Network proximity as a base for a new hyper-local Internet

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***Abstract*— The paper describes the model of hyper-local Internet. This refers to a set of Internet resources that are, to one degree or another, relevant (useful) for users located in a certain limited area. At the same time, such a network is not visible outside the selected area (it simply does not exist). This is another example of using the network spatial proximity model developed in the authors' works. As resources in such a network, there can be both specially marked existing Internet resources, and special content hosted on mobile devices participating in such a network. For example, these resources discuss the functioning of a housing complex, an educational institution, contain information about local services, etc. The paper proposes both a model for organizing the markup of such areas based on the use of wireless technologies and a scheme for describing (presenting) resources. Collections of this kind can be dynamically created and maintained by any user. The result of the work is a working prototype of a spatially restricted local area network running on mobile phones running Android. As a technical basis of the system, we propose a special model of using Wi-Fi Direct.**

***Keywords*—WI-FI Direct, network proximity**

I. INTRODUCTION

This work is an expanded and revised version of the report at the DCCN-2020 conference [1]. The paper describes one of the possible applications of the spatial network proximity model, which represents a new architecture for services that use location information. According to this model, work with geo-coordinates is replaced by a direct calculation of the proximity of the client to the place where the service (service, data) is provided. And as a measure of such proximity, a limited area of propagation of the signal of wireless networks is used [2, 3].

This work is a continuation of a series of articles on information services based on the concept of network proximity [4, 5]. We are talking about services for mobile users (that is, about mobile services), when access to any information is provided depending on the proximity of the mobile device (and, accordingly, the mobile user) to a certain selected point. As such a point acts as a node in wireless networks. It can be some fixed element of the network infrastructure (for example, a Wi-Fi access point), or it can be some node that is specially created (often dynamically) just to act as a reference node to represent such services. In other words, it is spatial proximity. But only instead of calculating the distances and evaluating whether to consider such a distance as close (small) or not (which, of course, depends on the service), the fact of physically limited signal propagation of wireless networks is used here.

Here is the distance over which such a signal extends and is considered close. This allows you to determine the proximity directly, without any work with geo-coordinates. It is a complete rejection of the calculation of coordinates that allows us to evaluate such proximity for arbitrary devices, including those created specifically for this type of task. For example, the position of a mobile device can also be estimated by the signals of wireless networks. But in all such cases, there is some previously known (prepared) marking of the terrain with affixed nominal RSSI signal strength values [6]. And the essence of navigation is to, compare the measured value of the signal strength with the reference values, to determine the deviation from the known coordinates of the wireless node [7]. Metrics that are used to determine deviations, methods of organizing and constructing such markups may vary, but the essence of the process remains the same - it is still working with geo-coordinates [8].

Why does the idea of not working with geo-coordinates come up? Here we can specify several reasons. For mobile services, working with coordinates is GPS systems. All the rest is just GPS refinement and adjustment. Accordingly, the refusal to work with geo-coordinates is explained precisely by the shortcomings (problems) in using GPS. This is for example:

– Indoor services
– Ability to block signal (GPS spoofing)
– Cold start
– Measurement accuracy. GPS exists in two versions - military and commercial. In public services, a commercial version is used, and its accuracy can be significantly exceeded by other means
– Moving objects (coordinates are constantly changing)

Accordingly, for modern navigation systems using information about wireless networks, two points can be noted. The need for preliminary markup excludes public (third-party) services from consideration, since for them, in most cases, the markup on third-party sites will not be

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available. Such markup needs to be updated, which, of course, affects the economy of services. With this approach, navigation, of course, can only be tied to fixed wireless nodes with known coordinates. If you refuse to use geo-coordinates, then arbitrary nodes of wireless networks can be used as reference nodes (their coordinates are unknown and will never be used). Instead of some computational model, proximity will be described by a set of rules, such as:

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If Node1 AND Node2 are available then ...
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Moreover, in the conditions can be used any measured characteristics, and not just the signal strength. The most suitable models here are fuzzy logic systems [9].

Another consequence of this approach is the ability to use advertising information for wireless nodes. From a software point of view, the visibility (accessibility) of a wireless node means the ability to receive some information that this node sends out (distributes). The Wi-Fi access point is “visible” to applications on the mobile device if its identification information (SSID) is available. A similar statement is true for Bluetooth nodes in the so-called discoverable mode. For Bluetooth Low Energy nodes, there is an advertising mailing list when a node can send out some information. For Wi-Fi Direct, there is an advertisement for services where a wireless node can advertise (represent) a certain service. The service description is distributed (advertised) in this case, which is represented as an abstract set of pairs The point is that all such “advertising” of wireless nodes can be customized. Accordingly, in this way, it is possible to transmit some applied service information via such “advertising”. It turns out some useful dualism in practice - obtaining this kind of information is fixing the fact of proximity (accessibility / visibility of the wireless node) and, at the same time, obtaining some useful (as part of the service) information. This allows, in many cases, to refuse the use of servers (cloud components) in services.

What, for example, looks like a classic service using location information:
– Mobile device receives location information
– The received data is used as a key when accessing a cloud service that will search for data In the case of network spatial proximity, this can be reduced simply to searching for the nearest nodes, when the necessary data will be transmitted through the advertising presentation of these nodes, simultaneously with the search.

The remainder of the article is structured as follows. In section 2, we consider hyper-local Internet. In section 3, we discuss the existing prototypes. In section 4, we discuss the technical details, and section 5 provides the conclusion.

II. On hyper-local Internet

In this section, we would like to dwell on the model of services that are considered in this article. As shown in the previous section, the network proximity model (or spatial network proximity) allows you to mark (outline, limit) a certain spatial area. Mobile users (mobile applications or even mobile web applications) can determine the presence (visibility) of network nodes and, thereby, determine (fix) their affiliation at a particular point in time to a given site (spatial area). Moreover, such a fixation of belonging to the spatial domain (fixing the fact of being nearby a wireless network node) is accompanied (may be accompanied) by the receipt of some information (data set) from this node [10].

The idea of our service is to use a similar approach in marking up Internet resources. We want to describe in a similar way resources that are relevant in some local context. It is known that services using location information in most cases are used precisely for searching for local information, information that relates to a certain area near the requestor. However, there is no reliable way to describe the resources of the Internet related specifically to a certain local area. What is meant here is a description of the resources, and not the issuance of any geo-coded information upon request. For example, all sorts of wiki sites and discussion forums for residents of a community are very popular. It can also be not only traditional sites, but also specially created groups (communities) in social networks. You can also mention, for example, the increased popularity of channels in Telegram. Widely used. For example, dedicated Twitter accounts for publishing any data (including from some sensors / measuring devices). The question is how can new users of such resources find them?
Traditional models would consist of organizing some centralized catalog that would contain links with corresponding geo-coordinates. The client application would determine the coordinates of the user and refer to this directory for a list of resources. This is a completely working model (both theoretically and practically), but there is one blocking point that explains why this did not happen (why many attempts to create such directories did not work).

The very decentralized nature of Internet services suggests that authors create content (services) without any communication (verification) with some “authorizing” authority. Accordingly, the creators of the service have no incentive to register their resources somewhere. A centralized collection of such information is not possible because collectors themselves cannot find out about local resources.

Based on this, our idea is that the creators (authors) of such content (local services) themselves would advertise it, and local subscribers would have the opportunity to receive such advertising. This means that we want to create a wireless network node that will “advertise” some existing Internet service (content). Such advertising (in fact - a description of the Internet service) will be available to mobile subscribers (applications on mobile devices) located near this site. Such a node can be created (opened), including directly on the phone of the author of this content (service) [10].

At the same time, we will use standard Wi-Fi Direct mechanisms for advertising services, and for the presentation

(description) of services - a system with open code Hypercat [11]. This means that there can be many programs for scanning (viewing) such advertisements. This is not only tied to our application, which is just one example. There is a complete analogy with web browsers. Our proposal defines the layout format (conceptually plays the same role as HTML). The browser implementation can be any. We also note that obtaining resource descriptions in the proposed scheme is carried out without organizing a connection between devices - that is, in safe mode. The term hyper-local is used in Internet services in the sense of indicating short distances [12]. The proposed scheme can be called as a model of hyper-local Internet.

III. On prototypes and existing works

Firstly, as our prototypes and previous works, we can name our previous works on network proximity models. For example, when a node name modification (SSID) or customization of an advertising presentation was used to send information about a user's profile on a social network, this is also a link to a web resource. This web resource was relevant in this local context, since the user sending the link was here. In general, we considered services based on the network proximity model as context-sensitive services. The visibility of a particular wireless node (s) is the replenishment of context information. The attributes of each such node found are also context information. Accordingly, the host name (SSID), host address, signal strength (RSSI) - all this is context information. A service available on a particular device is also content. As types of possible actions (operations) with content, we can indicate the following:

– Entering a device into the accessibility (visibility) zone of specified devices / services or leaving this zone causes a change in status (state) in the application
– Entering a device into the accessibility (visibility) zone of specified devices / services or exiting from such a zone causes an information request (some kind of access to the data store) for subsequent processing
– Staying in the accessibility (visibility) zone of the specified devices / services causes a change in status or request for information upon the occurrence of some other conditions (for example, if the time spent is exceeded)
– Recording of events (entry / exit from the availability (visibility) zone of the specified devices / services and stay in such an area) for use in subsequent processing

Application Examples:

– Notification of the intersection (at the entrance or exit) of a certain virtual perimeter (analog of a geo-grating)
– Sending notification with a coupon / special offer in case of repeated presence in a certain area
– Turn off the call on your mobile phone when you fall into a certain area
– Notification when changing the set of received (available) codes, etc. In this case, we are talking about a model of a geo-information system. Instead of working with geo-coordinates, a network proximity model is used.

Fig. 1. On Internet proximity markup [12].

As a result, we want to get lists of Internet resources, which (lists) are tied to the area in which some mobile device is located (Fig.1). Available (visible) wireless nodes contain information about Internet resources. And getting information about available (visible) network nodes will be equivalent to getting information about network resources described with their help. Other models that can be mentioned in this regard are floating content [13] and partially ICN [14].

IV. On a new model of Wi-Fi Direct usage

As a means of markup, we will use Wi-Fi Direct services. This is a technology that involves the direct interaction (in the sense - the connection) of Wi-Fi devices. Here, in fact, there are two technologies: Wi-Fi Direct and Wi-Fi Aware [15]. The latter is based on the Neighbor Awareness Networking Specification - the definition of services that are provided by local (nearby) Wi-Fi devices. The Wi-Fi alliance talks about technology similarities, the difference is that Wi-Fi Direct requires some kind of coordinator to make connections, and Wi-Fi Aware creates decentralized, dynamic peer-to-peer connections. At the moment, phones with Wi-Fi Aware are not yet widespread, so all the considerations below relate specifically to Wi-Fi Direct. Wi-Fi Direct supports the ability to define services before forming groups and connections [16]. It is this property that can be used to organize models based on network proximity. A service in such a model is simply a dataset associated with a particular device. Search (disclosure) of a service is, in fact, simply a determination of the characteristics of a wireless node. Requests for searching for a service are performed using Bonjour, UPnP, Display, WS-Discovery protocols. The recent version of the Android SDK supports Bonjour and UPnP [17]. The service description is set in abstract form as a set of pairs: Here is an illustrative fragment from the Android SDK manual: three keys with their values.

// Create a string map containing information about your service.

```
Map record = new HashMap ();
record.put (”listenport”, String.valueOf
```

```
(SERVER PORT));
record.put (”Name”, ”Links”);
record.put (”Description”, ”test service description”);    record.put    (”URL”, ”https://some-
server.org/catalogue.json”);
// Service information. Pass it an instance name, service type
// protocol. transportlayer, and the map containing
// information other devices will want once they connect to this one.
WifiP2pDnsSdServiceInfo serviceInfo = WifiP2pDnsSdServiceInfo.newInstance (” test”, ” presence. tcp”, record);
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Accordingly, advertising a service in Wi-Fi Direct is, in fact, broadcasting a hash table over the network (in this example, record). That allows you to implement all of the above schemes for the implementation of information services without contacting the server (cloud) for processing or intermediate data storage. Confirmation of the fact that you are in the vicinity of a device will mean simultaneously receiving some information from it without establishing a connection. This form of presentation makes Wi-Fi Direct the most convenient for implementing models based on network proximity.

Our idea is to describe on a Wi-Fi Direct device a service that contains links to web resources. The presentation scheme will be as follows. On a device, each service defines three characteristics: Name - The default value of “Links” Description - search string URL - hypercat directory link The name of the service is used for searching, the description is used for possible refinement of the search (filtering), and the web resources themselves are described as the Hypercat directory. Hypercat is an open source project that solves the problem of finding (addressing) services in projects related to the Internet of Things. This is a fairly actively developing project. Its results form the basis of standards for the Internet of Things.

The British Standardization Institute (BSI) even claims to be the first standard in the world for the Internet of Things. Obviously, of course, this is more of a marketing statement, but, nevertheless, the importance and usefulness of this product are obvious. The corresponding BSI developments were translated into Russian and distributed by the working group, which is engaged in the domestic standards of Smart City and the Internet of Things. The Hypercat specification is designed to provide IoT application clients with search and discovery (disclosure) of information about available services on the Internet. The specification is based on the concept of a directory that describes an unsorted collection of links (Fig.2).

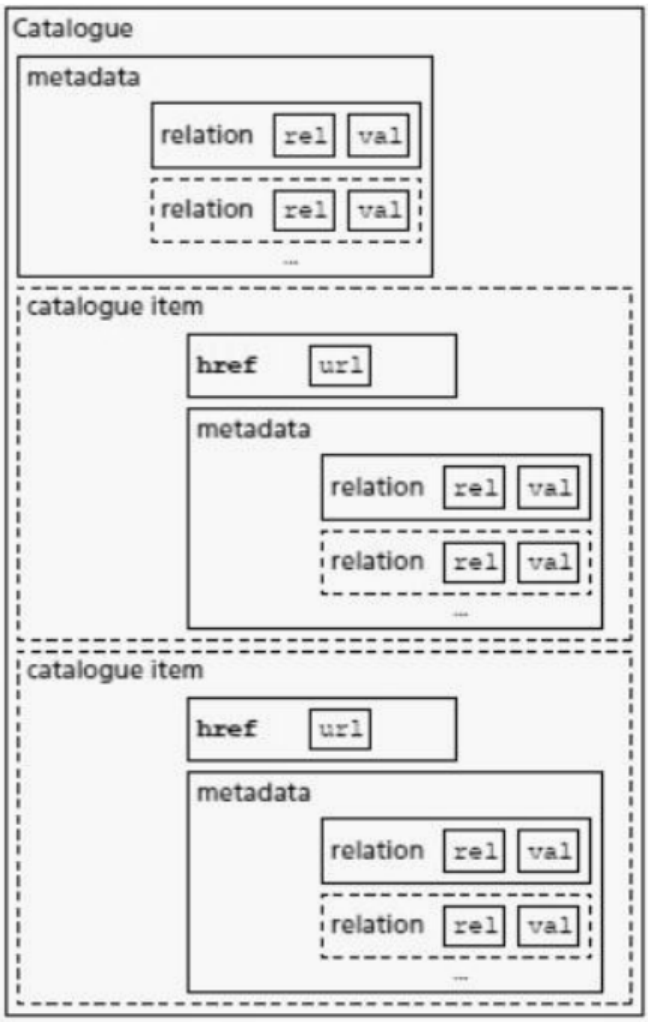

Fig. 2. On Hypercat model [10].

So, as a result, we get a scheme where a mobile device (mobile phone) can determine a link to a collection of arbitrary Internet resources, and this collection will be available to other mobile subscribers in the vicinity of this device. And this model will work both indoors (Fig.3) and outdoors. The model will support both static determining devices and devices that are in motion (Fig.3). In the latter case, the scope of the resources will “follow” the determining device (Fig.4).

Fig. 3. Indoor Internet proximity markup [10].

Fig. 4. Outdoor Internet proximity markup [7].

Technically, markup is not the only way to build a local information network. Another way is to directly use the service description in Wi-Fi Direct to save the content. That is, we consider the description of the service as a key-value database, the key is the characteristics (name) of the service, the value is the actual content. Content can be created directly on the device or downloaded to it (including from the global network). In this case, the keys can act as an analogue of symbolic names (what DNS provides). Due to the small area, it is not necessary to introduce a hierarchical classification, the names can directly correspond to the content of the content (for example, Documents for payment, Products, Taxi, etc.). Thus, we will have a network of nodes with a variety of content that can be searched for given keys. One of the characteristics of such a network is its security. Content is only available in the local area, to get to the content of the network you must be physically in this area. From a security point of view, it is much easier to physically restrict access. Accordingly, we get a secure view of the Internet.

From the point of view of organizing access to data within such a network, we can consider the solution proposed in the framework of the model of network spatial proximity - a physical browser [18].

V. CONCLUSION

This article describes a model for using Wi-Fi Direct services to advertise Internet resources. In fact, this proposal can be described as marking up space in terms of linking Internet services. The paper proposes both a markup scheme and a method for describing services. Together, this leads to a new scheme for representing web resources (more precisely, arbitrary resources that can be represented using a URI). Such a scheme is a hyper-local Internet. It is not proposed to use any new resources or a new programming scheme. The proposed model is focused on the description (reuse) of existing resources.

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