

# 52. IWK

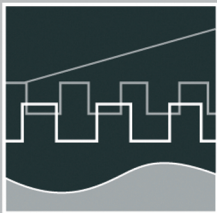
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## **FACULTY OF COMPUTER SCIENCE AND AUTOMATION**



## **COMPUTER SCIENCE MEETS AUTOMATION**

### **VOLUME I**

**Session 1 - Systems Engineering and Intelligent Systems**

**Session 2 - Advances in Control Theory and Control Engineering**

**Session 3 - Optimisation and Management of Complex  
Systems and Networked Systems**

**Session 4 - Intelligent Vehicles and Mobile Systems**


**Session 5 - Robotics and Motion Systems**



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## Preface

Dear Participants,

Confronted with the ever-increasing complexity of technical processes and the growing demands on their efficiency, security and flexibility, the scientific world needs to establish new methods of engineering design and new methods of systems operation. The factors likely to affect the design of the smart systems of the future will doubtless include the following:

- As computational costs decrease, it will be possible to apply more complex algorithms, even in real time. These algorithms will take into account system nonlinearities or provide online optimisation of the system's performance.
- New fields of application will be addressed. Interest is now being expressed, beyond that in "classical" technical systems and processes, in environmental systems or medical and bioengineering applications.
- The boundaries between software and hardware design are being eroded. New design methods will include co-design of software and hardware and even of sensor and actuator components.
- Automation will not only replace human operators but will assist, support and supervise humans so that their work is safe and even more effective.
- Networked systems or swarms will be crucial, requiring improvement of the communication within them and study of how their behaviour can be made globally consistent.
- The issues of security and safety, not only during the operation of systems but also in the course of their design, will continue to increase in importance.

The title "Computer Science meets Automation", borne by the 52<sup>nd</sup> International Scientific Colloquium (IWK) at the Technische Universität Ilmenau, Germany, expresses the desire of scientists and engineers to rise to these challenges, cooperating closely on innovative methods in the two disciplines of computer science and automation.

The IWK has a long tradition going back as far as 1953. In the years before 1989, a major function of the colloquium was to bring together scientists from both sides of the Iron Curtain. Naturally, bonds were also deepened between the countries from the East. Today, the objective of the colloquium is still to bring researchers together. They come from the eastern and western member states of the European Union, and, indeed, from all over the world. All who wish to share their ideas on the points where "Computer Science meets Automation" are addressed by this colloquium at the Technische Universität Ilmenau.

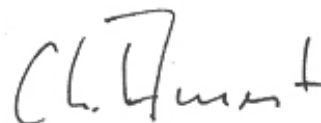
All the University's Faculties have joined forces to ensure that nothing is left out. Control engineering, information science, cybernetics, communication technology and systems engineering – for all of these and their applications (ranging from biological systems to heavy engineering), the issues are being covered.

Together with all the organizers I should like to thank you for your contributions to the conference, ensuring, as they do, a most interesting colloquium programme of an interdisciplinary nature.

I am looking forward to an inspiring colloquium. It promises to be a fine platform for you to present your research, to address new concepts and to meet colleagues in Ilmenau.



Professor Peter Scharff  
Rector, TU Ilmenau



Professor Christoph Ament  
Head of Organisation



## Table of Contents



## CONTENTS

	Page
<b>1 Systems Engineering and Intelligent Systems</b>	
A. Yu. Nedelina, W. Fengler DIPLAN: Distributed Planner for Decision Support Systems	3
O. Sokolov, M. Wagenknecht, U. Gocht Multiagent Intelligent Diagnostics of Arising Faults	9
V. Nissen Management Applications of Fuzzy Control	15
O. G. Rudenko, A. A. Bessonov, P. Otto A Method for Information Coding in CMAC Networks	21
Ye. Bodyanskiy, P. Otto, I. Pliss, N. Teslenko Nonlinear process identification and modeling using general regression neuro-fuzzy network	27
Ye. Bodyanskiy, Ye. Gorshkov, V. Kolodyazhniy, P. Otto Evolving Network Based on Double Neo-Fuzzy Neurons	35
Ch. Wachten, Ch. Ament, C. Müller, H. Reinecke Modeling of a Laser Tracker System with Galvanometer Scanner	41
K. Lüttkopf, M. Abel, B. Eylert Statistics of the truck activity on German Motorways	47
K. Meissner, H. Hensel A 3D process information display to visualize complex process conditions in the process industry	53
F.-F. Steege, C. Martin, H.-M. Groß Recent Advances in the Estimation of Pointing Poses on Monocular Images for Human-Robot Interaction	59
A. González, H. Fernlund, J. Ekblad After Action Review by Comparison – an Approach to Automatically Evaluating Trainee Performance in Training Exercise	65
R. Suzuki, N. Fujiki, Y. Taru, N. Kobayashi, E. P. Hofer Internal Model Control for Assistive Devices in Rehabilitation Technology	71
D. Sommer, M. Golz Feature Reduction for Microsleep Detection	77

F. Müller, A. Wenzel, J. Wernstedt A new strategy for on-line Monitoring and Competence Assignment to Driver and Vehicle	83
V. Borikov Linear Parameter-Oriented Model of Microplasma Process in Electrolyte Solutions	89
A. Avshalumov, G. Filaretov Detection and Analysis of Impulse Point Sequences on Correlated Disturbance Phone	95
H. Salzwedel Complex Systems Design Automation in the Presence of Bounded and Statistical Uncertainties	101
G. J. Nalepa, I. Wojnicki Filling the Semantic Gaps in Systems Engineering	107
R. Knauf Compiling Experience into Knowledge	113
R. Knauf, S. Tsuruta, Y. Sakurai Toward Knowledge Engineering with Didactic Knowledge	119
<b>2 Advances in Control Theory and Control Engineering</b>	
U. Konigorski, A. López Output Coupling by Dynamic Output Feedback	129
H. Toossian Shandiz, A. Hajipoor Chaos in the Fractional Order Chua System and its Control	135
O. Katernoga, V. Popov, A. Potapovich, G. Davydau Methods for Stability Analysis of Nonlinear Control Systems with Time Delay for Application in Automatic Devices	141
J. Zimmermann, O. Sawodny Modelling and Control of a X-Y-Fine-Positioning Table	145
A. Winkler, J. Suchý Position Based Force Control of an Industrial Manipulator	151
E. Arnold, J. Neupert, O. Sawodny, K. Schneider Trajectory Tracking for Boom Cranes Based on Nonlinear Control and Optimal Trajectory Generation	157



K. Shaposhnikov, V. Astakhov The method of ortogonal projections in problems of the stationary magnetic field computation	165
J. Naumenko The computing of sinusoidal magnetic fields in presence of the surface with bounded conductivity	167
K. Bayramkulov, V. Astakhov The method of the boundary equations in problems of computing static and stationary fields on the topological graph	169
T. Kochubey, V. Astakhov The computation of magnetic field in the presence of ideal conductors using the Integral-differential equation of the first kind	171
M. Schneider, U. Lehmann, J. Krone, P. Langbein, Ch. Ament, P. Otto, U. Stark, J. Schrickel Artificial neural network for product-accompanied analysis and control	173
I. Jawish The Improvement of Traveling Responses of a Subway Train using Fuzzy Logic Techniques	179
Y. Gu, H. Su, J. Chu An Approach for Transforming Nonlinear System Modeled by the Feedforward Neural Networks to Discrete Uncertain Linear System	185
<b>3      Optimisation and Management of Complex Systems           and Networked Systems</b>	
R. Franke, J. Doppelhammer Advanced model based control in the Industrial IT System 800xA	193
H. Gerbracht, P. Li, W. Hong An efficient optimization approach to optimal control of large-scale processes	199
T. N. Pham, B. Wutke Modifying the Bellman's dynamic programming to the solution of the discrete multi-criteria optimization problem under fuzziness in long-term planning	205
S. Ritter, P. Bretschneider Optimale Planung und Betriebsführung der Energieversorgung im liberalisierten Energiemarkt	211
P. Bretschneider, D. Westermann Intelligente Energiesysteme: Chancen und Potentiale von IuK-Technologien	217

Z. Lu, Y. Zhong, Yu. Wu, J. Wu WSReMS: A Novel WSDM-based System Resource Management Scheme	223
M. Heit, E. Jennenchen, V. Kruglyak, D. Westermann Simulation des Strommarktes unter Verwendung von Petrinetzen	229
O. Sauer, M. Ebel Engineering of production monitoring & control systems	237
C. Behn, K. Zimmermann Biologically inspired Locomotion Systems and Adaptive Control	245
J. W. Vervoorst, T. Kopfstedt Mission Planning for UAV Swarms	251
M. Kaufmann, G. Bretthauer Development and composition of control logic networks for distributed mechatronic systems in a heterogeneous architecture	257
T. Kopfstedt, J. W. Vervoorst Formation Control for Groups of Mobile Robots Using a Hierarchical Controller Structure	263
M. Abel, Th. Lohfelder Simulation of the Communication Behaviour of the German Toll System	269
P. Hilgers, Ch. Ament Control in Digital Sensor-Actuator-Networks	275
C. Saul, A. Mitschele-Thiel, A. Diab, M. Abd rabou Kalil A Survey of MAC Protocols in Wireless Sensor Networks	281
T. Rossbach, M. Götze, A. Schreiber, M. Eifart, W. Kattanek Wireless Sensor Networks at their Limits – Design Considerations and Prototype Experiments	287
Y. Zhong, J. Ma Ring Domain-Based Key Management in Wireless Sensor Network	293
V. Nissen Automatic Forecast Model Selection in SAP Business Information Warehouse under Noise Conditions	299
M. Kühn, F. Richter, H. Salzwedel Process simulation for significant efficiency gains in clinical departments – practical example of a cancer clinic	305

D. Westermann, M. Kratz, St. Kümmerling, P. Meyer Architektur eines Simulators für Energie-, Informations- und Kommunikationstechnologien	311
P. Moreno, D. Westermann, P. Müller, F. Büchner Einsatzoptimierung von dezentralen netzgekoppelten Stromerzeugungsanlagen (DEA) in Verteilnetzen durch Erhöhung des Automatisierungsgrades	317
M. Heit, S. Rozhenko, M. Kryvenka, D. Westermann Mathematische Bewertung von Engpass-Situationen in Transportnetzen elektrischer Energie mittels lastflussbasierter Auktion	331
M. Lemmel, M. Schnatmeyer RFID-Technology in Warehouse Logistics	339
V. Krugljak, M. Heit, D. Westermann Approaches for modelling power market: A Comparison.	345
St. Kümmerling, N. Döring, A. Friedemann, M. Kratz, D. Westermann Demand-Side-Management in Privathaushalten – Der eBox-Ansatz	351
<b>4      Intelligent Vehicles and Mobile Systems</b>	
A. P. Aguiar, R. Ghabchelloo, A. Pascoal, C. Silvestre , F. Vanni Coordinated Path following of Multiple Marine Vehicles: Theoretical Issues and Practical Constraints	359
R. Engel, J. Kalwa Robust Relative Positioning of Multiple Underwater Vehicles	365
M. Jacobi, T. Pfützenreuter, T. Glotzbach, M. Schneider A 3D Simulation and Visualisation Environment for Unmanned Vehicles in Underwater Scenarios	371
M. Schneider, M. Eichhorn, T. Glotzbach, P. Otto A High-Level Simulator for heterogeneous marine vehicle teams under real constraints	377
A. Zangrilli, A. Picini Unmanned Marine Vehicles working in cooperation: market trends and technological requirements	383
T. Glotzbach, P. Otto, M. Schneider, M. Marinov A Concept for Team-Orientated Mission Planning and Formal Language Verification for Heterogeneous Unmanned Vehicles	389

M. A. Arredondo, A. Cormack SeeTrack: Situation Awareness Tool for Heterogeneous Vehicles	395
J. C. Ferreira, P. B. Maia, A. Lucia, A. I. Zapaniotis Virtual Prototyping of an Innovative Urban Vehicle	401
A. Wenzel, A. Gehr, T. Glotzbach, F. Müller Superfour-in: An all-terrain wheelchair with monitoring possibilities to enhance the life quality of people with walking disability	407
Th. Krause, P. Protzel Verteiltes, dynamisches Antriebssystem zur Steuerung eines Luftschiffes	413
T. Behrmann, M. Lemmel Vehicle with pure electric hybrid energy storage system	419
Ch. Schröter, M. Höchemer, H.-M. Groß A Particle Filter for the Dynamic Window Approach to Mobile Robot Control	425
M. Schenderlein, K. Debes, A. Koenig, H.-M. Groß Appearance-based Visual Localisation in Outdoor Environments with an Omnidirectional Camera	431
G. Al Zeer, A. Nabout, B. Tibken Hindernsvermeidung für Mobile Roboter mittels Ausweichecken	437
<b>5      Robotics and Motion Systems</b>	
Ch. Schröter, H.-M. Groß Efficient Gridmaps for SLAM with Rao-Blackwellized Particle Filters	445
St. Müller, A. Scheidig, A. Ober, H.-M. Groß Making Mobile Robots Smarter by Probabilistic User Modeling and Tracking	451
A. Swerdlow, T. Machmer, K. Kroschel, A. Laubenheimer, S. Richter Opto-acoustical Scene Analysis for a Humanoid Robot	457
A. Ahranovich, S. Karpovich, K. Zimmermann Multicoordinate Positioning System Design and Simulation	463
A. Balkovoy, V. Cacenkin, G. Slivinskaia Statical and dynamical accuracy of direct drive servo systems	469
Y. Litvinov, S. Karpovich, A. Ahranovich The 6-DOF Spatial Parallel Mechanism Control System Computer Simulation	477

V. Lysenko, W. Mintchenya, K. Zimmermann 483  
Minimization of the number of actuators in legged robots using  
biological objects

J. Kroneis, T. Gastauer, S. Liu, B. Sauer 489  
Flexible modeling and vibration analysis of a parallel robot with  
numerical and analytical methods for the purpose of active vibration damping

A. Amthor, T. Hausotte, G. Jäger, P. Li 495  
Friction Modeling on Nanometerscale and Experimental Verification

**Paper submitted after copy deadline**

**2 Advances in Control Theory and Control Engineering**

V. Piwek, B. Kuhfuss, S. Allers 503  
Feed drivers – Synchronized Motion is leading to a process optimization



T. Behrmann / M. Lemmel

## **Vehicle with pure electric hybrid energy storage system**

### **Abstract**

Hybrid systems to power vehicles are developed to compensate certain disadvantages of the main power supply, like low power dynamics in respect to the environmental factors or low power density relative to mass and costs. The advantages of hybrid systems are bought by higher level of system complexity and the need to handle these additional degrees of freedom. The quality of energy management systems is essential for the performance of the whole hybrid system.

The basis of this presentation is the German pilot project EFRB<sup>1</sup> - funded by the BMWi. The main focus of this project was the development, implementation and proving of a hybrid energy storage system consisting of different storage components. Well-known German automotive and energy storage manufacturer like DaimlerChrysler, Varta, Epcos etc. were partners within a consortium that was coordinated by BIBA/MAQ<sup>2</sup>.

Within this research project a flexible automotive concept has been developed, which enables flexible adaptation of the operation mode appropriate to power requirements of the hybrid vehicle application. The key idea is a composition of different electric energy storages into one energy storage system. The objective is to achieve both: large mileage and high acceleration in the same vehicle. The results can be transferred on other usual hybrid combinations of fuel cells, combustion engines, batteries and UltraCaps. The system components developed in this project could lead to an optimised possibility for building hybrid vehicles.

The system complexity of a hybrid vehicle leads to new degrees of freedom which require an operating control combined with an optimised energy management. It has the objective to set the power flow of each storage device appropriate to drive situation and the optimised working point of the combined system. Basic and advanced methods of control theory, modelling, rapid control prototyping, optimised control and model

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<sup>1</sup> Mobile electric storage system for vehicles with great mileage and high acceleration

<sup>2</sup> Bremen Institute of Industrial Technology and Applied Work Science at the University of Bremen  
Division Metrology, Automation and Quality Science

predictive control are the tools used for the development process.

### 1. Basic idea and concept

The comparison of energy density and power density shows that energy storages can either be optimized for a maximum energy density with considerable reduced power density or alternatively for a maximum power density thus in a decreased energy density. Electric energy storages with different properties of energy and power density have been chosen purposely for application in vehicles (see Fig. 1). The target is to compensate these divergent design objectives by combining different energy storages.

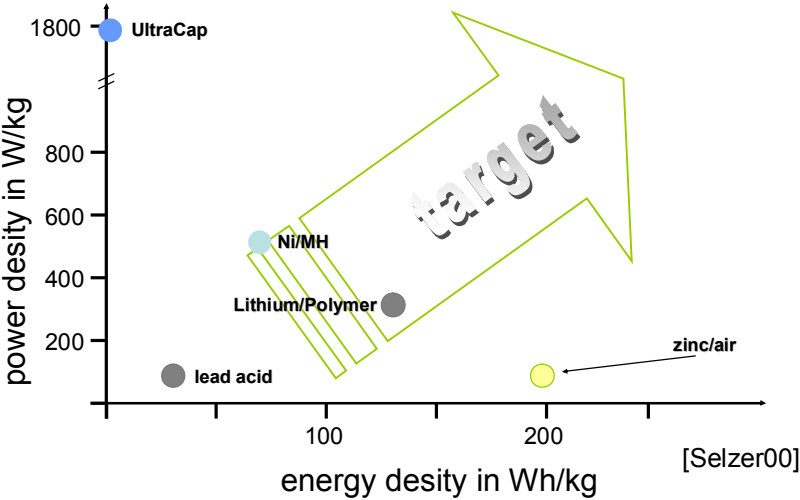


Fig 1 Ragone diagram of typical battery systems according to [Selz00]

Great mileage is covered by a long-term energy supply. Electric Fuel Company provides a zinc/air-battery with a high energy density. It has a relative low power density. In practice the fuel cells and small internal combination engines with generator have similar technical features, so that the results can be transferred on this issue.

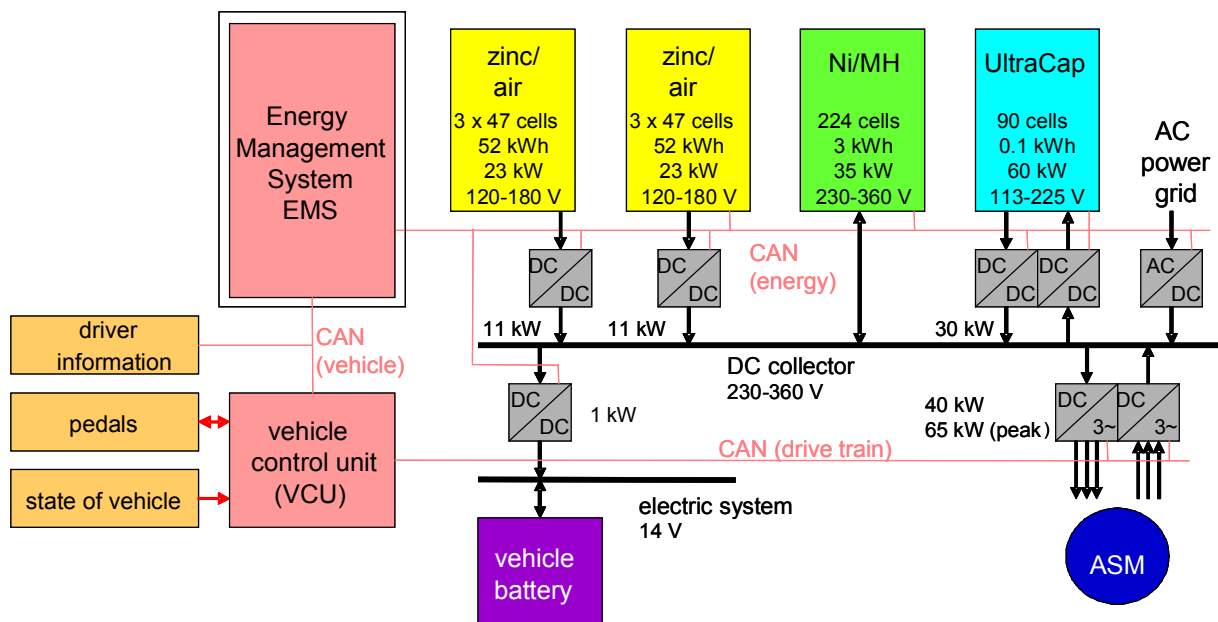
The supercapacitor UltraCap from Epcos has a high power density and is able to supply and sink high currents. In recuperation mode it stores energy from breaking manoeuvres. This component is an ideal for covering short term power demand. This brings high acceleration abilities into electric vehicles while energy balance increases. A Ni/MH battery from Varta provides mid-term energy and power supply. It supports in case of sustaining acceleration processes the zinc/air basic supply and serves as recuperation storage for long down hill routes.

To handle the hybrid storage system energy management is essential. It identifies ac-



tive drive situation (drive, roll, break, stop, acceleration, stop and go etc.) and computes the state-of-charges (SOC) of the storage units. Depending on this an assessment the power flows will be controlled according to the expected drive state [Stan03]. The state-of-charges will instead be controlled for strategic planning depending on the expected drive state [Qu04]. E.g. an empty UltraCap is useful in case of high probability of breaking manoeuvres like in city traffic. It influences the overall efficiency.

The schematic image in Fig. 2 shows the drive train and the energy storage system with all vehicle components. On the left hand side the logical in- and output units for the operating system are shown. The Energy management for the control of the power converters and reaction to the drivers' decisions is situated at the centre.



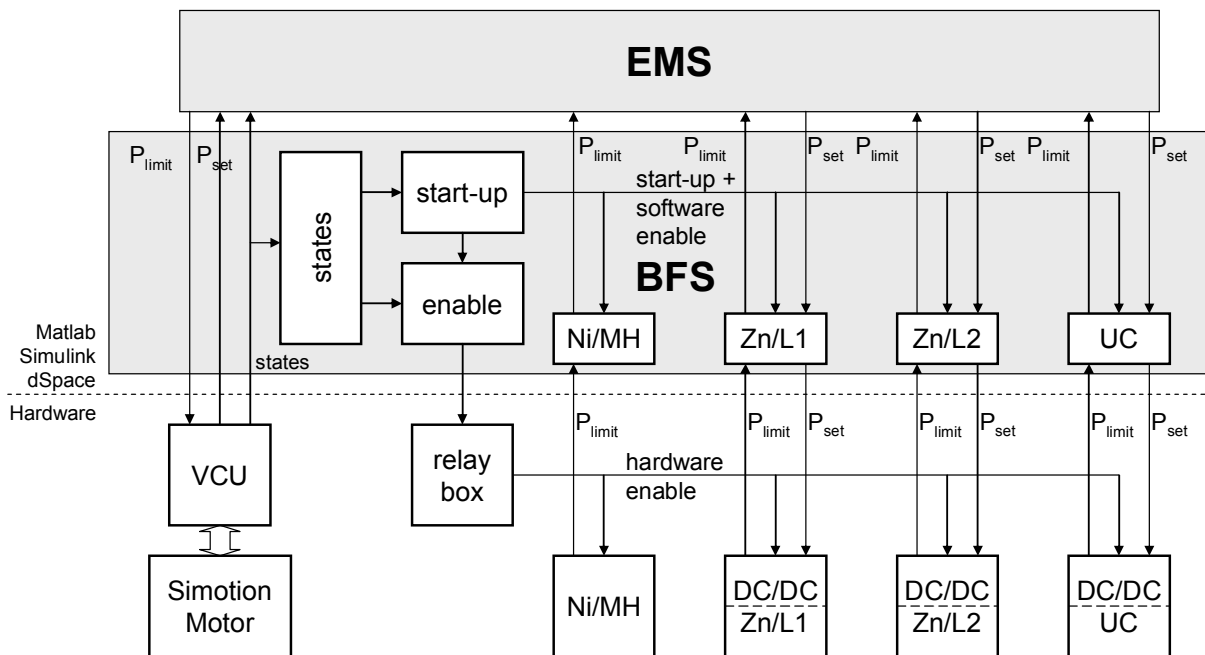
**Fig 2 Schematic picture of the EFRB hybrid energy storage concept**

The energy storages have different voltage operating ranges, so DC/DC converters are necessary for the connection over a main power bus. Direct connection of the Ni/MH battery keeps the bus voltage almost constant and has a robust behaviour in emergency situations. The zinc/air battery is connected by a unidirectional DC/DC converter with continuous power profile, while the UltraCap has to be operated bidirectional with high peak power characteristic.

The real-time communication of the active components of the storage system is implemented by a storage systems CAN bus.

## 2. The management of the traction energy

The two main components of the vehicle power supply are the energy management system (EMS) and the operating system (BFS). They ensure the operation of the three storage components and take care for optimal power flow. See Fig 3.



**Fig 3 Scheme for the management of the supply of traction energy**

The operating system (BFS) coordinates the boot process by enabling the single components in correct order. It supervises thresholds and global safety parameter and activates emergency modes if necessary. It interfaces the access of the available components to the energy management system (EMS).

The energy management contains several levels of decision and processing, which are illustrated schematically in Fig. 4 from left to right. Input data feeds are marked with arrows from the bottom.

The strategic planning components on the left hand side of the block diagram in Fig. 4 lead to the controller of the state of charge (SOC) of the energy storages. This controls the fraction of power supplied by each component (P-Mix-Planning). The planning components are implemented in rule based fuzzy controllers [Sorg04].

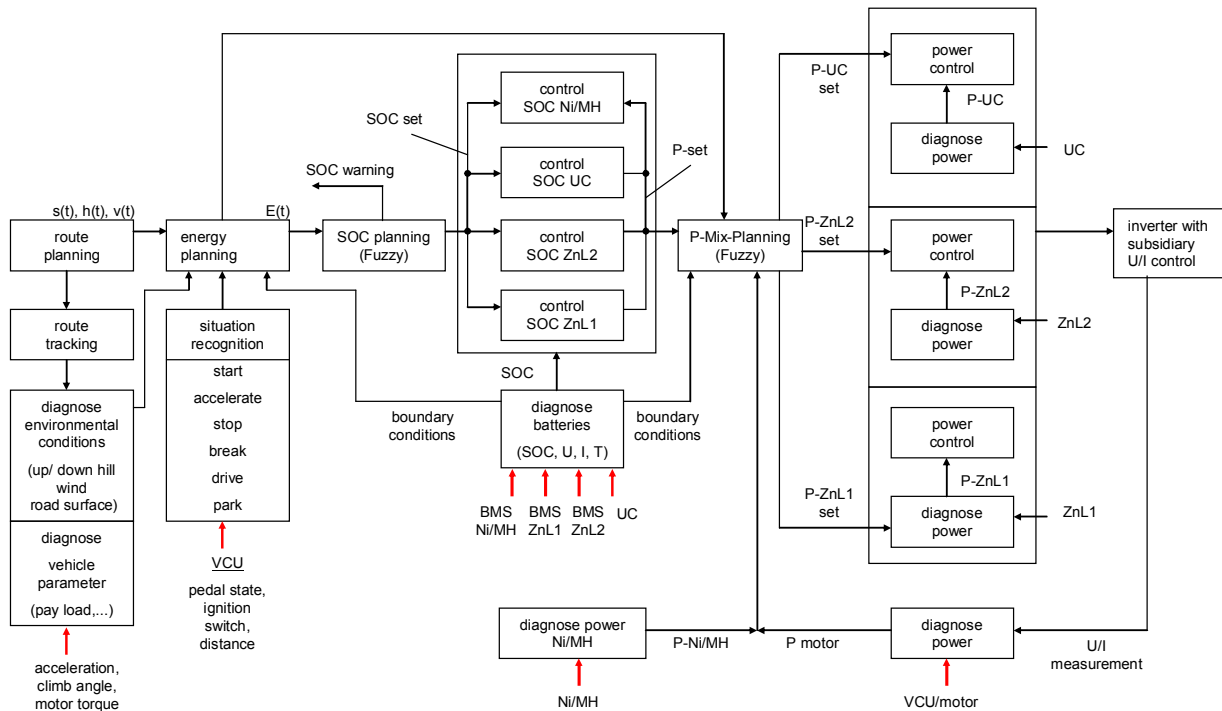


Fig. 4 Schematic overview of the energy management system (EMS) [Sorg04]

### 3. Conclusion

It has been shown, that the option to use a low power energy supply like zinc/air batteries or fuel cells can be supported by additional mid- and short-term components like Ni/MH batteries and UltraCaps. This situation dependant energy management leads to an up-to-date drive appeal with high efficiency. The results can be transferred to other hybrid constellations.

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