Research Note:

The GDL Data Transmission Experiment

D. Rumpel, D. Proske, W. Kempinski, M. Hummel

Abstract

The experiment was designed to demonstrate the data transmission capabilities of a language-oriented data system (GDL). In a realistic simulation, an unknown computer-controlled substation was connected to a control centre. By inquiry to the substation, the control centre computer got informed on the stock of objects and the topological connections in this substation, then designed interactive diagrams for its switchyards. Finally, this substation was controlled as for switching and transformer tapping by an operator. The time required to couple the previously unknown substation to the control system amounted to 100 s.

1 Introduction

In power system control, process data have to be transmitted between substations and control centres, as well as within control centre hierarchies. Data transmission requires, that the data make sense at the sending and receiving end. The present endeavour to achieve mutual understanding is to agree and possibly standardize positional ordered transmission formats, which have to be filled from the sending data base by data transformations and which have to be entered to the receiving data base via transformations, in order to be interpretable by the control centre programs. Even if it is possible to standardize all transmission formats, a continual administration of the data transformations is triggered by changes in data requirements as well as by reconstructions and extensions of the power system.

A language-oriented approach will require a standard syntax, which is capable to formulate any expressions (commands, indications, measurand files etc.) useful in power system data transmission. The wording applied in these expressions has to be collected and defined in a dictionary, which is distributed to all sending and receiving points in order to achieve a full mutual understanding. Such a dictionary could also, with medium effort, be standardized within one utility and would require amendment only, when a new notion appears in a new design. Using the dictionary and the syntax, any required data expression could be formulated combinatorial at demand, be transmitted, and be understood even without imbedding it into the receiving data base.

Further, it is possible to structure language-oriented process data bases according to the very same syntax. Thus, data transformations for extraction and insertion of messages shrink to simple selection rules, which can also be formulated at demand and require no special administration. As such selection rules can also be expressed by the general syntax, it becomes possible to send data requests at demand and get them answered in understandable form.

If, then, the data base is in the general syntax, it would be possible to transmit whole – or parts of – data bases in a form interpretable without further data transformations.

2 Available Tools

The introduction first illustrated the possibilities of a language-oriented data transmission, then the advantages of a language-oriented data base in that scheme. In the present experiment, actually, this approach is inverted:

- A data language and a language-oriented data base has been developed at Duisburg University in form of the GDL (Grid Data Language) data system. Since several years, it is applied to describe any given power system in operative detail, in order to fill it into a training-simulator. The advantages of language orientation exploited in this application are the efficiency and flexibility of the data acquisition; further the transparency of the data in the trilateral relationships between data describer, application programs and operator's surfaces [2].
- The present task was to extend this data transparency also to remote installations in order to show the capability of this language-oriented system in data transmission.

For that aim, the language and the data base of the GDL-system, as well as the routines for automatic substation diagram design and event management were adopted from the training simulator. The communication- and coupling routines had to be newly developed.

3 Frame of the Experiment

The experiment was part of a research project on Hierarchical Power System Control [1] supported by the DFG (German Research Council), in which Zittau Uni-

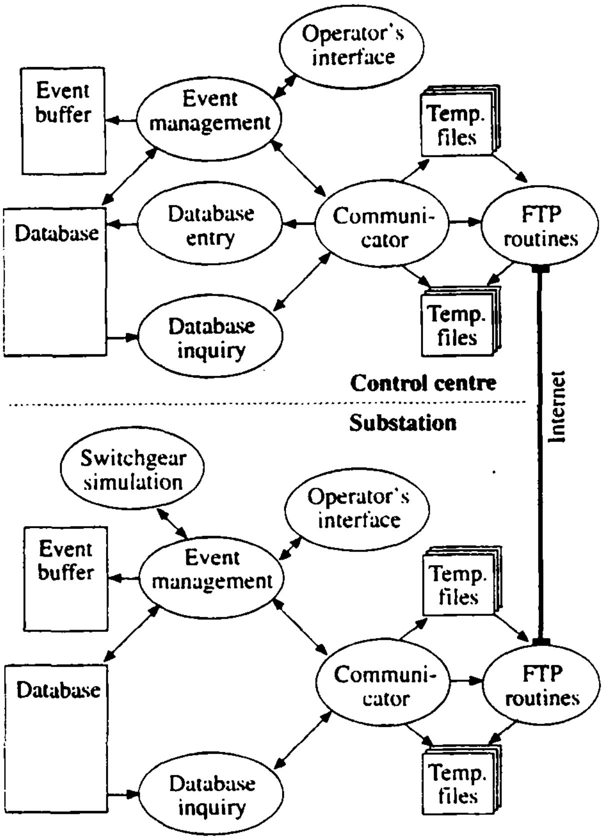

Fig. 1. Processes for communication between control-centre and substation

versity (presently HTWS-Zittau-Görlitz) studied the substation issues and Duisburg University cared for the control centre part. The distance between Zittau and Duisburg, by the way, is 560 km.

The GDL data system was available at both ends. The communication- and coupling routines were developed at Duisburg. Using these facilities, the system illustrated in **Fig. 1** was set up. A communication via Internet was foreseen, as this network is available to universities at a cheap price.

For the Internet data communication using the File-Transfer-Protocol (FTP), the following communication routines were implemented:

- Announcement of a substation to the control centre.
- Confirmation of the control centre.
- Bulk data transmission.
- Event element transmission.
- Measurand set transmission.
- Cancellation of the substation.

The coupling between the communication routines and the existent program system required the development of a larger interface program named Communicator.

4 The Experiment

For application in their research, Zittau had been given the documentation of a main substation near Dresden. This substation contains three switchyards on 220 kV, 110 kV and 20 kV and comprises 65 bays, 268 switches and 238 measurands, further six transformers and ground-fault compensation on 110 kV and 20 kV level.

The GDL description of this substation was done by Zittau and, on data base-level, amounted to 12.25 kByte. Additional requirements arose from the fact that Zittau had entered their own definitions to the GDL dictionary (14.77 kByte) and used special symbol definitions (58.77 kByte). Thus, in total 85.79 kByte of data had to be transmitted in the experiment in order to get the full substation information.

All these data were unknown to the "control centre" Duisburg, when the experiment was started by the announcement of the substation to the control centre, followed by the acknowledgement, and the request for bulk data transmission of the 86 kByte specified above. After the automatic diagram design in the control centre and the request for cyclic measurand transmission, the previously unknown substation (resp. its model in the Zittau computer) was under full display and control at Duisburg.

For these procedures, a gross time of about 20 min was required, which mainly resulted from waiting for Internet operations. The net time for transmission and computer operation took about 100 s, as detailed in the following.

- *Preparation*

Global data transmission (86 kByte):	60 s
Integration of substation to control centre data base:	< 1 s
Design and integration of diagrams:	5 s

- *Measurand-set transmission*

Preparation in substation:	< 0.8 s
Transmission (2 kByte):	6 s ... 16 s
Refreshing the control centre data base:	< 0.2 s

- *Control*

Switch command from Duisburg until back-indication on the screen:	13 s ... 15 s
Indication of a spontaneous status change to Duisburg:	9 s ... 12 s

The transmission times were evaluated using a continuous telephonic contact between Zittau and Duisburg during the experiment.

Fig. 2a to **2c** show the three interactive substation diagrams, which were automatically designed at Duisburg on the base of the transmitted GDL description. The measurands were cyclically transmitted at zero value, as the dynamic computation part of the Zittau simulator was not active during the experiment. The ground-fault compensation plant appears in both (110 kV and 20 kV) switchyard-diagrams in full, albeit only one bus is actively connected, because this plant was described in a common "GDL section".

5 Consequences

As a matter of course, the transmission times via Internet can be largely reduced using a WAN, e.g. on fibre optics, dedicated to utility process-data communi-

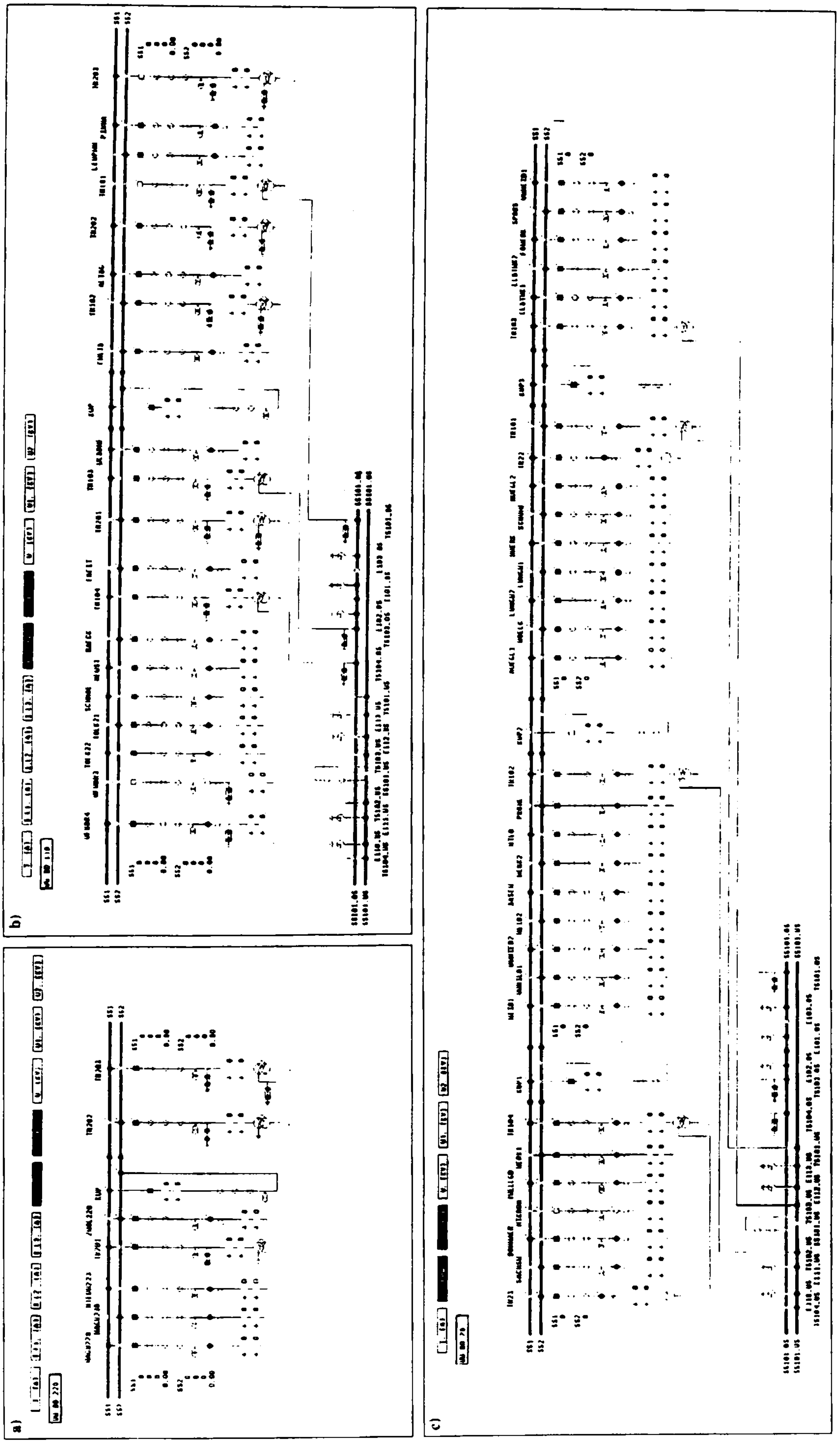

Fig. 2. Automatically designed diagrams of the three switchyards contained in UW_DD
a) UW_DD 220   b) UW_DD 110   c) UW_DD 20

cation. Also, with a bit of standardization work within a utility, the special transmission of the dictionary and of the symbol set could be avoided, thus shrinking the bulk data for initializing the control centre data base (in our case) from 85 kByte to 12 kByte. On that basis, one can envision to install an emergency control centre within some 10 min at any place, where the WAN is accessible.

On the other hand, substation data bases have to provide a content, which is diverging from the data set usually administered in control centres. This fact was already apparent in the experiment, where – to the astonishment of Duisburg – three-phase measurements, measurand transformers and surge diverters appeared in the transmitted description and, thus, in the diagrams. A filtering, and – in some cases – also a compression of the substation data is required. In language-oriented systems, such requirements can be expressed by rules formulated in the general syntax. Extending the system of Fig. 1, selection rules can also be transmitted to the substation in order to do the filtering there, before transmission.

The facility to formulate and send selection rules can also be used at demand to inquire for substation data which are normally not under the administration of the given control centre and are normally not transmitted there. As the answers are received in an understandable form, they can be processed and visualized from the temporary files using the same tools in parallel to the control-centre data base.

References

[1] *Rumpel, D.; Proske, D.:* Transparent Data Communication in Substation/Control Centre Hierarchies. CIGRE-Sympos., Helsinki/Finland 1995, Proc. pap. 600-10

[2] *van Ommeren, P.; van Son, P.; Rumpel, D.; Litzinger, A.:* Training the Restoration of Electricity Supply Systems in The Netherlands. ETEP Eur. Trans. on Electr. Power 4 (1994) no. 6, pp. 547–550

Acknowledgement

The authors have to give their thanks for the support by the DFG and for the realistic data provided by several utilities.

Manuscript received on July 16, 1996

The Authors

Dr.-Ing. Dieter Rumpel (1932), VDE, is full professor and since 1978 head of the Power Systems Institute of Duisburg University, Germany. He got his Dipl.-Ing. degree from the Technical University Munich, Germany, and his Dr.-Ing. degree from the Technical University Berlin; Germany. Before his call to Duisburg he worked at Siemens AG for 23 years. (Gerhard-Mercator-Universität-GH-Duisburg, Fachbereich Elektrotechnik, D-47048 Duisburg/Germany, Tel +49 203/379-3437, Fax +49203/379-2749)

Wolfgang Kempinski (1964) received his diploma (Dipl.-Ing.) degree in Electrical Engineering from the University of Duisburg/Germany in 1989. From 1989 to 1991 he joined the AEG Softwaretechnik GmbH & Co. KG, Frankfurt/Germany and was involved in software development for the control center of a large electricity transmission and supply utility. Since 1991 he is member of the Electrical Power Systems Institute at the University of Duisburg. His main research activities are in visualisation concepts for a training simulator for electrical power systems. (Gerhard-Mercator-Universität-GH-Duisburg, FB 9 Elektrotechnik, D-47048 Duisburg/Germany, Tel +49203/379-3211, Fax +49203/379-2749)

Professor Detlef Proske (1943) received the Dipl.-Ing. and Dr.-Ing. degree, special subject "Electric Drives", at the University of Technology, Dresden/Germany, Faculty Electrical Engineering, in 1971 and 1975, respectively. He was appointed as a Senior Lecturer in 1978 and as an Assistant Professor (Dozent) in 1987 at the University of Technology, Zittau/Germany. There he received his Dr. sc. techn. (Dr.-Ing. habil) degree, special subject "Control of Power Systems". In 1993 he became a Professor at the HTWS Zittau/Görlitz (FH). (HTWS Zittau/Görlitz (FH), FB Elektrotechnik, Theodor-Körner-Allee 16, D-02763 Zittau/Germany, Tel +4935 83/61 1549, Fax +4935 83/61 1330)

Dipl.-Ing. Matthias Hummel (1964) studied from 1986 to 1990, special subject "Technical Cybernetics and Automation Technology", at the University of Technology, Dresden/Germany. Afterwards he worked as a research student at the University's Institute "Automation Technology" in the field of "Programmable Logic Control". Since 1993 he is a scientific assistant at the HTWS Zittau/Görlitz (FH)/Germany, special subject "Control of Power Systems". (HTWS Zittau/Görlitz (FH), FB Elektrotechnik, Theodor-Körner-Allee 16, D-02763 Zittau/Germany, Tel +4935 83/61 1305, Fax +4935 83/61 1330)