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A Proposal for Telecommunications Strategy in Serbia

By Milan Lj. Jankovic and Miroslav L. Dukic, Serbia and Montenegro

According to the Constitutional Charter, which regulates relations between Serbia and Montenegro, adopted in 2003, telecommunications policy is under the Republic's governance competence. The world's first global information and communications technologies (ICT) ranking of countries by the International Telecommunication Union (ITU) Digital Access Index (DIA), presented in the *World Telecommunication Development Report 2003*, classified Serbia and Montenegro in the category of middle access (0.45).

Institutional reforms in the telecommunications sector represent an important element of overall economic reform in Serbia over years to come. These reforms will provide a regulatory framework in compliance with WTO and EU demands. Despite world trends, development of the telecommunications sector in Serbia has developed relatively slowly in the last two decades. An institutional reform process has not yet been initiated in Serbia, besides the new Telecommunications Law adopted in May 2003, which introduced an independent regulatory body [1].

Therefore, a national telecommunications development platform should define the following basic objectives:

- Create clear and consistent policy for telecommunication market liberalization, providing equal conditions for all operators
- Fixed telephony market demonopolization, an especially important task
- Ensure investments in modernizing and expanding the present telecommunication infrastructure in order to provide an environment for implementation of new services
- Clearly define ownership relations in the ICT sector, an essential prerequisite for strategic investments
- Deploy and extend the use of new telecommunications technologies (3G, WLL, CATV, multimedia, IP, xDSL, VoIP, etc.)
- Reach the average European telecommunications development level in the next five-year period

The ICT Sector in Serbia

There was no strategy for development of the telecommunication sector in Serbia in the past 10 years. Partial privatization of Telecom Serbia in 1997 (Telecom Italia, 29 percent; OTE-Greece, 20 percent) had no significant influence on further development of telecommunications, although considerable investments in this field were anticipated in the shareholders' agreement. At the beginning of 2003, Telecom Italia sold their ownership to the state of Serbia through the public enterprise of postal, telephone, and telegraph (PTT) Communicaitons Srbija. Telekom Srbija a. d. today is a joint stock company owned by two shareholders: the Public Enterprise (PE) of PTT Communications Srbija (80 percent) and OTE-Greece (20 percent). The shareholders' agreement awarded Telekom Srbija a monopoly over the fixed telephone network until 9 June 2005. The mentioned agreement does not refer to a mobile telephone network or Internet services. In the lack of competition, Telecom Srbija maintained control over Internet access.

Very fast growth of the public mobile market is another reason for slow development of the fixed telephone network (2.7 million main telephone lines in operation). There are about 3.5 million mobile subscribers in Serbia. Only two operators operate GSM networks: Telekom Srbija and Mobtel. State ownership (through the PE of PTT Communications Srbija) is 80 percent in Telekom Srbija and 49 percent in Mobtel. Investments of Telekom Srbija and Mobtel were mainly focused on the development of mobile networks. In only four to five years of mobile market development, penetration and coverage reached and exceeded the value of the fixed telephone network realized over a period of almost 100 years. Two mobile operators offer their subscribers standard Global System for Mobile Communications (GSM) services and different data transmission services. At the end of 2003 Telekom Srbija put a 3G mobile system in trial operation.

There are several fast Internet connections in Serbia, a very small number of digital subscriber line (xDSL) connection,s and, particularly important, practically no existing broadband digital access systems. According to Internet provider records, there are more than 220,000 Internet accounts registered in Serbia. The total estimated number of subscribers is 700,000, but the number of PCs is considerably smaller. Internet providers are primarily accessed via dialup access, while basic ISDN access is less used. The price for Internet access is about 0.3 dinar/h.

Officially, there are 26 CATV operators, but their real number is higher. The two biggest operators are PTT Communications Srbija and SBB (owned by Soros & Stanton). They all offer exclusively basic TV service. The estimated number of cable TV subscribers at the end of 2002 was about 100,000, with penetration of about 1.2 percent.

About 6000 km of optical cable was laid in the backbone national and international network for digital synchronous digital hierarchy (SDH) transmission systems for the purpose of multimedia services. In addition to terrestrial links, there were three Earth stations used for international and intercontinental traffic till mid-April 1999. These three stations were heavily damaged and put out of operation as a result of NATO air strikes. The total roughly estimated value of damage in the public broadcasting system is about US$350 million, including about US$70 million for telecommunication (broadcasting) equipmen. ITU accepted Resolutions 33 (Istanbul, 2002) and 126 (PP-02 Marrakech, 2002), "Assistance and Support to Serbia and Montenegro for Rebuilding Its Broadcasting and Telecommunication Systems."

Total revenue of telecommunication equipment manufac-

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Routing on Overlay Networks: Developments and Challenges

By Adrian Popescu, Sweden

Overlay networks are networks operating on the interdomain level, where the edge hosts learn of each other and, based on knowledge of underlying network performance, form loosely coupled neighboring relationships. These relationships can be used to induce a specific graph, where nodes represent hosts and edges represent neighboring relationships. Graph abstraction and the associated graph theory can be further used to formulate routing algorithms on overlay networks. The main advantage of overlay networks is that they offer the possibility to augment the IP routing as well as the QoS functionality offered by the Internet.

One can state that generally, every peer-to-peer (P2P) network has an overlay network at the core, which is mostly based on TCP or HTTP connections. Because of the abstraction offered by the TCP/IP protocol stack at the application layer, the overlay and physical network can be completely separated from each other as the overlay connections do not reflect the physical connections.

Overlay networks allow designers to develop their own routing and packet management algorithms on top of the Internet. Overlay networks can therefore be used to deploy new protocols and functionality atop of IP routers without the need to upgrade the routers. New services can easily be developed with their own routing algorithms and policies.

Actually, there are two general classes of overlay networks: routing overlays, and storage and lookup overlays. Routing overlays operate on the interdomain IP level and are used to enhance Border Gateway Protocol (BGP) routing and provide new functionality or improved service (e.g., as reported in [2]). However, the overlay nodes operate, with respect to each other, as if they belong to the same domain on the overlay level. QoS guarantees can be provided as well.

On the other hand, storage and lookup overlays focus on techniques to use the power of large distributed collections of machines (e.g., Chord [15]). These overlays are actually used to support a number of projects on large distributed systems.

Overlay Routing

There are a number of research activities today on overlay routing as well as resource discovery, load balancing, and security to find optimal solutions for QoS provisioning [8, 11, 16].

Strategies for overlay routing describe the process of path computation to provide traffic forwarding with soft QoS guarantees at the application layer. There are typically three fundamental ways to do routing. These are source routing, flat (or distributed) routing, and hierarchical routing. Source routing means that nodes are required to keep global state information, based on which a feasible path is computed at every source node. Distributed routing relies on a similar concept but with the difference that path computation is done in a distributed fashion. This may, however, create problems like distributed state snapshots, deadlock, and loops. Better routing algorithms usie flooding but at the price of large volumes of traffic generated. Finally, hierarchical routing is based on aggregated state maintained at each node, and the routing is done in a hierarchical way. The main problem in this case is related to imprecise states.

There are two main categories of routing protocols, proactive and reactive. Proactive protocols periodically update the routing tables, independent of traffic arrivals. On the other hand, reactive protocols update the routing tables on demand (i.e., only when routes need to be created or adjusted due to changes in routing topology or other conditions, e.g., traffic must be delivered to an unknown destination). Proactive protocols are generally better at providing QoS guarantees for real-time traffic like multimedia. The drawback lies in the traffic volume overhead generated by the protocol itself. Reactive protocols scale better, but experience higher latency when setting up a new route.

A specific difficulty with overlay routing is related to the presence of high churn rates in P2P networks [14]. The consequence is that the topology information is very dynamic, which makes it difficult to provide hard QoS guarantees.

QoS constraints associated with each route define an optimization problem. To solve this problem, the overlay nodes have dedicated algorithms associated with a traffic flow or a group of flows sharing common characteristics (e.g., similar QoS constraints). To solve the optimization problem each algorithm can be connected, for example, to a random neural network (RNN) to continuously adapt the existing routes according to the quality experienced by traffic flows passing the node. This can be done by reinforcement learning [7]. Other methods to solve the optimization problem may be applied as well, such as swarm intelligence [4] and genetic algorithms [6].

Multipath Overlay Routing

IP routing protocols forward data on a single path between source and destination nodes. Single-path routing has the drawback that the achievable throughput could be limited due to many policy routing decisions existing today. BGP is primarily a policy-based routing protocol, which means that it may route a specific data flow on a path with lower bandwidth even if alternate paths with higher bandwidth are available. Furthermore, single-path routing does not perform well in wireless (ad hoc) networks either. This is because of the relatively high route failure rate, due to mobility or false failures created by interference effects.

An interesting solution is to develop multipath overlay routers [13]. Multipath overlay routing is an algorithm that can be deployed at the source node to stably and optimally split the data flow sent to a specific destination node. The algorithm may increase throughput, reduce latency, and balance traffic loads. It may also provide robustness to link failures due to mobility and false failures that occur as a consequence of, say, the IEEE 802.11 medium access control (MAC) protocol.

There are several fundamental questions that must answered about multipath overlay routing and the associated algorithms. Some of the most important questions are: How many paths are needed for the transfer of a specific amount of data? Given a specific topology, how do we select the paths to provide the requested QoS and balance traffic loads? Where should the multipath overlay routers be placed given an existing network topology? What is the effect of multipath overlay routing on TCP stability and performance? Given a specific topology and a specific multipath routing algorithm, how does one design a stable TCP congestion control mechanism that exploits the multipath routing capability?

Overlay Routing vs. BGP

Today, BGP suffers from performance problems created by the increasing size and complexity of the Internet backbone [3, 9]. The increasing number of autonomous systems and the associated advertisements mean that routing tables are increased. Furthermore, increased interdomain connectivity means that the Internet topology is becoming less hierarchical due to multihoming. Increased demand for policy-based routing also has a serious consequence in that the amount of reachability advertisements further increases. Altogether these

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factors create the situation in which BGP routers need longer time (e.g., at least several minutes) to converge to a new valid route after a link or path failure. There are studies showing that interdomain routers may even need tens of minutes to come to a consistent view of the network topology after a fault [10]. This further increases the risk of routing flaps (i.e., routing table oscillations) and instability. One can therefore state that although the Internet is actually performing well, it is also inherently unreliable. Today's Internet is quite sensitive to router and link faults, configuration errors, and malice, and this has a direct impact on performance.

It is actually extremely hard to understand the dynamics of interdomain routing and debug routing problems [3]. It is therefore important to also focus interest on alternative solutions such as using overlay routing to bypass BGP's path selection and improve performance and fault tolerance. Furthermore, it is important to compare the relative benefits of overlay routing with interdomain routing as well. A number of key metrics can be considered, such as achievable throughput, end-to-end and round-trip delays and availability.

Two key elements can be considered for comparison: route availability and the route selection algorithm. Route availability refers to the number of available routes, whereas the route selection algorithm refers to protocol complexity, performance, and resilience.

It is important to study the performance of interdomain routing and compare it with that of overlay routing protocols. Furthermore, a very interesting question is related to the best architectural solution (with reference to performance) regarding the route selection algorithm itself. Does the solution with two route selection algorithms existing today (i.e., BGP and overlay routing) offer acceptable performance, or would a solution with only one route selection algorithm at the overlay (as suggested by [5]) offer better performance? The first alternative also raises the question of coordination of routing mechanisms existing in two parallel overlays (i.e., BGP and overlay routing) to obtain the best performance, for instance, in the case of IP and multiprotocol label switching (MPLS).

Security Issues

Unstructured and unadministered P2P networks like Gnutella present serious security challenges. There are generally three categories of threats that act at different levels: threats to the individual user, threats within the P2P network itself, and threats to the Internet. For instance, one of the most serious threats acting at the individual level is free riding [1]. Free riding is when users download documents and use network resources, but do not share files and do not answer other P2P searches. This is mainly a fairness problem, as users with selfish behavior are consuming resources and deteriorating the network performance for their own profit only.

Another important threat issue at the individual level regards copyright infringement concerns as well as the drive of media industry to protect proprietary content and constrain file copying. A consequence of this could be an eventual persecution of Gnutella supernodes, which generate the bulk of data content. This further limits the technical development of P2P and overlay networking. A possible solution could be to develop and build up anonymity on top of Gnutella, but this further raises the question of interoperability among anonymized and non-anonymized users.

Another important research issue regards the protection of P2P and overlay networks facing security attacks, such as denial-of-service (DoS) attacks. This problem is further complicated because actually many standard security mechanisms are not effective for P2P and overlay networking. This is because P2P and overlay communication protocols are more sophisticated, communication patterns and more dynamic, and port selection is more random than with other applications. Moreover, accountability and privacy are not yet solved in a satisfactory manner [12].

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Joint Symposium: A Sister Societies Activity
By Dr. Jacob Baal-Schem, Israel

A Symposium on Personal Area Communications and the Smart Home was held in Tel-Aviv, Israel, on June 1-2, 2005 with more than 120 participants. This Symposium was the first event in a series of Consumer Communications and Networking Symposia, Israel (CCNSI) planned to be held yearly in conjunction with the Sister Societies agreement signed between the SEEEI and ComSoc in 2004. The Symposium was organized by the Society of Electrical and Electronics Engineers in Israel (SEEE) in agreement with the Israel IEEE Communications Chapter, and received technical co-sponsorship of the Communications Society. It was co-chaired by Jacob Baal-Schem (SEEEI) and Alex Gelman (ComSoc), and enjoyed the presence of ComSoc President Curtis Siller and CCNC Steering Committee Chair Robert Fish.

The idea of holding a series of joint Symposia was brought up during the signing ceremony of the Sister Societies agreement renewal, held during the IEEE Israel 50th Anniversary Convention in 2004. The SEEEI is a "young" national society, which has split recently from the Association of Engineers and Architects in Israel (AEAI) and conducts many professional activities, including conferences with large audiences. CCNSI is scheduled to become a "daughter symposium" of ComSoc's yearly CCNC.

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TELECOM STRATEGY IN SERBIA/*(cont'd from page 1)*

turers is estimated to be some US$40 million in 2000, representing 0.41 percent of the gross national income (GNI).

Proposed Strategy for Telecommunication Development in Serbia

The national telecommunication development strategy shall define:

- Long-term development of telecommunication networks and services
- Modalities of investments in public telecom networks
- Choice of technology for public telecommunication coverage of rural and poorly developed areas in the Republic
- Adjustment of telecommunication development policy to bring it in line with evolving market demands

Principles of telecommunication development strategy in the Republic of Serbia shall be based on the European experience in development of a modern information society, with usage of new ICT technologies. This means:

- Carrying out institutional reforms in the telecommunication sector in Serbia to include a regulatory framework, with subsequent liberalization of the telecom market and possible privatization of state capital in the telecommunication sector. Appropriate preparations for privatization and liberalization are of key importance.
- Sustainable development of economy and society, as well as a transparent, steady, and non-discriminatory policy of telecommunication development, based on regulatory frameworks, in compliance with internationally recognized standards.
- Speeding up technological modernization of telecommunication in Serbia in order to reverse a backward trend in the telecommunication sector in the 1990s; modernization of telecommunication will create an economically attractive environment for foreign investors.
- Special attention shall be paid to education and specialized training of human resources.
- Basic principles for the development of Telekom Srbija, the biggest national operator, shall also be considered in the platform of the Government of the Republic of Serbia.
- Through the strategy for telecommunication development in Serbia, it is necessary to analyze different options for Telekom Srbija to enter telecom markets in the region.

The main objectives of telecommunication policy in the development of the telecommunication sector are:

- Adjusting national technical and legislative solutions to European and world standards
- Reaching the EU average level of telecommunication development: penetration of 55 percent in the fixed telephone network and 80 percent in the mobile network by 2005
- Digitalization of the backbone and regional telecommunication network infrastructure covering 95 percent of the territory of Serbia by 2005 at the earliest, and implementation of modern telecommunication services
- Fast building of core and regional networks, particularly reconstruction and modernization of access networks
- Accessible and affordable universal service for all
- Construction of control test centers in the territory of Serbia
- Intensive development of intelligent and business telecommunication networks together with diversification of services and improving quality of service, especially for the Internet
- Transformation of the national operator Telekom Srbija in accordance with the European experience, based on modern operational principles
- Definition of ownership relations and the government role in the case of important national telecom operators, especially regarding mobile operators
- Restoration and reorganization of national, regional, and local broadcasting (radio and TV) systems
- Starting digitalization of broadcasting systems (DAB and DVB)
- Protection of national security interests
- Active participation in the work of both international telecommunication bodies and international bilateral activities

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JOINT SYMPOSIUM/*(cont'd from page 3)*

The Symposium Opening Session included greetings by the ComSoc President and SEEEI President, a keynote lecture, "Pervasive Peer-to-Peer Consumer Communications" by Dr. Alex Gelman of Panasonic Laboratories, and a guest lecture, "Using Personal Communications to Close the Digital Gap" by Mr. Hanan Achsaf, former vice president of Motorola Inc.

The keynote lecture of the plenary session on the second day was presented by Dr. Stefano Galli of Telcordia and dealt with recent results on the modeling of the indoor power line channel. Both keynote lecturers, sponsored by ComSoc, were well received, and their presence enabled information exchange and discussions on methods and applications of personal area communications.

Lecturers from Israel academic institutions and industrial companies presented visions and applications for the smart home and smart car via wireless and power lines as well as control systems for buildings and highways. In general, it was felt that this was a good result of the Sister Societies program.