9 Urban Mobility and Smart Cities = a survey from a European R&D perspective

Prof. DI Günter KOCH
Humboldt Cosmos Multiversity, Tenerife

9.1 Abstract

Several members of the "European Research Consortium for Informatics and Mathematics" (ERCIM), an association combining major European Research Centers, engage in projects in building systems in support for Transport Mobility and Smart Cities.
Extracted from ERCIM's rich pool of knowledge and from current R&D projects being concentrated and available at different international ERCIM R&D sites, some of their concepts are discussed. The attempt is to demonstrate in a survey style the complexity and multi-dimensionality of the problems to be approached when building integrated and user friendly mobility systems – as much as technology can contribute to urban and regional mobility.

In order and for orientation to stay on a bird's view level, the discussion in this presentation opens with some references to charts and pictures, in conclusion providing the motivation for moving from today's silo approaches to more integrated and consolidated systems in support of urban mobility, not denying that the systems to be constituted are technically highly complex and by far not yet homogeneously integrated. The key message is, that it is not enough to combine different sources of information, the real challenge is to integrate information by semantic integration.
Finally, coping with the complexity of building such integrated systems, politicians, administrators, engineers, IT specialists and project managers too often forget to (re-)start from and to serve users' or customers' interests and needs. An example from Vienna is given. The conclusiving plea therefore is to include the user in the planning process not only for legal or formal reasons, but to make use of his/her competence by applying methods and tools well known and practiced in knowledge management. Such methods can ideally be applied for getting citizens involved and participating in mobility system and smart cities construction. To exploit such competence also applies to questions of data protection, data safety and security and privacy.

9.2 Keywords:

Urban Mobility, Smart City, IT Architecture, Knowledge Management, User Involvement
JEL: R – Urban and Regional Economics ; O – Economic Development, Technological Change, and Growth; M – Business Administration.

9.3 Resources for research on smart city development: The ERCIM network

ERCIM, the European Research Consortium in Informatics and Mathematics (www.ercim.eu) is a group of more than 20 leading and relevant European research institutions committed to information technology and to applied mathematics, by…
… building a European-wide, open network of “centres of excellence” in ICT,
… excelling in research and by acting as a bridge to applications,
… being internationally recognized as a major representative organisation in its field. Its portal gives access to all relevant ICT research groups in Europe,
…acting as an interface also for the non-EU member institutions within the European Community and other international organisations
In addition to its key function of bringing European ICT research together, the legal body of ERCIM, being a so called EEIG , in January 2003 became the European host of W3C. Quote: “With the move to ERCIM, there is the potential for considerable growth and synergies of Web technologies across Europe” (Tim Berners-Lee, W3C director and inventor of the Web).
The current fields of basic or semi basic research disciplines in which ERCIM member institutes engage are:

- Computational and Methodological Statistics
- Constraint based algorithms
- Dependable Software-Intensive Embedded Systems
- E-Mobility
- Environmental Modelling
- Formal Methods for Industrial Critical Systems
- Grids, P2P and Services
- Image and Video Understanding
- IT and Mathematics applied to Interventional Medicine
- Media Technology and Edutainment
- Models and Logics for Quantitative Analysis
- Security and Trust Management
- Sensor Web
- Software Evolution
- Software Engineering for Resilient Systems

ERCIM publishes regularly its ERCIM News, each edition under a key theme. The one issue in relation to the subject of this paper has been published under the title “Smart Cities” in July 2014.

9.4 Research projects in mobility and smart cities reported from the ERCIM community

The contributions to the subject of “Smart Cities” in this special ERCIM News issue are as numerous as indicated by the following list of ERCIM members’ projects indicated in the following list (quotation from the table of contents) which gives the impression that

- “Smart City” must be a hype subject in our decade,
- the definition of what a smart city is evidently is extraordinarily broad,
- the number of projects in this field, not only in research, must be uncountable,

- aspects of smart cities range over all disciplines, i.e. IT technology, environmental, political, sociological, geographical / geolocation, cartography… - in other words: it is a true multidisciplinary if not even a transdisciplinary challenge.

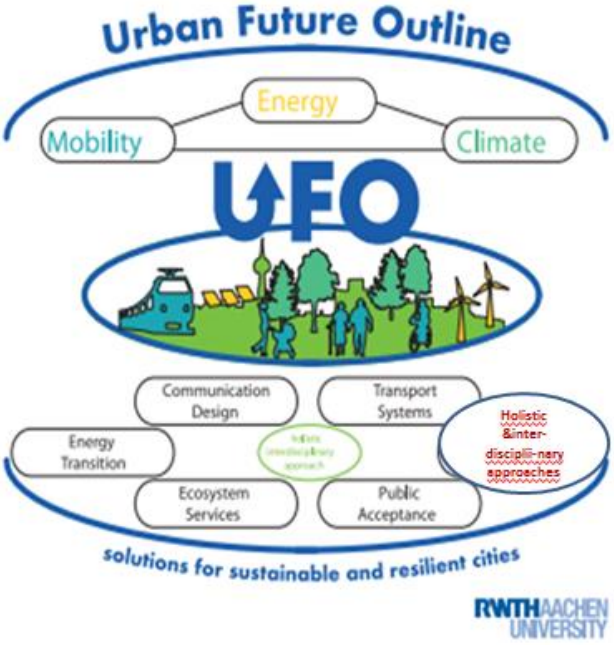
- Urban Future Outline - A Roadmap on Research for Livable Cities
- Urban Civics - Democratizing Urban Data for Healthy Smart Cities
- AppCivist - A Service-oriented Software Platform for Social Activism
- CityLab@Inria - A Lab on Smart Cities fostering Environmental and Social Sustainability
- A Framework for Improving the Multi-Device User Experience in Smart Cities
- Moving Towards Interoperable Internet-of-Things Deployments in Smart Cities
- Realizing Smart City Scenarios with the ALMANAC and DIMMER Platforms
- Internet of Things Applications for Neighbourhood Embedded Devices
- Internet of Things: A Challenge for Software Engineering
- Semantic Management of Moving Objects in Smart Cities
- Flexible Access to Services in Smart Cities: Let SHERLOCK Advise Modern Citizens
- Quantifying the Benefits of Taxi Trips in New York through Shareability Networks
- Integrated Electric Vehicles Sharing and Pooling Mobility Solutions for Smart Cities
- A Carpooling Recommendation System in the Smartphone Age
- A Smart Parking Campus: An Example of Integrating Different Parking Sensing Solutions into a Single Scalable System
- Stochastic Travel Planning for Unreliable Public Transportation Systems
- A Quantitative Approach to the Design and Analysis of Collective Adaptive Systems for Smart Cities
- Query-Driven Smart Grid City Management
- 'U-Sense', A Cooperative Sensing System for Monitoring Air Quality in Urban Areas
- Monitoring and Controlling Energy-positive Public Lighting: The E+grid System
- Demand-Side Management in Smart Micro-Grids: An Optimization Perspective
- Cyber Physical Systems give Life to the Internet of Energy
- When Smart Cities meet Big Data
- cItyAM: Managing Big Urban Data for Analyzing and Modelling Cities
- Urban-Scale Quantitative Visual Analysis
- Mobile Augmented Reality Applications for Smart Cities
- Monitoring People's Behaviour using Video Analysis and Trajectory Clustering
- Trusted Cells: Ensuring Privacy for the Citizens of Smart Cities
- Smart City Operation Center: A Platform to Optimize Urban Service Rendering
- Building Smarter Cities through ICT-driven Co-Innovation

From these 30 contributions the following key insights can be abstracted:

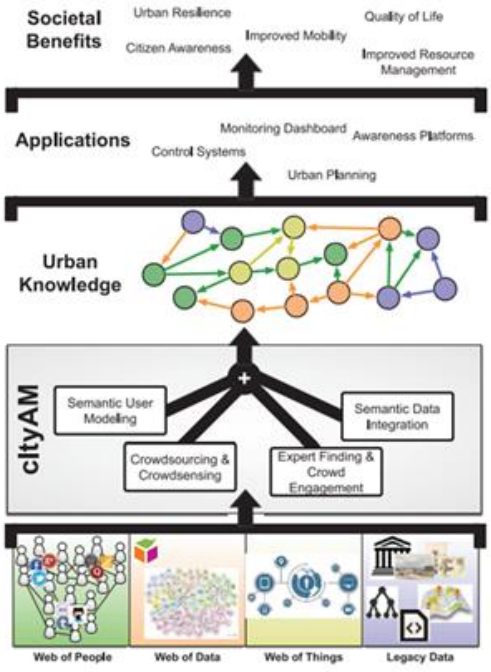
9.4.1 A larger framework needs to be taken for reference

The model of a smart city and its mobility infrastructure needs to be mapped into a framework which is wider than that only defined by technology. The two following charts draft the overall framework of a future urban environment as well as define the "benefit architecture" of a smart city based on its collective knowledge and its

transformation into benefits instantiated by “apps” to be offered to and used by the citizens.



UFO: matthias.jarke@fit.fraunhofer.de



TU Delft: direct.tudelft.nl/ahine-117.html

9.4.2 Mobility as a matter of optimal routing and transport

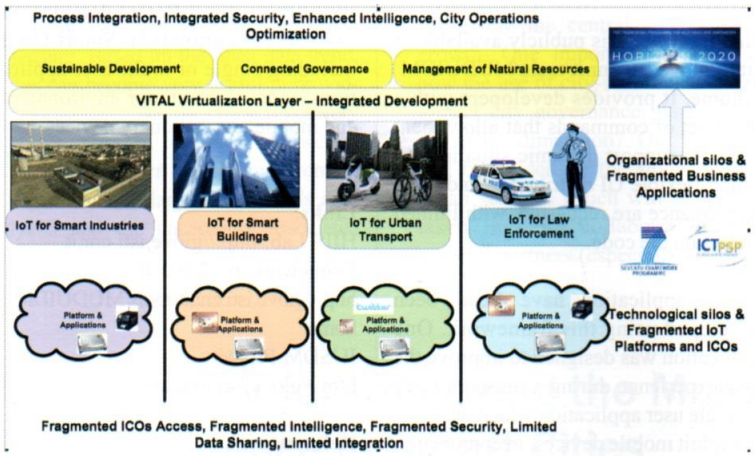
As for mobility, the simple question, hard to answer in practice is: What is the optimal transport connection from where I want to start and to where I want to go?

Optimisation criteria are manifold: cost, time, modality, comfort, minimal changes + walking distances, transport capacity, environmental stress, energy consumption, com-/ entertainment-facilities in carriers, …

Providing a routing solution based on a well specified individual “profile” may end up in a highly complex combination of data drawn from different sources, especially if the data sources are not compatible. Broker services as available in air transport based on common databases such as Amadeus do not yet exist over all modes of transport, although integration of information of public transport services and its timetables have been extended stepwise in larger municipality areas during the last decade.

9.4.3 Today's smart infrastructures are not (yet) smart – they are aggregations of mutually disjunctive function domains

There is no question that today's series of seemingly intelligent services in supporting our transport and mobility needs are in place, but eith respect to. to their level of interoperability they are still fragmented – as is presented in the EU FP7 project VITAL (www.vital-iot.com) – see :



9.4.4 The number of types of "web objects" being in place is increasing with the venue of every new technology

Part of the fragmentation problem is that the "objects" existing in structures for the support of services provided for the mobility of users moving around are manifold, as demonstrated by the following chart. It also gives an insight,of how many different references for any moving subject need to be maintained in order to identify the location of a user, to build connection to the device/s he or she is using, what preferences and what rights in a local context he/she has and what services he/she is requesting and using.

Mobile device object	*Makes use of multiple sensors (GPS, NFC, Accelerometer, etc.) to measure physical quantities. It is used to identify the user in other systems and to access the user's profile. It supports the user with GNSS (Global Navigation Satellite System) capability.*
NFC Door object	*Operates an NFC-tagged electromechanical door lock using a mobile device (equipped with an NFC sensor).*
User Profile object	*Stores users' preferences to query about them.*
GNSS Location object	*Represents the user's location.*
Location Rules object	*Represents the rules concerning location sensor-based services in order to trigger the corresponding requests to the home automation platform.*
Request object	*Stores the URI and Payload corresponding to the request performed by the mobile device.*
Home Automation Platform object	*Handles the mobile device requests, and also monitors and manages the home automation appliances.*

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9.5 Complexity of smart city development

The real challenge with respect to the design of a smart city and its mobility structure is to master the complexity of systems contributing to a smart city and their integration. But what generates complexity?
The interrelationships and dependencies in ICT systems providing the services for smart city mobility have developed towards a size, a level of opacity and multi-dimensionality which can only be characterized as complex – not just complicated. Being complicated is not being complex; it means that a certain effort is needed to solve a problem, but it is manageable anyway. Not so a complex problem.

There does not exist one common definition of complexity: A mathematician aims to find formulas describing phenomena that have proven hard to capture, such as changes in weather or financial markets. The interest of a technician is to learn how to master huge and virtually impossible to understand machinery or facilities. A medical doctor is hardly in a position to consider all factors which are relevant in a disease which is new or not yet curable. A psychologist or a cognition scientist may wonder how people take decisions in situations in which they do not have all data and facts needed and may be irritated. Such a scenario would be a human definition of complexity. At the “lower end” of obfuscations, computer scientists do research on the complexity of algorithms, and, at the “upper end” they are confronted in understanding the complexity of large systems, the largest being the Internet. And finally, sociologists seem to have surrendered in interpreting how society in its rapid development can be explained.

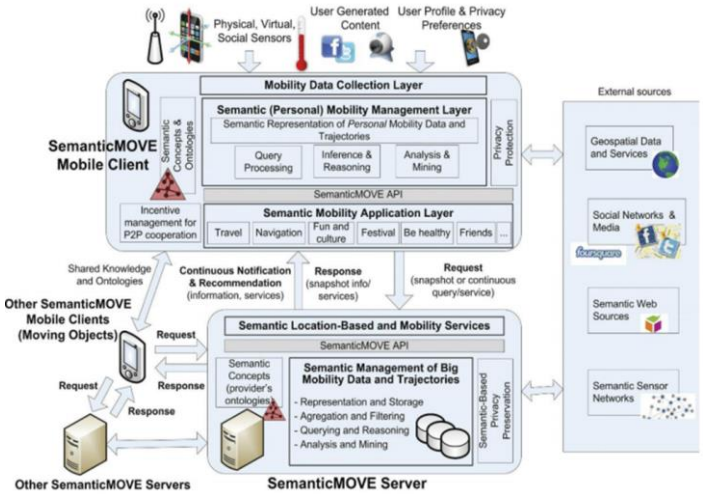
(There is no question that in such a situation, where large parts of society no longer understand in logic terms what is happening in reality tend to adopt esoteric models of explanations communicated by some self nominated Messiahs, most often consultants who want to make us believe that complexity can be reduced, as though factual complexity could be spirited away).
There exist options in terms of research institutes and researchers on a world scale who take up the challenge to study and to resolve complexity, as such, are the Santa Fé Institute in New Mexico, the IIASA Institute near Vienna, Austria, the COSY research group of Stefan Thurner in Vienna or the department for foresight research at the Austrian Institute of Technology. These experts are quite engaged; however, within the large community of scientists they are represented in subcritical numbers only.
“Complexity research” and the resulting knowledge body about complexity and its mastering still has not yet been introduced in education plans of universities, given that everybody perceives that the problems at hand as e.g. are smart cities, by their nature are complex and would need competence in mastering them. This holds for all the different grand challenge aspects of securing citizens’ future living conditions, e.g. climate, demography, diseases, finance, etc.
Citizens are becoming aware that those who are members of parliaments and governments are not as much in the know as is conceded. Polls made e.g. in the Austrian Parliament finding out about competences of the MPs in the field of financial politics disclosed concussive results showing that the number was lower than 10%. This is a typical, but in no way a singular case.

Albert Einstein, who himself was convinced of the rational, calculable and logical foundations of the world, was intelligent enough to state that (complex) problems

cannot be solved with the methods which have generated them. In a metaphoric (!) sense, this conforms to Kurt Goedel's discovery, which tells us that within a formal system of mathematics there may exist mathematical problems which cannot be decided if they can be solved within that system. Thus, the paradigm which limits the potential of humans in understanding complexity still results from the enlightenment of 250 years ago. So far its "laws" were helpful and produced the whole body of knowledge on which our modern society and technologies relies. However, the example of not understanding complexity demonstrates that we need new foundations of thinking. This is being achieved in science – an excellent example is quantum physics – but certainly not yet in everyday life.
We can identify new directions in founding a new paradigmatic basis that is helpful in dealing with complexity. One of the "ideological" preconditions, which makes us humble in our expectations, emerges from the discussion on constructivism. It tells us that in the end one only can master what one can understand, i.e. what we as humans are able to explain, being founded on scientifically sound insights. Beyond our own competences and capacities there do not exist absolute and objective truths. The silver bullet to cope with and to "master" complexity is to behave in a competent and educated way versus complex situations. The future, which is always a complex animal, cannot be foreseen, but what can be done is to participate actively in the design of the future, and that is mainly what constructivism tells us.

9.6 Semantic integration as the key challenge

In a formal sense the real complexity of a smart city system does not result from the aggregation and combination of components and functions which constitute the ICT foundations, much more it is the sensible and meaningful integration of the diverse information stemming from different sources as already has been pointed out above in 2. (3).
If we consider a full scope ICT architecture of a "smart city system" as the following one, it is evident that such system is not only complex, but its concern is to integrate all information so that the user will receive coherent information:



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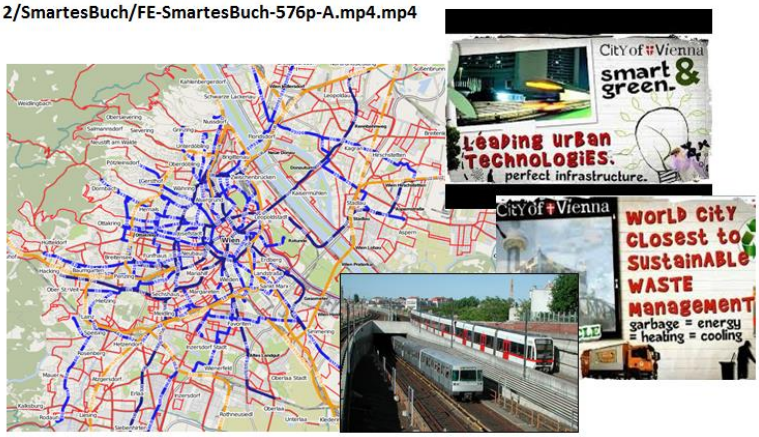
Semantics, by definition, is the study of meaning. It focuses on the relation between signifiers, like words, phrases, signs and symbols and what they stand for, their denotation. Forms of semantics include the semantics of programming languages, formal logics, and semiotics.
In computer science the term semantics refers to the meaning of languages, as opposed to their form (syntax). Semantics provides the rules for interpreting the syntax which do not provide the meaning directly but constrains the possible interpretations of what is declared. In other words, semantics is about interpretation of an expression. Additionally, the term semantics is applied to certain types of data structures specifically designed and used for representing information content.
A semantic network is a network which represents semantic relations between concepts. This is often used as a form of knowledge representation. It is a directed or undirected graph consisting of vertices, which represent concepts, and edges combining them.
In summary: Any real integration of information forming a “complete” information body delivering sensible information to its users needs mechanisms of semantic integration, which is more than just interfacing data formats, which, in the worst but practical case are incompatible.

9.7 The case of Vienna: an example for participative development

Complementary to the discussion on how to construct ICT systems underlying a smart city, the question is who specifies what the services of a smart city to its citizens are or shall be. Or, with other words, how do citizens participate in the development of “their” city.
A showcase on how and to what intensity citizens are involved can be studied in Vienna.
Already in the 1st decade of our century the city administration started a public consultative project what should be understood as a smart city Vienna – see copy of report here:

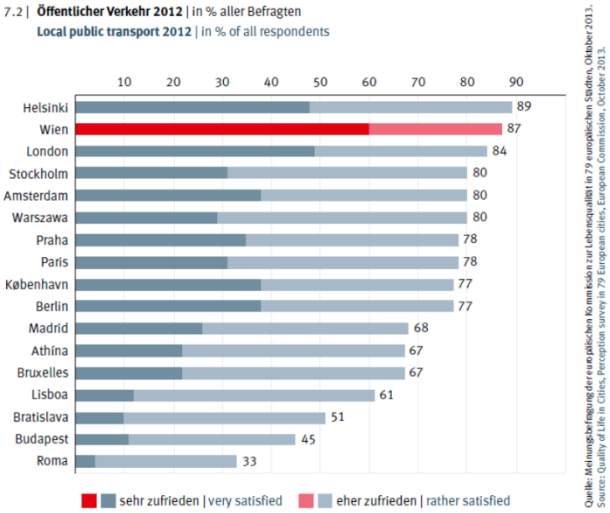
http://forschen-entdecken.at/fileadmin/user_upload/Forschen_Entdecken/videos/2013-2/SmartesBuch/FE-SmartesBuch-576p-A.mp4.mp4



This initial workshop was the starting point of a process finally leading to the self definition of the city to be a smart city. Today, the smart city logo is displayed on large posters welcoming visitors arriving by car to the city on motorways, as well on brochures, posters, and in cinema ads..

The city continuously aims to involve its citizens by means of so called “Smart City Forums” explicitly declared as events for citizens’ participation. (When this article wa written, an announcement was made for such a forum in May 2015, also announcing that methods of knowledge management will be applied in order to stimulate and to structure contributions).

As a result, a recent study authorized by the city displays the satisfaction of the Vienna citizens with “their” public transport infrastructure which, in Europe, ranks 2nd after Helsinki:



Zufriedenheit der Bevölkerung mit dem öffentlichen Verkehr, z.B. Bus, Straßenbahn oder U-Bahn.
Citizens’ satisfaction with public transport, for example the bus, tram or metro.

9.8 A plead for using knowledge management methodologies

Citizens’ participation, especially when larger numbers of citizens are invited to constructively contribute, needs a professional and goal oriented moderation.

Knowledge management has grown towards a mature practical discipline to manage such kind of collective or individual or institutional generation of ideas and contributions.

The “tools- and methods box” of today’s knowledge management – as shown in the figure below listing some 80 methods - is well filled and ready to be applied for all kinds of meetings. I.e. managing processes in developing smart cities, if not technical in nature but defining the objectives of city development following the informal needs and wishes of the inhabitants, can be captured best by applying the methods indicated.

Going one level beyond, i.e. defining a long term development strategy from the perspective of responsible persons in government and administration, methods of intellectual capital analysis / design / reporting might be applied, as has been exercised by several municipalities in Europe. Not only the city of Vienna, but Austria as a whole has committed to apply methodologies for finding a strategy towards becoming an “knowledge country” by publishing a report on “Austria’s Transformation to the Knowledge Society” – see bibliography below.

After Action Review, Analogie-Modell, Balanced Scorecards, Best Practices, Bibliothek, Bildung von selbststeuernden, interdisziplinären Teams Brainpool, Brainstorming, Business TV, Coaching, Cognitive Mapping, Computer/Web-based Training (W/CBT), Corporate Universities, Data Warehouse Datenbanken, Debriefing, Diskussionsforen, Dokumenten Managementsystem, Elektronisches Who-is-who, Erfahrungsaustausch, Erfahrungsdatenbank, Experteninterview, Expertensysteme, Externe Partner, Externes Benchmarking, Fachliteratur, „Graue" Beraterstäbe, Handbücher,	Hotline, Info-Center, Informationsreisen, Interner Wissensmarkt, Internes Benchmarking, Internet, Intranet, Intranet-Portal, Job Rotation, "Kaffeeecken", Know-how-Bilanzen, Knowledge Communities, KnowledgeLinks, Kommunikationsforen, Kommunikationstraining, Kooperation, Lernlabor, Lernmodule, Lessons Learned, Management by Knowledge Objectives, Mentoring, Mergers& Akquisitions, Methode 4+1, Methode 635, Mitarbeiterzeitung, Morphologie, Newsgroups, Open Space, Patenschaftsmodelle, Patentbewertung, PE-Matrizen, Personalgespräch, Planspiele, Protokolle, Rundschreiben,	Schwarzes Brett, Selbstreflexion, Seminare, Senior-Junior-Pools, Stakeholdernetzwerke, Success stories, Synektik, Szenariotechnik, Szenenetzwerke Technologiescouts, Telefonkonferenzen, Teleworking, Think Tanks, Videokonferenzen, Vorschlagswesen, WI Data Mining, Wissensbewertung, Wissensbilanzen, Wissensbroker, Wissenslandkarten, Wissensmatrizen, Wissensmessen, Wissensportfolios, Wissenszirkel, Workflowoptimierung, Work-Out-Sitzungen, Workshops, Yellow Pages, etc.

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All further references are made by footnotes or mentioned in line in the text.