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Dissemination of Air Quality Information: Lessons Learnt in European Field Trials

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Abstract

Prime objective of project APNEE has been a citizen-centred dissemination of air quality information. It was initiated during the hype of novel information services. At that point in time, content was considered as the most promising business opportunity. In addition, emerging EU directives called for novel services to advise the public on health-related instances. In this light, a multi-channel dissemination platform for the distribution of air quality information has been implemented in APNEE. This set of information services towards the citizen has been evaluated in major field trials across Europe in order to identify those services with the best acceptance and impact. Main achievements include a reference architecture for future exploitation and a catalogue of information services accompanied with guidelines for use. This paper will report on the experiences gained over the last four years and present major results in human-centred and process-oriented stance.

1. Introduction

Ambient air quality is a raising public concern, since air quality directly impacts on people with certain health problems. Lack of knowledge about the exceeding of thresholds and lack of behavioural guidelines might cause further harm. Exceeding of thresholds is not a millennium event, but happens rather often in certain regions and seasons of the year. The question arises of how to reach the citizen?

Dissemination and presentation of historical air quality data to the public were mainly done by the use of various printed material in the form of reports, brochures, fact sheets etc. In addition, news media were often used as a dissemination channel. At the beginning of APNEE (Air Pollution Network for Early warning and information Exchange in Europe) in 2000, the use of the Internet was starting to increase for the dissemination of environmental data. Especially environmental organisations used this medium as a fast and low-cost window to the public. However,

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- only pull services where supported, i.e. no active information or notification to the citizen,
- most of the services where limited to aggregated data and raw values of air quality without guidance on effects, index, risks and advices for behaviour,
- no intuitive or user friendly navigation in information, data or background information sources was considered.

APNEE embarked on the use of online data for improving the knowledge of air quality (Bøhler et al., 2002). Availability of online data is decisive, since air quality carries a direct impact on people's health. Moreover, online data gather much more attraction than a report on last year's air quality. The dissemination of online data is not only a technical challenge with respect to collecting, aggregating and quality assuring data, but is also demanding with regard to the presentation of air quality information. While technology and organisational processes have matured to provide a seamless supply chain from sensor networks via air quality management systems towards central data repositories, reports on content acceptance and communication towards the citizen are sparse.

APNEE established a multi-channel information service platform for the dissemination of air quality information (Peinel et al. 2002) thus offering an implementation for eGovernment information services (European Commission 2003b). The dissemination platform builds upon modern communication channels, like World-Wide-Web, SMS, MMS, WAP via mobile phones, PDAs, and smart phones, as well as voice servers und street information panels. Field trials for the evaluation of these innovations in APNEE and in the Take-Up measure APNEE-TU comprised nine test sites (Oslo, Grenland, Athens, Thessalonica, Marseilles, Canary Islands, Madrid, Andalusia, and whole Germany) while the project includes 21 partners from research, government, and the IT- and telecommunications sector.

This paper reports on the evaluation of the use of online data and its communication towards the citizen. It provides an overview and assessment of options for the dissemination and presentation of air quality information (APNEE-TU 2004).

2. Forecasts

APNEE delivers not only the current state of air quality for a region, but more importantly forecasts for the following days. This is accomplished by using a fully automatic system with model results from dedicated air quality management systems or air quality models running on fixed intervals. But the results depend on the quality of the statistical datasets used for the calculations as well as the meteorological forecasts, and therefore the hit probability is mostly below 100%. Defining levels of dust particles in air is especially difficult because they are extremely dependent on humidity and rain-out. This imprecision proved to be a major concern for authorities, since they demand that the information to the public is as correct as possible to

avoid defending against forecasted episodes that did not happen or episodes that the systems could not detect. The resulting retention of authorities to publish forecast data lies in contrast to our feedback of the public showing that they are strongly interested in forecast values to plan their whereabouts in advance, if they are affected by related health impacts. This interest in forecast values was of course conjectured by the APNEE partners, but it was finally proved by the evaluation of field trials.

Due to the authorities' claim of accuracy each country showed a different offer of forecasts. For example, in Germany the authorities accepted only to publish ozone forecasts. Other pollutant forecasts are still "under consideration". In other countries special forecasts are also not shown, or research institutes/universities overtook the role of the authority in being responsible for the forecasts.

In Spain it is interesting to observe that the air quality forecasts for "today" have been more interesting in comparison with the forecasts for "tomorrow" or "the day after tomorrow". Also, an appealing 3D visualization (implemented in VisAD and VisAqD, (San Jose 2004)) is requested almost as often as the air quality forecasts of "today" (except in Andalusia on the Spanish server). This is a surprising result since the procedure to activate the 3D visualization requires downloading a Java plug-in and the Sub Java 3D package at the client side.

3. Presentation and Air Quality Index

Showing air pollution values in a somehow chemical way by presenting text like "NO_2 60 µg/m^3" will not suffice, since citizens usually simply want to know whether the displayed values are dangerous for themselves and their relatives or not. APNEE answered this requirement with gradient scales, like *little*, *some*, a *lot* and *very much* to indicate the level of pollution, combined with links to health recommendations for each of these classes. These gradient scales can easily be symbolised by colours or icons as an easy to grasp metaphor (figure 1).

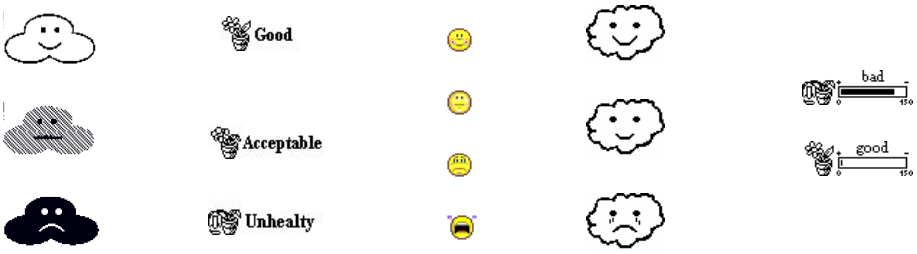

Figure 3
Colors and icons for air quality indices

This visualisation performs especially good, if not only individual pollutants are presented this way, but the overall air quality state is symbolised in terms of *good*, *medium* or *bad*, which means utilisation of an air quality index allowing the public to judge air quality without having to be a pollution expert and puzzling about the meaning and impact of NO2 or PM10. There are in principle two ways to generate such an index. Either it is calculated by allocating a fixed weight to the various compounds of the monitored data, or the index is compiled as a result of one or more components which values being "highest" and such collecting the evildoers. The former has been proven to be too complicated to calculate correctly (huge variations due to complex situations in urban environment might falsify the results). The latter, that could be named a more information-oriented index, is much easier to relate to and has been chosen by most of the APNEE-TU partners.

Unfortunately, each country or region authority insisted on creating and/or using an own index, thus no European air quality index was available for use in APNEE. In France, a nation-wide index called ATMO is already in place and was used in APNEE. In Spain and Greece, the respective universities as partner in the project created indices based on their own research and experiences. In Norway, the authorities and NILU developed an index for Norway. In Germany, the LQI (Luftqualitätsindex) was investigated and developed by order of the state institute for environmental protection Baden-Württemberg (Landesanstalt für Umweltschutz, LfU) (FoBIG 2000), and the other federal states had no objection to use it for APNEE. Interestingly, it was not publicly published until APNEE asked for it.

Since a European wide air quality index is missing, cross border air quality information is still not harmonised, and Europeans travelling across borders or living near one or more borders will currently have to live with different calculations and presentations of air quality indices. This might not foster environmental awareness, and hinders service establishment across Europe.

4. Interpolation

In cities measurement stations are installed according to national and EC regulation, but of course not necessarily according to districts. To allow citizens to get air quality measurements for the districts of the city where they live or where they work, an interpolation of measurement values between measurement stations has to be made, i.e. a mathematical estimation of values between measured values. This has been done by our French, Spanish, Greece and Norwegian partners, while the partners from Germany showed the values from the measurement stations without giving a surrounding coverage (figure 2). Since interpolation requires a very complex modelling in particular for urban areas, the estimated values might not be correct in any location. Authorities have to decide, whether to be utmost correct and let the citizen make his/her own mental interpolation (like on a weather map where people nor-

mally guess the weather condition for their specific location), or to try to serve citizens preferences with these maybe wrong but best as possible mathematic interpolations.

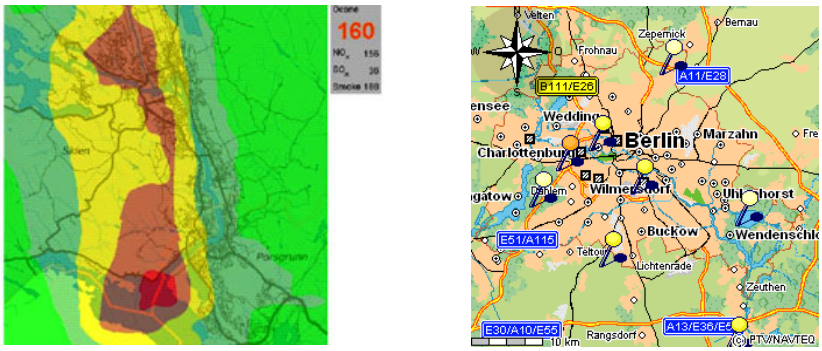

Figure 2
Grid based interpolation on a map (Norway) and coloured icons per measurement station locations on a map in Germany

As the feedback from our trials showed, the offer of geo-referenced information per district seems to be overdoing it for most users in cities. People moving in the city from and to work, kindergarten, shopping, and leisure places are often crossing several districts, and therefore an overall air quality state for the city gives enough information for them, better than checking several districts.

A natural way to present such geo-referenced information is a map. Users can navigate on the map by zooming, panning, and selecting regions to get further information (figure 3). Also, the air quality values can be embedded in the map as icons, coloured numbers, or coloured regions (including a legend on how to read the symbols and colours). For Internet, WAP and PDA we used a map based presentation (on WAP only for navigation), while for SMS a textual specification of the region took place.

5. Location-Based Services

The second purpose of location reference was tested during the French and German field trials with location-based services (LBS). A notification service was established, which tracked the users location via its mobile phone and air quality changes where sent by SMS when a change of location also meant a change of air pollution

state. A pre-defined subscription profile determined which pollutant at what level during which interval should be observed.

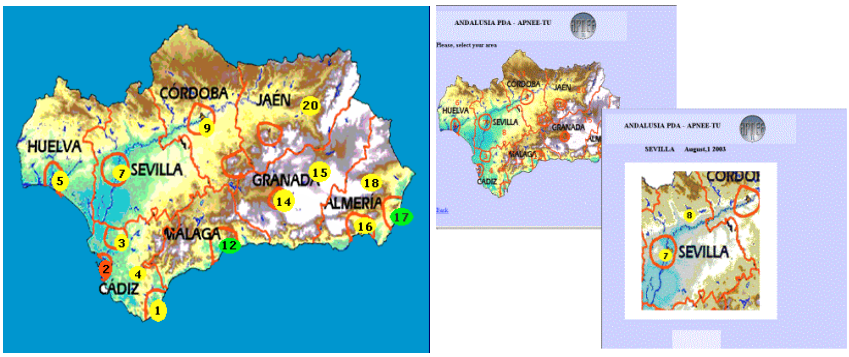

Figure 3
Examples for presenting air quality values on maps with predefined regions
(Andalusia web and PDA interfaces)

The evaluation afterwards showed a very positive feedback on this kind of service with SMS being a perfect means to warn on the move, and even affecting people's behaviour to some extent to avoid being exposed to the pollution or to help others from being exposed. 90% of the users who received an alert message as part of the geo-localization service found it comprehensive, while 62% of the persons are willing to take out a subscription to such a service, if it is complemented with other specific information such as weather forecast or information on pollen. 48% said they would be ready to subscribe to such a service for 10 € per year.

In Germany they were able to select test users with allergies and persons with no such problems. Alert-SMS was significantly more preferred by allergy sufferers than by non-allergy sufferers. 5% of the allergy sufferers would use an SMS tracking and alert service definitely, 22% probably. 4% of non-allergic test users would use it definitely, and 10% probably. The price acceptance for a monthly subscription proved to be near to 3 Euro. Since the tracking of mobile users is very costly, such an offer at this price will be very probably not offered in the near future in Germany.

6. Push Services

Introducing push services for air quality information is a clear new element in APNEE and implemented in advance the EC regulations on actively informing the public about environmental hazards with new telecommunication means (European Commission 2003a) . Push services are predestined for early warnings of any kind,

and therefore also perfect for notifications about air quality episodes. In a pull service, users decide with a direct interaction actively when and what kind o<f information to get, whereas in a push based service the system sends information based on a user profile given in advance during a subscription process. In APNEE, the end-users defined what kind of air quality information to receive for which event or when. Evaluation of these profiles also opens new ways of understanding end-user needs for air quality information.

The different services tested can partly be used both for push and pull. In APNEE, Internet and WAP is only used for pull, while e-mail is only used for push. SMS and MMS are used for both. For all countries push techniques where tested for SMS, while only a few tested MMS.

The push services were used to give the users information about air quality levels either because they have subscribed to receive information on a regular basis, like *every morning*, or because they decided to receive information when certain levels of pollutants were exceeded.

For push services a user profile must be provided, and therefore users must be able to understand and accordingly select the information they want to receive. The different regions in APNEE have implemented different types of subscription modules based on the respective trial options. For the first field trials far too many different options were given resulting in a confusion of users and a tendency to request too many information. The later field trials reduced significantly the given options in the subscription modules. A typical problem discovered is that many users got overloaded with information when they had requested notifications from several areas or if they selected to get also regular status information. Forecasts were sent only once a day. But when an episode occurred, users might get new messages each hour in some country set-ups. This problem has been approached in different ways in order to inform the users only when the situation changes, either by sending information maximal four times each day, or only updating when the level changes to a new "class" of an index.

Looking at the overall results from all trials in APNEE there is strong evidence that the end-users really appreciate the information dissemination options enabled by push services. There is also a clear conclusion that the users only want to be informed in peek episodes. Many preferred an interval less than once a day. However, there was some interest in receiving forecasts every day, but again, only if the levels are said to be over a certain level.

7. Use of new dissemination techniques

Maybe the most obvious new element of APNEE is the use of a complimentary set of various dissemination techniques, i.e., users can decide which channel to use in which circumstances. In total, eight channels were tested: Internet, WAP, PDA,

email, SMS, MMS, voice server and street panels. The selection of services per country has been made according to technologies already existing, channels available, individual country habits and of course business perspectives of the telecommunication providers. Information content tested in the field trials include (selection varies between regions): air quality status (measurement values for selected pollutants), air quality forecasts (for selected pollutants), air quality index (depending on country), history, statistics, articles/links, UV, and pollen. This information was conveyed by text and numbers, sound, colours, icons, maps, graphs, animations, and photos depending on availability, country habits, channel requirements, and user friendliness. Based on the evaluation done in all the countries the following main conclusions can be drawn for the eight services tested:

Internet: Considered vital as the service that has all necessary facts and completeness. It backs all the other services.

WAP: Probably a solution that will not be much used in the future. However still good for some pull scenarios when people are on the move.

PDA: Difficult to conclude especially because of the low market penetration. Probably not interesting for public, might be interesting for expert users in the future.

Email: Positive response from users, recommended basic service since it is also so cheap to make.

SMS: The overall most preferred solutions for the public as push service.

MMS: Interesting new service, but can not beat the easy to use SMS, especially because a SMS in fact can provide all necessary facts.

Voice: In some countries outdated or less accepted, but worked very well in France.

Street panels: Uncertain effect. Might be outdated or too expensive.

When evaluating the answers to all questionnaires across all the five countries, the following overall conclusion can be made:

- Internet pages are the preferred pull service, and are considered vital, especially in combination with SMS.
- SMS is definitely the preferred push service.

When evaluating the overall conclusion on the new type of services, it is clear that there are great differences in the conclusions of the usefulness in the various countries. The services tested in Germany should generally – but also for those with allergies – be classified solely as "niche" services (especially for those sensitive to ozone) rather than mass market services. In France, the way the information was delivered was very well perceived by the participants: they confirmed the interest of receiving air quality information by SMS. Half of interviewed people declared they were ready to pay for the reception of air quality information by SMS.

It seems that the overall conclusion in Greece is somewhere between the French and the German, while the conclusions for both Spain and Norway are very positive, like the French one. It is difficult from the material obtained to explain the differences. The German partners explain the lack of interest in still rather low use of new

mobile services in Germany. This can for instance explain the high interest in Norway where APNEE type of services are available to all users in the two APNEE test sites on a permanent basis from March 2004. In Norway mobile services are among the highest in the world per inhabitant.

8. Conclusions

APNEE and APNEE-TU have implemented, customised and evaluated a carefully selected array of modern ICT services to convey information from trusted environmental sources towards the citizen. The array of technologies ranges from sophisticated presentations for the Internet, over stationary displays in selected locations, e.g. street panels, up-to mobile services to reach the citizen on the move even with location dependent content.

The complementarity and in particular the situateness of services have proven decisive for reaching the citizen, i.e. advising people about episodes that might cause harm to their health. MMS services sound attractive from a technology point of view and WAP services allow for more detailed information when being mobile. Yet, SMS services have proven sufficient in several field trials. The key findings for reaching the citizen with modern ICT include:

Regional and cultural diversity — information interests and service acceptance varies across regions, i.e. there are significant differences in terms of what users in different countries want and like. This means also that bringing APNEE solutions to new countries requires a careful evaluation of citizen culture and habits.

SMS most favourable — In a fairly high number of cases users expressed their favour for SMS as preferred means for receiving current and location dependent air quality data.

Air quality indices — The state of air quality has to be communicated in the context of an air quality index. The citizen does not consider air quality information when conveyed as raw data. Indices established at national levels, such as the ATMO in France and the newly supported LQI in the German field trial, have proven a significant raise of acceptance and awareness with regard to air quality. Indices at European level are needed and the grass root approach of APNEE succeeded to offer air quality information at index levels.

More health information — Information on air quality ought to be accompanied by health information. What citizen knows the impact of a specific peak of particular matters on his or her children? Shall my kid practice outside and play soccer when exposed to 50µg or better play monopoly inside? Here it is, where additional health information and advice produce an added value to the citizen and raise acceptance.

Forecast information — Current values are already of interest, but people request forecast information. Independent of the scientific complexity of forecasting air quality, there is a strong request for this kind of information that needs to be served.

Economic diversity — APNEE and in more depth APNEE-TU witnessed a diversity in the willingness to pay for this kind of services across Europe. While the willingness in Norway is rather high, willingness in Spain is rather low, which is also reflected by a Telco's business decision to offer APNEE -like services as incentive for their mobile service bundles.

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