IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Remote monitoring system of the Ob River

To cite this article: R S Vorobyev *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **232** 012019

IOP Conf. Series: Earth and Environmental Science 232 (2019) 012019 doi:10.1088/1755-1315/232/1/012019

Remote monitoring system of the Ob River

R S Vorobyev[1], S N Vorobyev[1], O S Pokrovsky[2], A A Poguda[3]

[1]Ecology and biodiversity laboratory, Tomsk State University, Lenin Avenue 36, Tomsk, 634050, Russia
[2]Géosciences Environnement Toulouse, UMR5563, IRD UR 234, Université Paul Sabatier, 14 Avenue Edouard Belin, Toulouse, France
[3]Faculty of innovative technologies, Tomsk State University, Lenin Avenue 36, Tomsk, 634050, Russia

E-mail: tsu@erd.su

Abstract The paper describes the remote monitoring system of water bodies that consists of three parts: the central controlling server, stand-alone sensing devices and applications to control devices and processing the collected data. The control server provides API for data access and implements flexible access policies to the system and all collected data. Stand-alone sensing devices accumulate the measurements made and send them at certain intervals to the control server by means of wireless connection via GSM network.

1. Introduction

The main part of the river basin (about 85%) is in the West Siberian Plain. Its average long-term run-off is 405.0 km^3 [1]. Its hydrographic network is a unified system of geochemical migration of matter and energy in the area. The main part of the hydrochemical flow of the Ob is formed on paludified watershed areas during snow thawing [2]. Chemical elements in the snow are accumulated mostly from the air. The input of snow flow into the river flow can be more than 70% for some elements. The aerial flow component is 37.4% for macro-components (Ca, Mg, Na, K, Fe, Mn) and for organic carbon it is 16.3% **[3].** During other periods chemical water load on the river is 2-3 times lower than during spring snow melt flood [4, 5]. During summer and autumn the flow has minimum concentrations of biogenic elements (i.e. nitrate nitrogen, ammoniacal nitrogen, and total phosphorus). In the Ob basin, there are around 150,000 rivers, which are diverse Ob tributaries [6]. All natural processes in the area are reflected in the hydrographic network. The water in the tributaries is sensitive to any changes in the landscapes and delivers the substance and information about these changes to the main river in the Western Siberia – the Ob. Each tributary characterises a particular part of the area [7]. This peculiarity of the hydrographic network is used to analyze the global processes [8]. Monitoring water bodies of the river network provides the information about the processes going on in the Western Siberia.

It is necessary to create an observation system to monitor water bodies, i.e. to install the equipment in the tributaries that give much information about the processes taking place in the area. Unfortunately, most part of the Western Siberia lacks road network and is difficult to access. Therefore we need a remote monitoring system to collect the data, transfer them through communication channels, process and present to users in a suitable form. The present work is aimed at developing a general concept of equipment and software for a remote water monitoring system.

We have great plans to deploy new monitoring stations and stand-alone sensing devices in the near future (Figure 1)

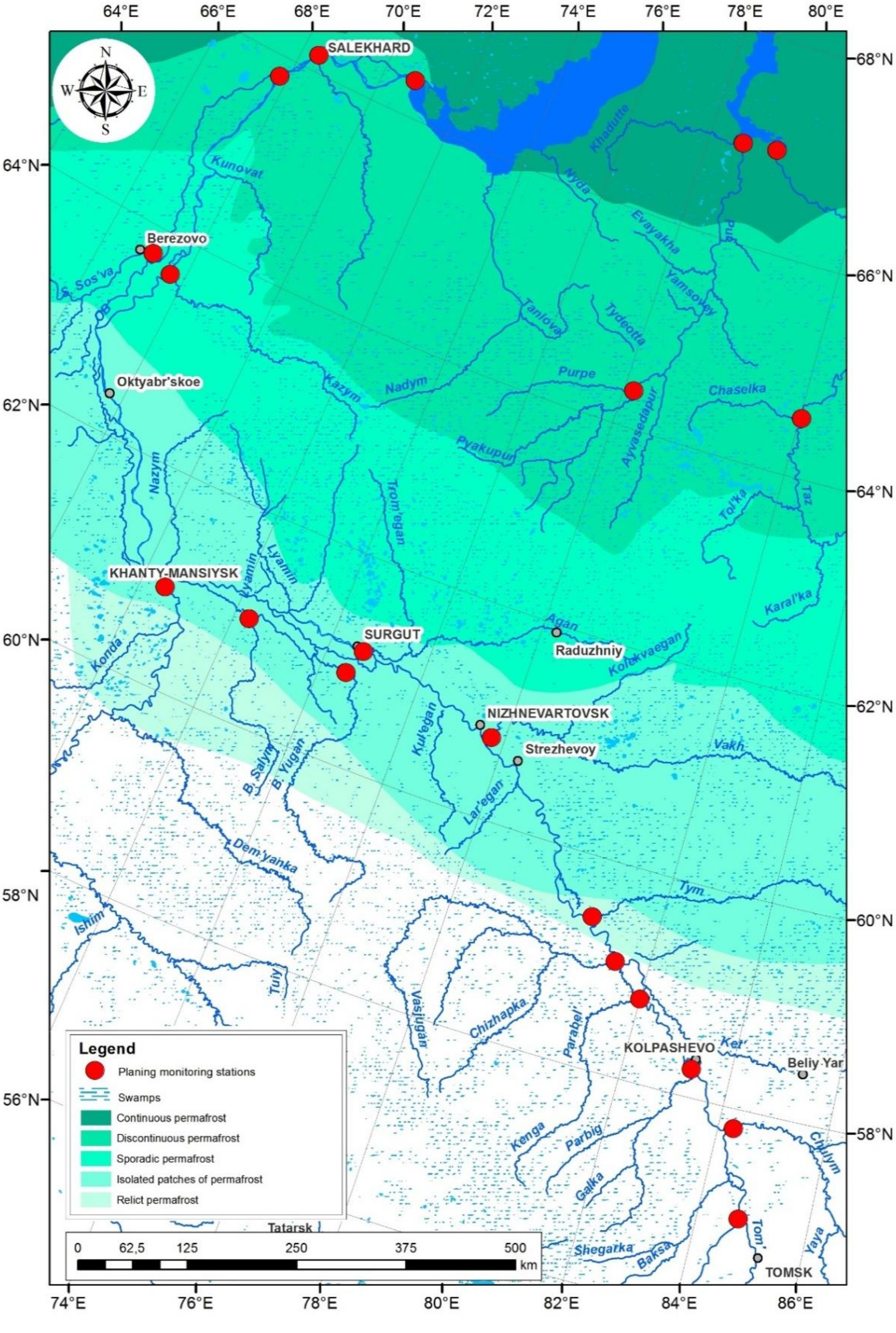

Figure 1. Planned observation points

The basic components of the system are to be determined, and a system draft is to be developed. The system should be multifunctional, easy to maintain and to tune to different sensors and be able to expand functions. Sensing devices should be stand-alone.

2. Materials and methods

We chose the board RobotDyn mega2560 pro mini based on the microcontroller Atmel ATMega2560 as a platform for a sample of a remote stand-alone device for a monitoring system. This board has all the advantages of ATMega2560 and a very small size - 5x5 cm. The board with all the modules was placed in a big watertight housing.

To measure temperature the digital devices ds18b20 produced by Dallas Semiconductor were used. They can measure temperature within the range from -55 °C to 125 °C. To measure pH and oxidation-reduction potential (within the range from -2,000 to 2,000 mV within the accuracy of ~10 mV) DFRobot electrodes were used. Dissolved carbon dioxide was measured by the MH-Z14A sensor with the range up to 5,000 ppm within the accuracy of ~50 ppm. The wireless connection module is based on the microcontroller Neoway M590E, which works in GSM network.

Apart from this, carbon dioxide was measured with Vaisala GMP-222 sensor. Dissolved oxygen was measured by a MiniDOT device with an optical sensor.

The system PostgreSQL 9.6 with the extension PostGIS 2.3 was used as DBMS.

The server part of the system was developed based on cross-platform application server Node.js.

3. Results and discussion

The system comprises 3 main blocks: stand-alone sensing devices; control server; a set of additional services and applications (Figure 2) [9, 10, 11].

Stand-alone sensing devices are intended to collect, accumulate and transfer the data obtained with the help of installed sensors. The set of sensors may be arbitrary. Both digital and analog sensors may be used. Our device includes digital sensors for temperature, pH, ORP, dissolved carbon dioxide and dissolved oxygen to observe water bodies. Such devices and be installed in remote places. They are easy to be moved from one observation site to another.

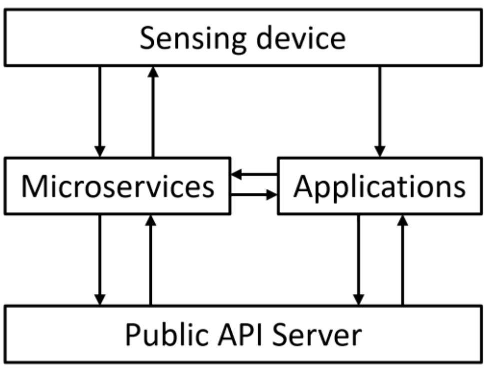

Figure 2. System architecture

An important element of the device is a wireless module. This module provides the connection between the device and a wireless connection microcontroller by means of a set of AT-commands, is registered in the mobile operator's network and connected to proxy-service. A special data transfer protocol apart from the usual TCP-connection is used. After establishing a connection to the device and determining its identifier the proxy-service translates the data sent by the device to API-calls to the controlling server of the system, sending there all the data received. In cases when wireless connection is not available, the data recorded by the device could be exported manually from memory card using a special application.

The server part of the system was developed based on the cross-platform application server Node.js. The access to control server was realized with the help of REST API [12]. In the described monitoring system the identification of requests to the server is realized due to a unique token accompanying each request, which helps to identify the user it belongs to; it triggers the list all the actions available in the system.

It is important to mention that as the access to API is regulated by HTTP protocol, the procedures of authentication and authorization are done every time HTTP-request is sent to the server [13].

Whether the device communicates with the controlling server through the proxy service or establishes a direct HTTP-connection and forms the request using API system is not important from the point of view of the controlling server. Everything depends on the proxy service realization and the degree of coverage of the implementation of requests to API.

The system supports two different device classes:
- devices that were originally developed to interact with this particular system, capable of establishing a direct connection to the central server and transferring data;
- third-party systems and sensing devices, which for one reason or another do not have the ability to interact with the central server directly (an unsupported protocol, or lack of wireless communication at all).

The monitoring system supports the differentiation of access levels. It is implemented due to the relationship between the entities, the user and the list of possible operations, which allows configuring a flexible access to certain operations within the system. Specific unique devices of different models can be combined into a single group, for example, by geographic location, or based on a semantic connection.

The system provided getting the continuous data on the dynamics of the temperature, oxidation-reduction potential, pH and the content of dissolved carbon dioxide and dissolved oxygen. The measurements were done in May 2017, during the flooding in the Ob basin. At the moment there are not many devices to provide the data in the system, which does not allow carrying out spatial operations on the data obtained [14, 15]. However, expanding the pool of measuring devices is just a matter of time. The next stage in the system development is going to be an implementation of spatial analysis of the obtained data to extrapolate the measurements from one site to other similar ones.

4. Conclusions

Thus, the general concept for the hardware, software and firmware of the remote monitoring system for water bodies was developed. The system consists of sensing devices, control server and a set of applications and services to control the devices and process the data.

Stand-alone devices work remotely. The connection with them is maintained by GSM networks at predetermined intervals. The primary sample of the system showed its multifunctionality. The system could support third-party devices and systems, which connection protocols are known. The system has an open data access protocol and provides a centralized access to the collected information as well as the possibility of public data access.

On the whole, the development of the remote monitoring system for water bodies is the first step on the way of automation of the processes of obtaining, processing and analyzing data from observable environmental objects. The work and fault tolerance of the communication protocol and data transfer between the stand-alone loggers and control server are going to be assessed in real conditions over a long-time interval. It is necessary to provide options for possible problems when placing devices on a wide range of different natural objects. Besides, the security connection model between the sensing device and control server needs further developing [12].

Acknowledgments

This research was supported by the RF Federal Target Program, project RFMEFI58717X0036.

References

[1] Rybalsky N G *et al* 2007 State Report On the status and use of water resources of the Russian Federation *NIA-Priroda* (Moscow) 408 (In Russian)
[2] Alenkin O A and Brajnikova L B 1964 Flow solutes from the territory of the USSR *Nauka* (Moscow) 144 (In Russian)
[3] Savichev O G and Ivanov A O 2010 Atmospheric deposition in the Middle Ob river basin and their impact on the hydrochemical river flow *Izvestia RAN* seria geograficheskaya 63-70 (In Russian)

[4] Temerev S V 2006 Assessment of the status of aquatic ecosystems to chemical stress *Polzunovsky Vestnik* **2** 185 - 90 (In Russian)
[5] Agafonov L I 2010 Flow Lower Ob and its changes in the XX century *News of Academy of Sciences. Geographical Series* **4** 68 - 76 (In Russian)
[6] Atavin A A *et al* 2000 Ob basin ed A M Cherniaev (Russia: River basins, Ekaterinburg: Aqua-n Press) vol 536 (In Russian)
[7] Black P E 1997 Watershed function *Journal of the American Water Resources Association* **33** 1 - 11
[8] Karen E F, Donald I S and Laurence C S 2007 Geochemistry of west Siberian streams and their potential response to permafrost degradation *Water resources research* **43** 1 - 15 W03406
[9] Rosenfeld L, Morville P and Arango J 2015 *Information Architecture: For the Web and Beyond* (4 edition) O'Reilly Media **486**
[10] Sharma U R 2017 Practical Microservices Packt Publishing **254**
[11] Vorobyev R S and Poguda A A 2017 *Innovatika-2017: XIII International School-Conf. of students, postgraduates and scholars (20-22 April 2017)* ed A N Soldatov and S L Minkov (Tomsk: STT) 352 - 5 (In Russian)
[12] Sheng M, Qin Y, Yao L and Benatallah B 2017 Managing the Web of Things: Linking the Real World to the Web, Morgan Kaufmann **482**
[13] RFC 2616 - Hypertext Transfer Protocol -- HTTP/1.1 https://tools.ietf.org/html/rfc2616
[14] Spatial Data Mininghttp://www.iasri.res.in/ebook/win_school_aa/notes/spatial_data_mining.pdf
[15] Obe R O and Leo S H 2015 PostGIS in Action (second edition) (Manning) **600**