial data required for a particular use case in a reliable, efficient and easy-to-use manner. A good example of this is the Infrastructure for Spatial Information in the European Community (INSPIRE), which legally mandates the EU member states to ensure that spatial data services and data sets are interoperable (Picture 1) within the European Community.



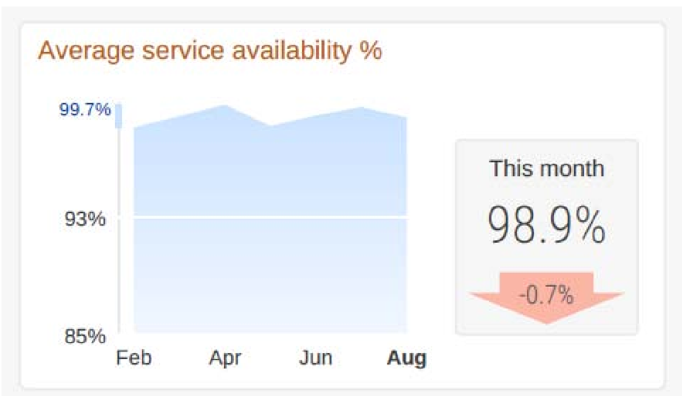
Picture 1: Interoperability scheme

Large scale Global and national SDIs are not the only technical environments, where up-to-date spatial data needs to be reliably available at all times. Spatial information is also a fundamental part of room, household, vehicle or office scale sensors and control networks taking an essential role in the Internet of Things (IoT). Keep the service health up (Picture 2) is very important in this kind of networking environments, where hardware and software components manufactured by different vendors need to establish ad hoc connections, discover the capabilities of each other and communicate mostly in an automated manner.

Service health	Now: ●	Last 7 days	Year 2017
Availability		100%	100%
Total downtime		0 hours	0.1 hours
Pre-announced service interruptions		0 hours	0 hours
Unexpected downtime		**0 hours**	**0.1 hours**

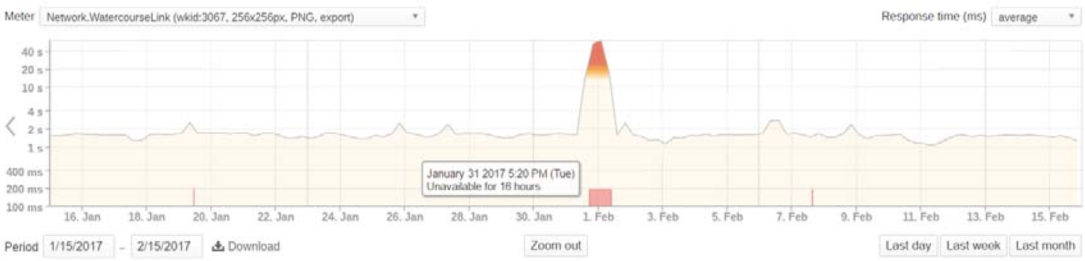
Picture 2: Service health

The technical standards aiming at increased interoperability of spatial data, services, and applications created by OGC and INSPIRE form a solid base for well-functioning Spatial Data Infrastructures. However, the technical capabilities of a particular software and hardware components alone is not enough to guarantee a fully functional and reliable distributed spatial data infrastructure. Even the most interoperable and advanced SDI components can be configured and connected sub-optimally, making their use difficult, inefficient and unreliable as parts of an SDI. As within any computer system, the SDI components and the networks connecting them also occasionally suffer from technical failures, which temporarily renders them unusable or unreachable for all or some of the users. The field of Quality of Service (Picture 3) deals with estimating, reporting and improving the experienced quality of communication between the components of distributed systems to inform users leveraging their capabilities to solve real-world problems.



Picture 3: Quality of Service

To establish a reliable SDI, measuring, improving and communicating information about Quality of Service criteria is one of the key success factors. These criteria include availability (Picture 3), performance based on the response time (Picture 4) and capacity (Picture 5) of the individual SDI components. Mature tools for measuring analysing the QoS of these do exist, but there is little to no support for a standardised way of communicating the expected QoS level of the services to the end users.



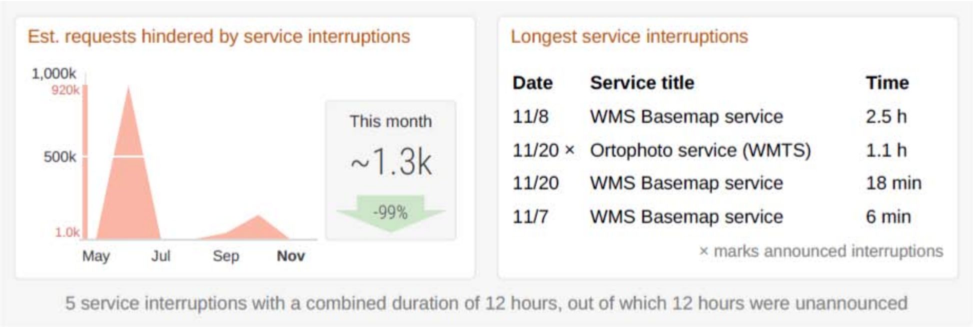
Picture 4: Performance of a service based on response time

Methodologies and tools exhibited here aim to solve the issues above by:

- Testing the capacity of services by generating realistic loads of requests per second, ranging from light to heavy use (Picture 5), so that bottlenecks can be identified and removed, and services can be prepared and modified in order to meet capacity requirements like those defined for INSPIRE View and Download Services. The tests typically send thousands of requests to the server(s) under test within a relatively short period of time. The requested area of the place-related requests, like the ones using WMS GetMap or WFS GetFeature operation, is varied from one request to another to ensure realistic test data results. The variation algorithm leverages the technology of generating requests in a way that the request area variation helps to verify the functionality and efficiency of any caching or tile pre-calculation scheme that has been configured to improve the service performance;

Picture 5: Test of capacity using realistic loads

- Keeping track of uptime by registering the service interruptions (Picture 6) for the services in the range as well as looking at the number of requests that were hindered due to service interruptions shed some light to the level of the quality of the service delivered to users;



Picture 6: Keeping track of uptime

- Identifying trends affecting service level and availability (Picture 7). By combining the information of most popular services with the ones with biggest changes in speed for the same period, you may find associations that can help to take more effective decisions finding from where the issues are coming;

Most used services

Service title	Requests	Users	Transfer	Type	Service ID
National Mapping Agency basemaps	22M	62k	51 GiB	WMTS	#1
NMA Ortophoto service	1.5M	5.1k	2.4 GiB	WMS	#2
NWA combined for mobile access	251k	1.3k	431 MiB	WFS	#3

Services with the biggest speed changes

Compared to Oct 2015

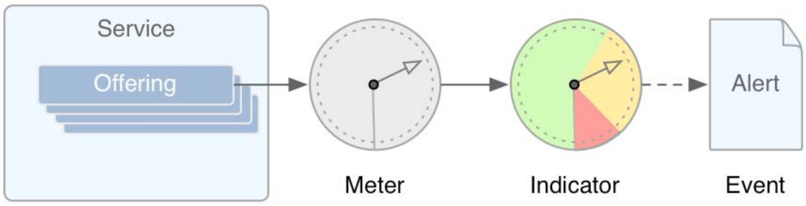
Service title	Response time		No. of users	
NMA Ortophoto service	460 ms	-7.5%	41k	+5.4%
National Mapping Agency basemaps	2 sec	-6.1%	16k	-2.1%
NWA combined for mobile access	252 ms	-1.1%	16k	+10%

Picture 7: trends in usage affecting service level

- Validating the service capabilities document against INSPIRE and OGC Standards (Picture 8). Validation is embedded for use for WMS Implementation Specification v1.3.0, WMTS Implementation Specification v1.0.0 and INSPIRE View Services v3.1. Validation test suites for compliance with other OGC specifications are available at http://cite.opengeospatial.org/teamengine/. These are included for the relevant parts in the new INSPIRE validator at http://inspire-sandbox.jrc.ec.europa.eu/validator/ (work in progress);

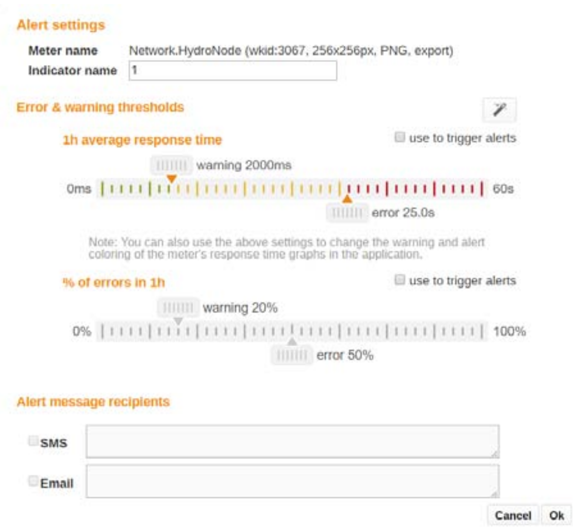
Picture 8: Validation against OGC and INSPIRE

- Establishing meter thresholds for indicators (Picture 9). Each organisation typically has their own thresholds for the Quality of Service of the services they use, whether the services are owned by themselves or provided by external parties. The follower organisation specific response time and error amount thresholds for a service are specified by an indicator. Indicators take the monitoring information produced by one meter, and derive the value for the current Quality of Service status for the service based on the monitoring results produced by that meter.



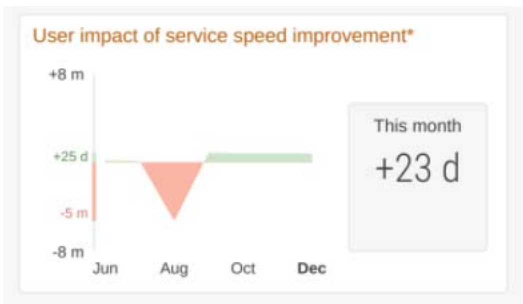
Picture 9: Service meters and indicators

- And setting up alerts and warnings (Picture 10). When an indicator changes the Quality of Service status of a service from "OK" to "Warning" or "Error", it creates an alert and records this alert event in the monitoring database.



Picture 10: Alerts and warnings for service-level indicators

- Measuring the impact of the implemented improvements to end users: One useful measurement that can be made after the implementation of a change which is expected to improve the speed of the services is the impact of saved time by users of the service or group of services included in the count. In the picture (Picture 11) below we show the difference of a particular month to the previous 6-month average response time multiplied by the monthly requests, counted for all services included, e.g. The results can be incredible;



Picture 11: Time saved by users

As conclusions, the Quality of Service can be maintained as high as reasonably possible by implementing some fine-tune adjustments to the infrastructure, based on the information generated by some intelligent analysis of both the performance and usage of the services combined, as the findings discussed above. Also, the utilization of customized reports and dashboards with easy and friendly visualization of indicators by the management level, aligned with the overall strategy of the organisation, can lead to a virtuous loop of optimization of investments for the SDI in an automated fashion, generating benefits to internal and external, private and public users, ultimately bringing more development to the correspondent city, region or country.

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