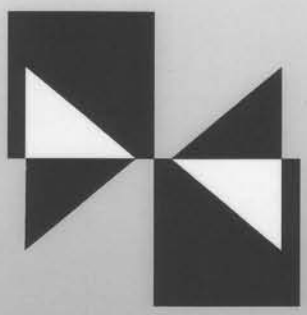

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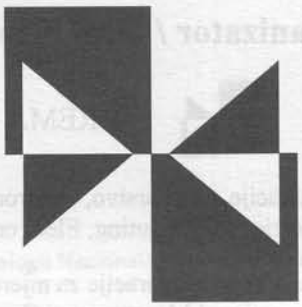

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PUBLIC ACCESSIBLE MICROMETEOROLOGICAL STATIONS NETWORK MODEL FOR ROAD TRAFFIC WEATHER CONDITIONED SAFETY SUPERVISION

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Abstract

One of important road traffic safety aspect is knowledge on road weather condition. Poor weather conditions are main cause of dangerous road traffic condition and make traffic unsafe generally. In function of traffic accident prevention and increasing traffic flow in safety aspect, a supervision of weather condition is necessary through road weather information gathering. Today those systems for weather condition monitoring exist but they are often very expensive in manner of applying in dense monitoring network. Also those systems are closed for public access and real time information gathering and distribution. In this paper is presented and developed a model for micro localized road weather condition supervision by utilizing cheap micro meteorological stations network based on existing GSM network data exchange with public access and informing through SMS.

1. INTRODUCTION

Road traffic safety doesn't depend only on driving skills nor road surface quality and terrain configuration. Weather and time-space conditions are one of significant causes and factors that influences on traffic safety as inseparable and unavoidable traffic parameter. Especially, poor weather condition like strong wind, rain, fog, icy pavement or snow are main cause of making a dangerous road traffic condition and make traffic unsafe generally [1, 2]. Weather as traffic parameter often is hardly to predict due many dependent parameters of weather forming and sustaining mechanism. Today science tries to make long term weather prognosis which relies only on mathematical forecasting methods of known weather mechanism. Quality of prognosis strongly depends on quality of on-field weather parameter measurements [3]. A way to increase quality of weather forecasting is by increasing a number of weather stations in manner of applying these in sufficiently dense sensor network which regularly can be very costly. Traffic infrastructures such roads, bridges, tunnels and other large can cause an appearance of micro localized weather condition. That is common cause of making an unsafe traffic conditions and road accident occurrences, especially on roads that are spreaded over much different terrain configurations. In function of traffic accident prevention and increasing traffic flow in safety aspect, a constant supervision of weather condition is necessary through road weather information gathering and control centers informing. Today these systems exist, such in [4], where a sensor network is formed and applied on road infrastructure. The systems for road weather condition supervision helps to on-time prevent weather related accidents and rises traffic safety easily through remotely control. Existing systems for weather condition monitoring are often very expensive in manner of applying in dense monitoring network for reliable supervision. Also those systems are closed for public access and real time information gathering and distribution. In this paper is presented and developed a model for micro localized road weather condition supervision by utilizing cheap micro meteorological stations network based on existing GSM network data exchange with public access and informing through SMS.

2. WEATHER MONITORING

As is stated in introduction chapter, traffic safety is tightly related to road and traffic weather

conditions. Also, the traffic safety law recognizes poor weather conditions and recommends or commands procedures for safely driving or sustaining traffic safety [5]. The foundation of such supervision system relies on weather station network alongside of road infrastructure combined with weather forecasting data which are regularly provided by national weather observation center.

2.1. Weather monitoring station

Weather station represents backbone of weather data gathering, [6], and distribution in weather based traffic safety supervision systems. A weather station gathers all related data that can cause unsafely traffic conditions like; rain appearance and its intensity, snow appearance and its intensity, surrounding air temperature, road surface temperature, ability of forming icy road surface, dew point temperature and ability of fog forming, wind direction and intensity and other relevant parameters.

Gathered data are distributed to supervision center over some kind of communication network, proprietary or existing one, and make a functional traffic supervision and control system, Fig. 1.

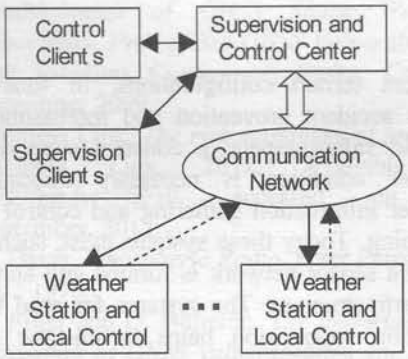

Fig.1. Functional block diagram of traffic safety supervision and control system.

Fully equipped weather stations are often very expensive in manner of applying in dense monitoring network. Station price arises with its measuring complexity and influence on infrastructure incorporation needs. Measuring complexity and incorporation needs can be reduced by reducing measuring parameters. The proposed weather parameter measuring station in this paper relies only on air temperature, humidity and wind parameter measurements and providing air temperature, air humidity, dew point temperature and wind direction and intensity information. Such simplicity of proposed station measurement requirements and ability lowers the station price and serves only as a weather measurement point in manner of increase of weather station network density. Secondary effect of applying this kind of dense monitoring network is expected in increase of a quality of road weather forecasting data by providing more weather information for forecasting model. Due such simplicity these stations are often called *micrometeorological weather stations*.

2.2. Micrometeorological station structure

A weather micrometeorological station consists of several functional units, Fig. 2.

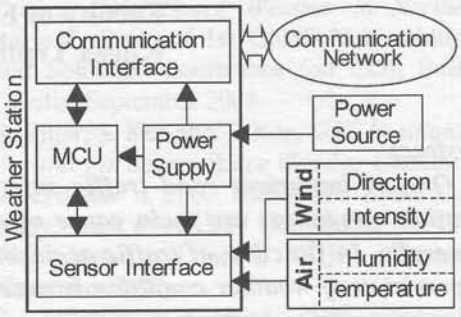

Fig.2. Functional block diagram of micrometeorological station.

These units make a standalone functional system and they are; *MCU* – microcontroller unit for data acquisition, processing and distribution preparing, *Sensor interface* –sensor connectivity, *Power supply* – powering requirements, *Communication interface* – connectivity to data exchange network for data distribution and station remote control.

Sensor interface consists of air temperature and humidity measurement sensor with air dew point calculation ability based on integrated digital *Sensirion SHT11* sensor [7]. The wind parameter measurements are done by utilizing an anemometer vane for wind direction and rotating cups for wind speed. Complete anemometer system utilizes fully digital interface even for vane and speed and relies on incremental encoder principle. Station power consumption in idle state is 0.2W and 4.5W in active state.

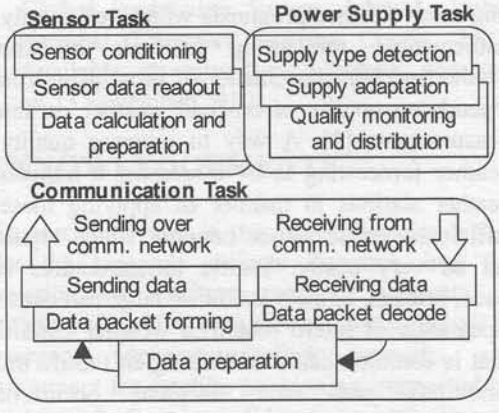

Fig.3. Block diagram of station algorithm.

Algorithm of this station does three tasks only, Fig. 3. First task maintain measurements jobs and measurements calculation. Second task does communication requirements of calling number recognition and data serving. Third task monitors power supply health and does solar charging requirements or conditioning of locally available power supply. Total producing cost of such system currently is less than $100 USD and like that much less costly than fully equipped one. Whole micro-station system is packed in small and sturdy box (30x20x10cm) suitable for fast mounting.

2.3. Connectivity and data model

Data connectivity of this station is done by utilizing a proven and existing data network infrastructure. Existing network that is used is a GSM cellular network of mobile providers. As a communication model for data exchange in this micrometeorological station is used. SMS method is suitable due its simplicity and sufficiently capabilities for small data amount data transportations requirements of this station. Amount of data of this station is accommodated within few bytes and doesn't exceed total amount of 160 characters of standard SMS packet size. Interface that utilizes and does all necessary communication steps is based on GSM data module (in this station is used Telit GM862). Data exchange procedure steps (data pooling) are shown in functional block diagram on Fig. 4.

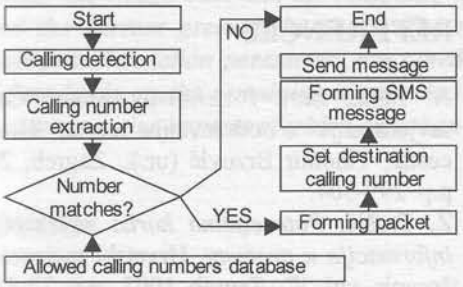

Fig.4. Data pooling diagram.

Data exchange procedure relies only on recognizing a calling number and responding with packet data structure in form of SMS message.

3. NETWORK MODEL

Alongside weather stations data distribution network is another important part. Existing network model for data exchange is mainly closed for public access and prevents end-user (driver) to have direct and instant information on road weather and traffic condition. In following text is presented a network model for data exchange with addition in form of public access ability.

Main idea of proposed network model is to grant access for end-users to gather instant and basic information of desired road traffic condition. The structure of proposed network, Fig.5, is similar to existing network model with difference in addition of separate data servers which serve end-user requests through simple SMS data pooling.

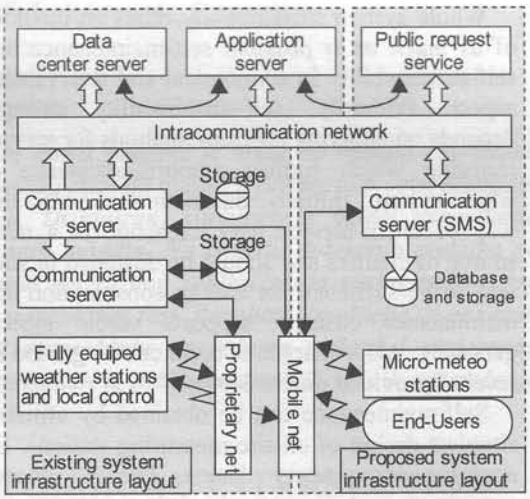

Fig.5. Proposed network model.

Stations are pooled by SMS communication server in regular period of time. Pooling servers pools every station and store its responses into a database and storage server where all data can be accessed by application server and/or server for servicing public requests. Application server uses gathered data as addition in improving of road and traffic weather condition estimation.

3.1. Public accessibility

Public servicing request server services a request of end-users and provides them an instant and on-time road and traffic condition information. The main idea is; end-user sends their request to public server as an SMS formed request. SMS request can contain and server responses are:

- *Road formally name only*; i.e. "A3", where end-user request global condition of A3 road. Public server response with globally estimated or on-time condition like, "*Temperature is 28°C, mild wind, no fallings, no wet sections, 130 km/h limit* " with addition of exception like, "*road closed on section xy, turn at ...*", or *on-site "road repairing at section xy, speed limit 60km/h, slow down".*
- or, *road formally name and section xy*; i.e. "A3, Bajakovo" where user request traffic condition at border crossing and paytoll nearby. Public server respones with i.e. "*Attention: Paytoll jams 2 km*

in length, temperature is 33°C, humidity 95%, no wind, border crossing estimation time: 1 hour"

Server response can be in variety of forms and can contain general and vital road and traffic condition data combined with commands and/or recommendations for safely driving.

3.2. Sustainability and payment

Whole system sustainability relies on methods of *as much as is possible* self-maintenance and self-sustainability in economical and intervention aspect. Primarily, self-sustainability strongly depends on applying efficient methods for service charging which further supports existence of whole system. Initially, due nature of SMS, this way of client-service data exchange is a main source of charges and should be designed in such way to be sufficient for energy consumption and maintenance costs - supports whole system generally. Also, charges of SMS can be graded by level of provided traffic details.

Self-maintenance can be obtained by utilizing simplest design of on-site measuring stations. By applying low energy design, keeping energy consumption low and designing robust and element-resistant construction, maintenance can be significantly reduced. A proposed micro-meteorological station structure and design, presented in this paper, have by its nature.

4. CONCLUSION

Traffic safety doesn't depend only on road physical quality or terrain configurations or driver driving skills. Great factor that is inseparable and greatly influences on traffic safety is weather and weather conditions. Roads as most significant part of traffic infrastructure can significantly influence on appearance of micro localized weather condition primarily by its large masses and areas. These conditions are hardly to estimate by utilizing only computer meteorological forecast models without on-site measurements. To improve meteorological condition estimates by its quality and accuracy using on-site measurements are mandatory. Today the variety of systems for these purposes exists.

The backbone of these systems is a network of meteorological stations that measures weather parameters. Today existing systems measures these parameters and controls entire roads or roads sections by informing drivers either by controlling on-site signalization or informing them through public information systems. Common characteristic of public informing is a delay in information appearance regarding real on-site weather forming condition. Due ability of fast weather forming and changing condition on specific road sections that kind of delay in information spreading chain can cause traffic jamms, closed roads or even traffic accidents. Main reason of appearance of such delay is closeness of existing systems for traffic safety control and supervision to end-users, drivers respectively.

In this paper is presented a network model that is open for public access in manner of providing instant and on-time information about road and traffic weather condition. This model of network relies mainly on existing network infrastructure by utilizing existing weather stations with addition of number of simpler weather station that measures only basic weather conditions of air. These simpler weather stations provide weather data in manner to make measuring network denser to achieve better and more accurate weather forecasting. Also these stations data combined with existing weather stations partially open enclosed existing monitoring system to public access.

Public access of this system is achieved by introducing separate service system which gathers data from simpler weather stations utilizing SMS and serving public request also through this channel. By that configuration and network modeling the public access has been made and instant and on-time informing of end-user is achieved. That greatly helps when travel is planned, routing has been made or traffic avoidance decided. Whole system upgrade can be self-sustained and self-maintenanced by utilizing SMS charging mechanism and designed in a way for low cost, low energy consumption with sturdy and simply design.

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