Downtown Parking Management System

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The planning and management of parking facilities within downtown areas are among the most challenging tasks facing transport planners. Information relating to a wide range of components in a city's transport and land use systems must be processed, analyzed, and effectively communicated to policy makers and concerned groups. These tasks are not easily performed by traditional methods because of the spatial nature of the data, the large amount of data required, and the large number of interactions involved. A microcomputer-based parking management system was developed to assist the planning of public car parks within a downtown area. The two major components of the system are a parking survey analysis package (PARKSTAT) and a graphical data base (PARKINFO). PARKSTAT allows data collected from parking surveys to be processed and analyzed. Numerous plots and tables specifically designed to highlight important operational features of car parks can be produced. PARKINFO allows data relating to the parking stock to be managed within a graphical environment. It also allows information of related systems, including traffic and land use, to be integrated. The main features of these packages are illustrated using a system that is based on the Wollongong downtown area. These tools have been used in evaluating development proposals as well as for developing parking contribution plans for commercial centers in the region. Both packages have provided information for parking operators, transport analysts, and policy makers and have assisted in the development and review of parking strategies.

The planning and management of downtown car parks are major responsibilities of transport planners. These roles present substantial challenges for analysts, particularly in processing, analyzing, and communicating information to policy makers and interested groups. Information relating to the operation and utilization of car parking facilities in downtown areas is critical for policy formulation and evaluation. Knowledge of the usage characteristics of car parks is also crucial for their efficient management.

Car parks are an important component of the transport system and can be considered valuable assets. Therefore, monitoring their usage is essential to ensure that existing parking, land use, and traffic policies meet their objectives.

The need to efficiently manage the parking stock is even more important if downtown areas are to be effectively revitalized. However, many parking management tasks are not easily performed by traditional manual methods because of the spatial nature of the data and the large number of interactions involved. Because the attributes of the parking and related systems are constantly changing, past surveys and studies quickly become out of date. Many existing procedures for processing, analyzing, and presenting these data are slow, costly, and inaccurate. They also are not generally integrated and the quality of presentation is poor.

Traffic engineers and planners require a large amount of information to adequately plan, manage, and operate parking systems in downtown areas. Recent developments in microprocessor technology have substantially increased both the quantity and quality of the data that can be collected (*1*). However, without the accompanying development of information delivery systems, transport planners can easily become swamped with data.

There is currently a gap between the technology available to collect parking data and the associated information processing software required to process, analyze, and present it. Traffic engineering, including parking, is currently experiencing a data explosion (*2,3*), in which enormous amounts of data are being collected using electronic equipment. New advanced parking technology (e.g., automatic ticketing machines and traffic detectors) allows an enormous amount of parking-related data to be easily collected. However, many of these data are not being adequately processed or transformed into useful information; therefore a large proportion of existing data are left unprocessed or poorly presented, resulting in the extraction of little, if any, knowledge.

New technology can significantly speed up analysis time and translate data into information by making the data more understandable, accessible, and presentable to decision makers (*4*). The role of computer graphics in delivering information to decision makers is becoming vitally important. Several microcomputer parking information systems have been developed recently (*5,6*).

PARKSTAT

PARKSTAT is an interactive parking survey analysis package developed using the Think Pascal programming language (*7*) for the Apple Macintosh series of microcomputers (*8*). It makes extensive use of business graphics as well as exploratory data analysis techniques to highlight important usage patterns at car parks. Several features of this package are presented here using data collected from a moderate (580 stalls) car park in the Wollongong downtown area.

Parking Utilization Analysis

A range of numerical indicators are produced by PARKSTAT to provide a description of the overall operations of individual parking facilities. These statistics include the average utilization, peak accumulation, space hours of use, and turnover.

Utilization profiles displaying the temporal variation of accumulation levels (demand) throughout the day (Figure 1) can also be produced. The vertical axes are used to express the utilization and entry and exit flows in terms of the number of vehicles as well as a percentage of capacity.

Parking Duration Analysis

PARKSTAT calculates parking durations by matching arrival and departure observations of individual vehicles. Numerous analysis

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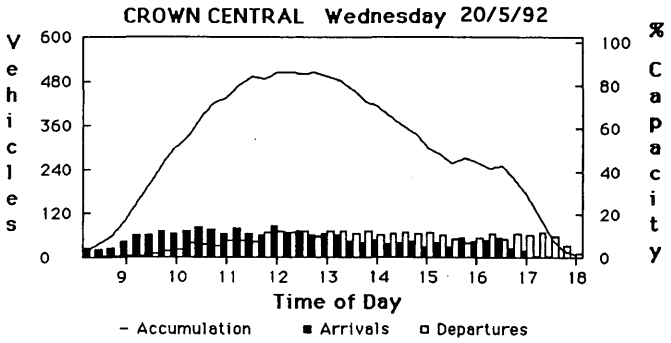

FIGURE 1 PARKSTAT utilization profile.

techniques are available for investigating the characteristics of these distributions, including summary statistics, cumulative frequency plots, and histograms.

PARKSTAT also allows the production of multiple box plots of parking durations (*9*). Parking durations are grouped according to their hour of arrival to highlight the temporal variation throughout the survey period (*10*). The width of the boxes indicates the number of vehicles arriving within the arrival hour, with a wide box indicating a large number of arrivals. Figure 2 shows that there were only a small number of arrivals before 9:00 a.m. and a large number of arrivals between 10:00 a.m. and noon. The decaying ranges and medians after 10:00 a.m. are also evident. The long-term parking durations are most prevalent in the hours beginning 8:00 and 9:00 a.m. This graph also highlights the skewed nature of the distributions as well as several outliers.

PARKINFO

PARKINFO is a graphical data base designed to manage car parks in downtown areas. It has been expanded to incorporate data from a number of related areas including the traffic, land use, and public transport systems.

The development of the system involved a process that incorporated numerous components and linkages (Figure 3). Initially, the data items to be included in the system were identified. These data were then collected and collated. Before they were recorded into the system the data had to be coded and edited. A large number of components had to be designed before any data could be transferred into the system. After the data had been input, an evaluation of the performance of the system revealed the need to collect more data and redesign several elements.

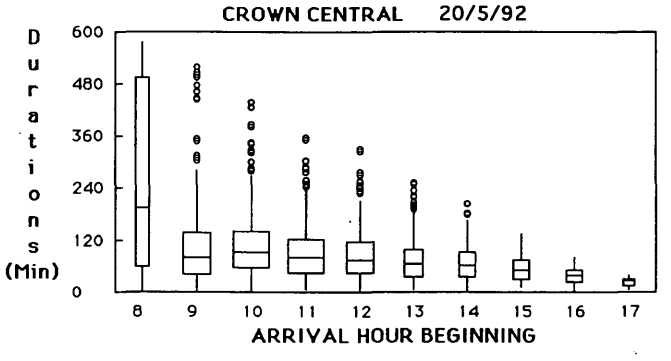

FIGURE 2 Multiple box plot of parking durations.

The aims of this information system were determined by identifying the requirements of the city council. The council's primary need was for a system to manage a large number of parking-related data (e.g., inventory and utilization survey results). There was also a need to produce a system that could present these data and allow them to be updated on an ongoing basis.

Two types of data are incorporated into this system: data necessary for implementing traffic and parking models (*11*) and additional items to enhance its usefulness as a general transport planning tool.

Designing PARKINFO involved specifying the types (data bases) as well as their associated attributes (fields). Each visual item belongs to a type that has an individual file structure with specified fields. Numerous types or data bases must be defined to create an integrated visual environment. These include site (land use parcels), garage (off-street parking stations), lot (off-street car parks), onstreet (on-street car parks), link (traffic), intersection (nodes), bus stop, bus terminal, railway station, and movement (traffic turning movements).

Graphical images, reports, and screen layouts were designed, including specific symbols for intersections and parking facilities as well as turning movements. Clear and attractive screen layouts were also created. This involved defining icons, line styles, buttons, and network drawings. Standard colors, shades, and orientations of shapes consistent with data types were determined. Textual reports which included parking inventories and land use summaries, were also developed.

WOLLONGONG CENTRAL BUSINESS DISTRICT SYSTEM

PARKINFO was used in the Wollongong central business district (CBD) traffic and parking study conducted by the local council to allow the generation of numerous maps and reports. It provided information to assist in the planning and reviewing of parking and traffic operations together with their relationship with land use. It also provides an ongoing tool that can be used to monitor the downtown transport system and undertake parking policy analysis. The Wollongong CBD parking information system was developed using the FILEVISION software package (*12*) on an Apple Macintosh IIci, microcomputer.

Numerous data items relating to the characteristics of car parks are stored for each car park (Figure 4). These include the physical characteristics (e.g., capacity), management policies (e.g., duration limits, restricted times, direct fee rates), and performance measures (e.g., average utilization and turnover). Several graphical images associated with each car park were also constructed, including a lot's geometric layout, daily profile utilization (Figure 5), and a duration histogram. These are used to store the results of analysis undertaken using PARKSTAT. Data relating to a specific car park can be accessed by double clicking the mouse on its image. This feature provides a convenient medium for managing a variety of relevant textual and graphical data for each facility. Data were similarly stored for road links, intersections, and land use sites.

Text and numeric data fields associated with objects can be used to search and highlight the graphical map-based images (records) meeting specified criteria. This allows reporting of complex queries

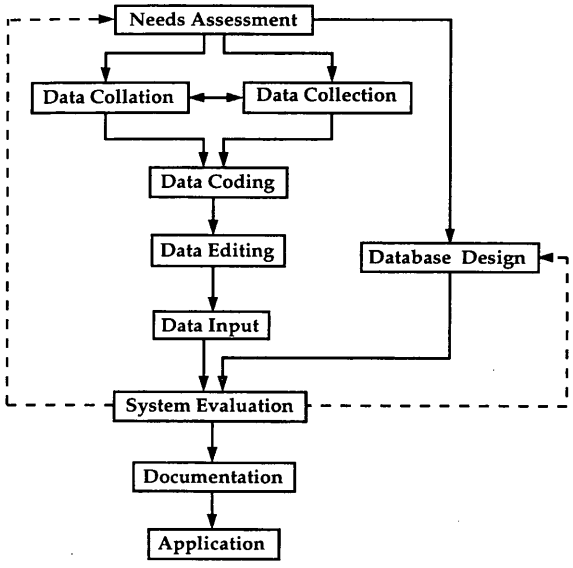

FIGURE 3 PARKINFO development process.

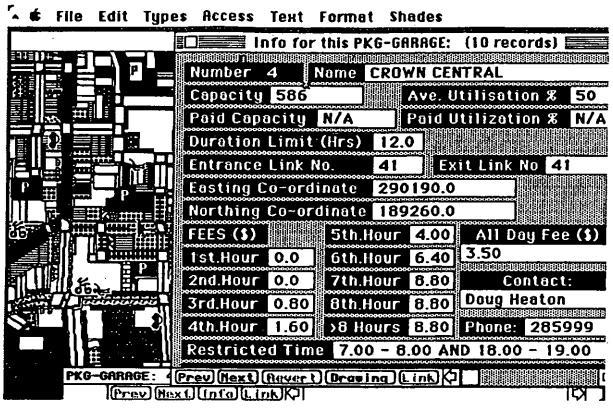

FIGURE 4 Numerical attributes of garages.

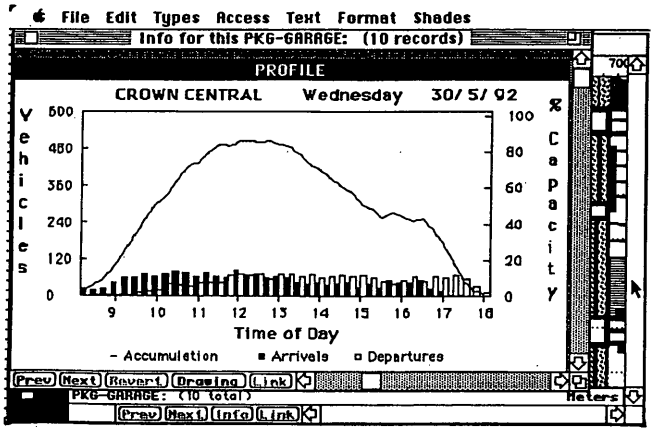

FIGURE 5 Utilization profile of a lot.

in graphical form. This particular example involves identifying parking lots within the CBD that have a capacity of more than 50 stalls and an average utilization level of less than 50 percent. Car parks satisfying these criteria are highlighted as a result of such a query (Figure 6).

Additional searches can be undertaken to highlight related objects that in turn can be shaded to create thematic maps with legends that indicate the characteristics of objects. Figure 7 shows a map of the location of public on-street car parks; the shading indicates their duration limits. Predefined textual reports can also be produced in a manner similar to that for traditional data base management systems.

Numerous data also have been stored for traffic links and turning movements, allowing the management of a wide range of traffic data. Important data relating to the traffic generation characteristics of land use sites have also been incorporated, including the number of employees and area of floor space. Details relating to the public transport services, including terminals, timetables, and routes also have been included.

This system has been expanded to incorporate other major business centers within the region. These centers are linked, providing an integrated system for managing and presenting parking-related information throughout the region.

APPLICATIONS BY WOLLONGONG CITY COUNCIL

PARKINFO and PARKSTAT have been used extensively by Wollongong City Council's traffic section and have been found to be essential parking management and planning tools.

The traffic section of Wollongong City Council has recently been required to undertake detailed parking studies as a direct consequence of amendment to Section 94 of the New South Wales Environmental Planning and Assessment Act, 1979. This section of the act gives local governments the power to impose conditions on a development so that surrounding public infrastructure is provided and existing infrastructure capacity and performance are not adversely affected.

Most government authorities have numerous policies with which various types of development must comply. Under certain circumstances where a development is considered desirable or appropriate and some or all of the required infrastructure cannot be provided, the local authority has the power under Section 94 to charge a levy on the development for a monetary contribution toward the future provision, by the authority, of those facilities. These facilities may include open space, public roads, or parking garages or lots.

The recent amendments to Section 94 of the act now require a local government authority to have a publicly adopted plan or strategy in place for each type of public infrastructure for which a Section 94 levy is sought.

Wollongong City Council was fortunate because some 12 months beforehand extensive inventory surveys of downtown parking were done as part of the development of the PARKINFO data base. Time constraints and the incorporation of a downtown computer traffic and parking model necessitated the following approach for the development of the Section 94 parking plan. The study included downtown Wollongong (referred to as the CBD) as well as some eight suburban commercial centers of significance. Numerous actions were identified and applied to various parts of the city, depending on the locality, existing public availability, and levels of utilization (Figure 8).

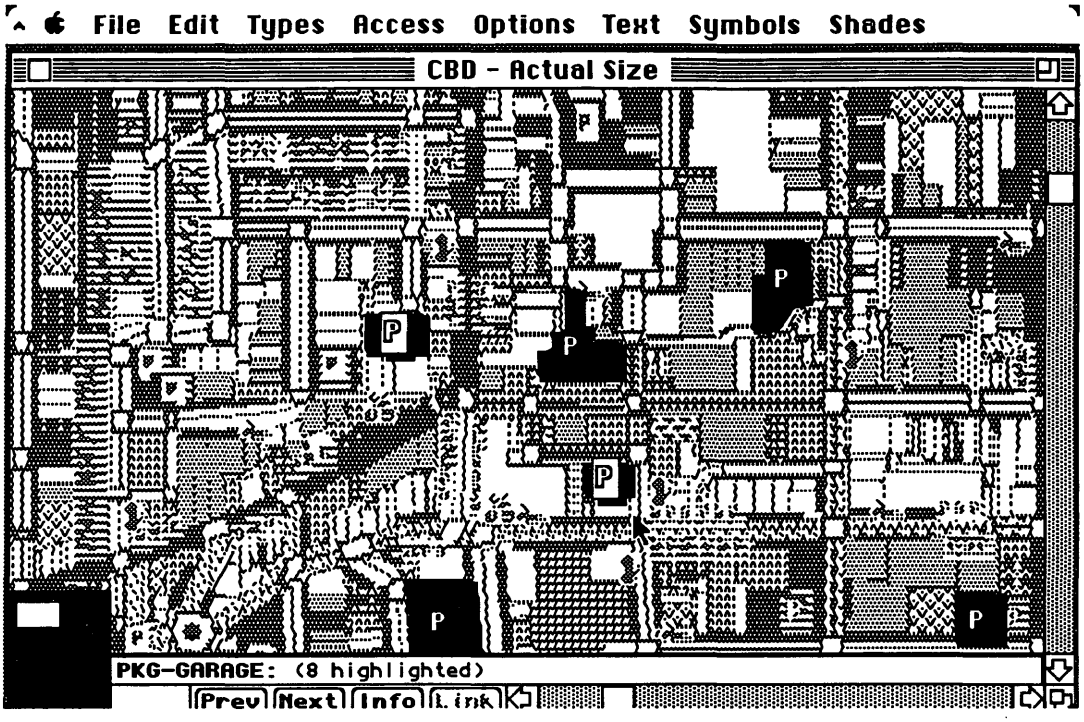

FIGURE 6 Large and underutilized lots highlighted.

The Section 94 parking study was therefore planned to be undertaken in two stages:

- Stage 1, which involved (*a*) inventory of all parking (on street and off street), (*b*) establishment of precincts and selection of locations, (*c*) development of policies and actions, (*d*) parking surveys and analysis, (*e*) data base design and modifications, and (*f*) documentation and adoption of Section 94 plans; and
- Stage 2, which involved strategic planning of infrastructure using advanced land use, parking, and traffic modeling techniques to evaluate various future planning scenarios.

Both the PARKSTAT and PARKINFO software packages were used extensively during Stage 1 of the study. Significant amounts

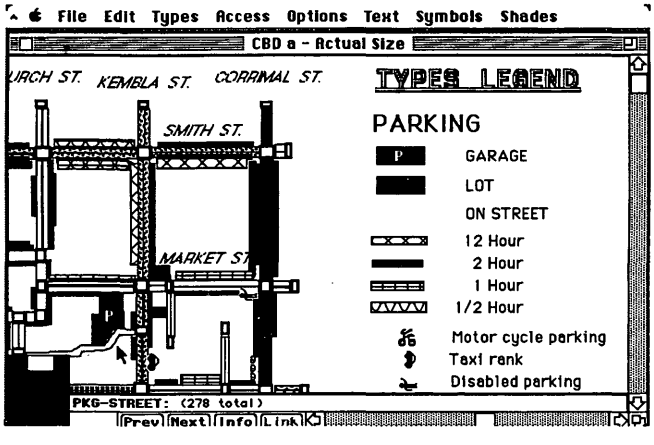

FIGURE 7 Car park duration limits.

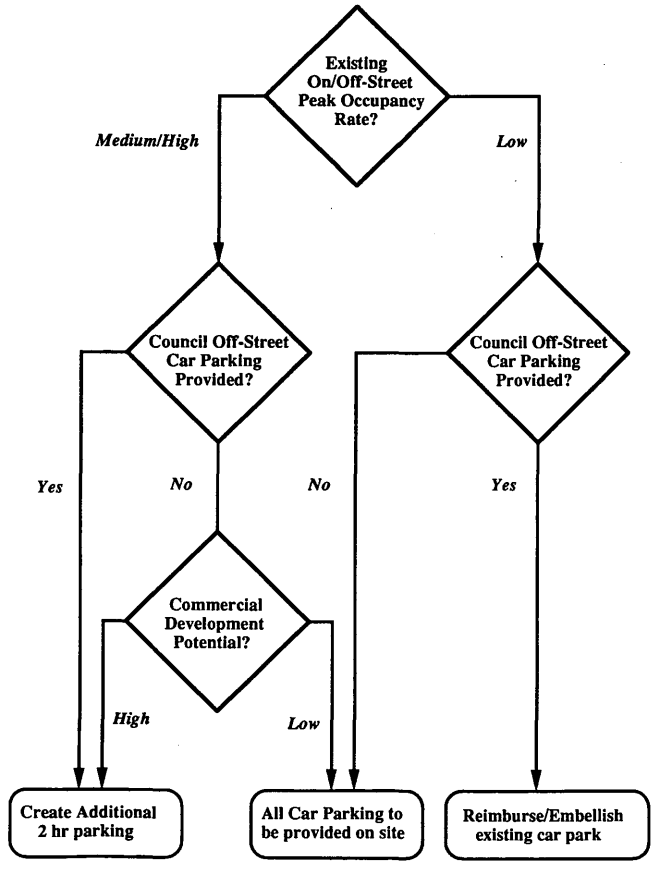

FIGURE 8 Section 94 parking contributions plan action flowchart for commercial centers.

of data were collected, processed, and input into the relevant data bases within the PARKINFO system.

On-street parking was surveyed hourly and data were input into the PARKSTAT software to provide estimates of utilization and peak occupancy. PARKINFO map presentation facilities were then utilized to present output showing those areas where, for example, peak occupancy was less than 50 percent. On-street parking lots with peak occupancies of 50 percent or greater were also highlighted and presented in map form.

Visual examination of the map output revealed general areas of either low or medium-to-high parking usage, allowing the predetermined policy actions to be applied.

The plan for car parking contributions in Wollongong is anticipated to be a dynamic document. As new developments occur, further parking will be undertaken with these statistics also stored in PARKINFO and compared with those previously surveyed. The contribution plan can then be amended as necessary.

As computer modeling is about to commence, the parking data held within PARKINFO will be called on in the model validation process. Furthermore, output from computer modeling can also be stored in PARKINFO and retrieved and presented in color graphical form as an aid in interpretation and communication of results.

CONCLUSIONS

Both the PARKSTAT software and PARKINFO data base have greatly assisted the Wollongong City Section 94 parking study. The efficient management of quantities of data has allowed the timely completion of Part 1 of the study by the due date set by legislation. The PARKINFO data base will continue to be used during Stage 2 of the study and will be modified and updated as required according to future planning needs.

PARKINFO has also been used to assess the impacts of development applications. Numerous maps have been produced that show the location of major car parks and developments, combined with traffic and public transport networks. Another major application of this system has been to manage a wide range of transport-related data required for modeling exercises. It has also allowed for easy identification of planning issues within precinct. The system is extremely easy to use, requiring minimal training and technical support.

Both PARKINFO and PARKSTAT utilize relatively inexpensive microcomputer hardware and software to provide tools for aiding the planning and management of parking facilities within downtown areas.

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