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Activities: Vehicle Repair and
Maintenance and Dental Services**

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**Dynamic Scheduling for Two Service
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Maintenance and Dental Services**

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Abstract

The objective of the project is to provide dynamic scheduling solutions to two different services, automobile dealerships and dental clinics, in order to help them schedule in a dynamic way their daily service activities to increase customer satisfaction through the minimization of delay times. The paper serves as preliminary work for further research between the authors. Three real scheduling cases are presented: two related to different dealerships and one corresponding to a dental clinic. The principal characteristics of each of the actual scheduling systems are presented and compared, then a first approximation is established for scheduling improvements in order to increase efficiency and customer satisfaction.

Résumé

L'objectif de ce projet de recherche est de proposer des solutions d'ordonnancement dynamique à deux types de services différents : des concessionnaires automobiles et des cliniques dentaires. Nous voulons les aider à ordonner leurs activités quotidiennes de façon dynamique pour augmenter la satisfaction des clients en minimisant les temps d'attente. Ce rapport se veut un travail préliminaire. Trois cas réels d'ordonnancement sont présentés : deux concessionnaires automobiles qui fonctionnent complètement différemment et une clinique dentaire. Les principales caractéristiques de chacun des systèmes actuels d'ordonnancement sont présentés et comparés entre eux. Nous essayons par la suite d'établir une première approximation des améliorations qui peuvent être proposées à leur méthode d'ordonnancement pour augmenter leur efficacité et la satisfaction des clients.

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1 Introduction

“As service industries become a more important business sector, the efficiency and effectiveness of running service systems is gradually receiving more attention from both academicians and practitioners . . .” This observation was made by Ho et al. in 1995 and is today a topical subject matter. As has been stated by Simons et al. (2004), the discipline of operations management has historically focused on the production of physical goods, and therefore most of the scheduling models have been developed in the context of manufacturing. In some cases these models can be transferred directly to the services sector because service activities are usually assumed to be sufficiently similar to manufacturing, but in other cases this is not possible due to the specific characteristics of the problem. Simons et al. (2004) establish that “while similarities to manufacturing make existing research a useful starting point, the differences are sufficient to make the resulting problem both interesting and worthwhile”. But although some studies can be found in the literature presenting scheduling methods for the services industry, these have mainly focused on adapting demand to capacity (appointment systems) or adjusting capacity to match the demand (service personnel scheduling). Models and methods seeking to schedule activities and customers in the services industry are harder to find in literature.

As quality is increasingly becoming the key factor for success in the services industry, more research in the scheduling field must be undertaken to study the strong relationship between delay times and customer satisfaction. This question has been widely studied in the literature of economics, marketing, and management science (Ittig, 2002). In particular, it has been shown how in the services industry management, additional capacity may produce additional customers, particularly if the additional capacity reduces the waiting time imposed on customers (Ittig, 2002).

Nevertheless, additional capacity in the services field does not always suppose increasing the available material and human resources. Management of time is a main question in order to determine the real capacity of a certain service.

The objective of this work is to provide dynamic scheduling solutions for automobile dealerships for its service, repair, and maintenance activities as well as for a dental clinic for their daily scheduling in order to help increase customer satisfaction by minimizing delay times. This last question is pivotal for the success of activities in the services field (Kiff, J. S., 2000).

The paper is organized as follows: in Section 2, a literature review is presented corresponding to the two types of services studied in this work. Section 3 is devoted to the description of three real cases of scheduling (two in different automobile dealerships and one in a dental clinic). In this section, we will present the principal characteristics of each of the actual scheduling systems, comparing them and trying to establish a first approximation for the improvements which can be easily made in their schedule in order to increase efficiency. Finally, in Section 4 the main conclusions of this preliminary study are presented.

2 Literature review

A service is a provider/customer interaction that creates and captures value. Several definitions of service can be found in literature. Hill (1977) defines a service as a “change in the condition or state of an economic entity (or thing) caused by another”. Sasser et al. (1978) establish that services are “intangible and perishable ... created and used simultaneously.”

A service is usually characterized by its nature (type of action and recipient), its relation to the customer (type of delivery and relationship), the decisions that have to be made (customization and judgement), economics (demand and supply), mode of delivery (customer location and nature of physical or virtual space) ... (Lovelock, 1983). More recently, Zeithaml and Bitner (1996) define services as “deeds, processes, or performances,” and Gronroos (2000) as “an activity or series of activities provided as solution to customer problems.”

In this work, two different services have been selected to be studied: vehicle maintenance and dental services. Both of them have great similarities but also some interesting differences based mainly on their nature: vehicle maintenance services focus on the transformation of a good (vehicle) belonging to the customer (owner), while dental services are, on the other hand, characterized by a direct change on the state of a person (the customer). This difference lays the foundation for a comparative study of both scheduling systems.

Vehicle maintenance and dental services also possess marked similarities and can be classified in the same field. The selected services can be classified into the field “service case”. Simons et al. 2004 establish that “a service case is similar to a manufacturing job in the sense that several distinct and significant tasks may need to be accomplished for the customer’s need to be met. However, while manufacturing jobs (as well as some service “jobs”) are simply routed from resource to resource, service cases are typically the primary responsibility of a single service provider”. The case manager (customer manager) does not have to accomplish all required tasks. On the contrary, many such cases (repair or dental services) require information from other service providers or employees (such as the activities manager, mechanics, hygienists), but although case managers may be expected to perform several functions, coordinating activities is considered to be the most important of them.

Case management methods have been widely used in the medical and social service professions. Some examples of services using case management include geriatrics, physical and/or mental rehabilitation, and adoption agencies to name but a few, but also in business, as in the cases of credit account management, telephone customer service, telecommunications, tax collection, order management in manufacturing, driver services in fleet management, and legal services (Simons et al. 2004). It is for this reason that two different services have been chosen for this study. The main difference between dental care and vehicle maintenance is the nature of the services. While for vehicle maintenance it is proper to refer to the benefactors of the service as “customers”, this appellation changes

with respect to health services where these benefactors are more likely to be called “patients”. The nature of the service is completely different in both cases; in a dental clinic services provided are related to customers’ health. This reality has important implications on scheduling.

The main problem the customer manager faces is how to prioritize or schedule the many activities required by a particular customer in a highly dynamic and sometimes imprecise and/or uncertain context.

In Section 3, a first approach to the solution of the scheduling problem in the service case field is presented on the basis of information obtained from three real cases. But firstly, a description of the principal elements which characterize an appointment system in literature, for both services, is presented in the next subsections.

2.1 Elements characterizing an appointment scheduling system for a dealership’s vehicle repair service

Emmanuel (1997), an internationally recognized expert in the field of consulting for the automotive industry and in matters of customer service, leadership skills, organizational development, and stress management, establishes that two of the main customer protests are long waiting times during vehicle repair and the fact that the vehicle is not usually repaired in one visit. These factors induce, in most of the cases, customers to only use the dealership service solely for warranty repairs and/or going elsewhere for expensive maintenance and out-of-warranty repairs. In order to minimize these problems, a system has to be established to schedule dynamically these service activities. To achieve this dynamic scheduling, an appointment system is needed in order to match the demand with the shop capacity, and a decision tool is required for inserting activities in an ongoing plan to minimize delays.

An appointment system has to provide customers with the best day to leave their vehicle and with the day to pick it up after servicing. This has to be based on a technician’s available time for the type of repair in order to prevent the technician from being overloaded with work and to improve their efficiency in performing accurate repairs.

In Table 1, the steps for the establishment of an appointment system are summarized.

The main idea, then, is to manage time as inventory using the software *TIMEngine*, allowing scheduling of the customer service appointments in real time, as opposed to the typical “appointment request forms”.

Following Gutierrez et al. (2005), a two-level framework is proposed in order to schedule service activities (see Figure 1). The first level, called *aggregated level*, is characterized by the cooperation between the customer and the customer manager. A first prediagnosis has to be made to determine the nature of the required service. Customer collaboration is essential in this level. Once the prediagnosis has been done in the second level, called

Table 1: Steps for setting up an appointment system

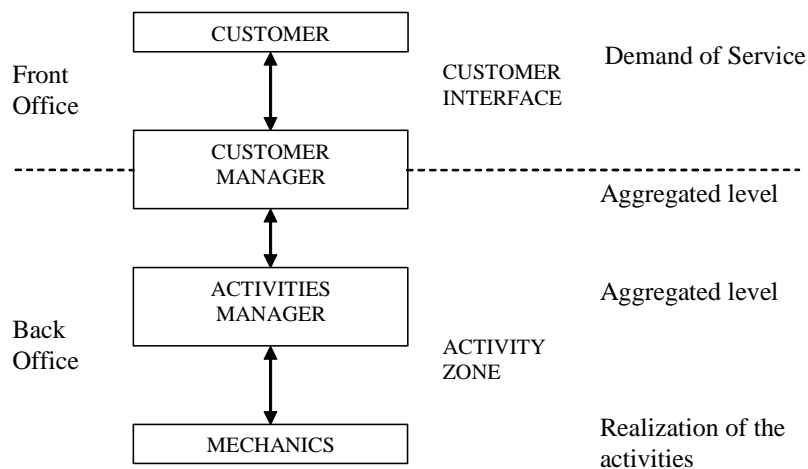
Step One	Organizing repair categories in an appointment tracking form
Step Two	Determining daily shop capacity and category capacity
Step Three	Determining the percentage of the shop capacity that will be used for scheduling
Step Four	Choosing the best day and time for the customer to leave the vehicle
Step Five	Estimating and logging the approximate repair time for appointments, walk-in, and emergencies

Source: Own elaboration based on Emmanuel (1997).

detailed level, cooperation between the customer manager and the activities manager is needed in order to plan in detail the activities required for the required service.

Fließ and Kleinaltenkamp (2004) have studied the relationship between customers and services providers. According to these studies, before the dealership (supplier) can really start with the production of a service (vehicle repair) the customer's requirements need to be specified. To this end, the dealership is dependent on the customer's input and instructions. From the service provider's point of view, increasing customer participation may lead to more efficiency.

Today, most vehicle dealerships are taking into account previous suggestions. Customer input in this field is related to the specifications of the services needed, to descriptions of the symptoms of the vehicle to guide the customer manager's pre-diagnosis of the problem, and to the timing for dropping off and picking up the vehicle.



Source: Gutierrez et al. (2005).

Figure 1: Stakeholders and their cooperation in service-on-demand

Most of the main dealerships nowadays have an online appointment system. First of all, general information about the vehicle is required from the customer, such as the year, make, model, VIN number, engine, fuel type, transmission, and drive system to name but a few examples. The customer, in most of the cases, then has to provide a description of the services needed and if there is a special problem, he has to make a description of the principal symptoms. Most of the dealerships do not appear to do it, but it may prove to be a good strategy to give the customer a full description of activities available, letting him choose the required services (see Step One in Table 1).

The previous information provided by the customer can help the customer manager determine if the requested service is routine work, in which case it can be scheduled immediately, or if it is not routine and requires a review with the activities manager. This information is sufficient to schedule an appointment.

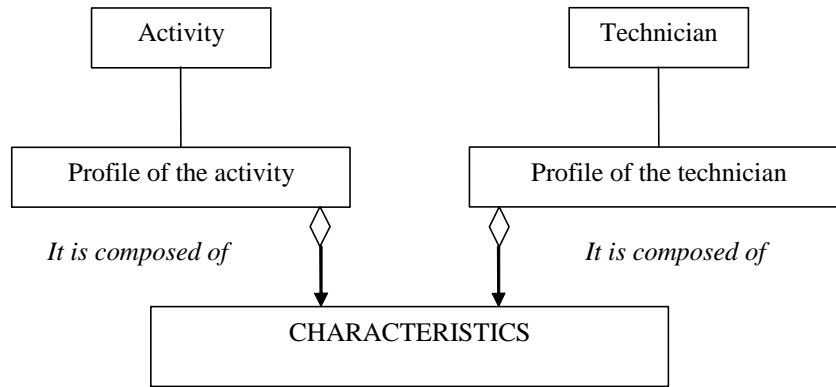
In most dealerships, once the customer has checked in for his service, an electronic repair order with all the parts and labour codes for complete service is generated. After that, the repair order is reviewed with the client to fully explain the breakdown of the repair costs. The electronic repair orders track all parts and labour. Proper electronic repair orders are essential for scheduling and activity insertion in an ongoing plan (see Tables 2 and 3).

The second customer contribution is related to dropping off and claiming the vehicle (steps 2 to 5 in Table 1). In some cases, service procedures can be performed while the customer waits. In the event they are not, customers are usually asked for their appointment preferences, namely preferred date and time. Customers may not have a preference but if they do, the following represent some possibilities for dropping off the vehicle: drop off the night before the appointment, drop off in early morning, drop off in mid morning, drop off in early afternoon, drop off in mid afternoon, or wait (for minor services only).

When the customers manager schedules an appointment with the client, he has a rough idea how long to schedule it, so he can look at the availabilities the day the customer has requested and, if necessary, negotiate the best day and time for dropping off the vehicle and picking it up.

Dealerships have to determine their Daily Shop Capacity and category capacities in order to know the amount of available technician hours each day in the shop as a whole and per repair category (see Table 1). Assigning technicians to activities is a difficult task because, as pointed out by Gutierrez et al. (2003), the resources being allocated are people. These authors introduce the concept of a *profile* of an actor (human resource) and an activity (see Figure 2).

For each activity (elementary stage of a service), a profile is established consisting of a vector in which each component corresponds to a set of possible values for several main characteristics. An activity can present several profiles. A technician is then associated to a profile represented by a vector composed of the set of values related to the characteristics. A technician could only be assigned to an activity if his profile is compatible with it. This



Source: adapted from Gutiérrez et al. (2003).

Figure 2: Class diagram: Technicians-Profiles-Activities-Characteristics

compatibility is usually verified by the activities manager but some automated management systems have recently been developed to solve this task (Service Power, 2003). Gutiérrez et al. illustrate the usual sequence for the execution of this protocol.

Dealerships do not use all the shop capacity for scheduled repairs. They usually allocate a percentage of the shop capacity for walk-ins and emergencies. The industry rule suggests that 80% of the shop capacity should be scheduled, but in the experts' opinion this depends on the location of the dealership and on such other factors as the weather and the season.

Estimating the duration of each activity depends on approximate service time; several methods may be used to estimate this duration, depending on the type of repair, which can be classified into three main activities: maintenance, repairs, and diagnosis only.

Maintenance services are the easiest to schedule. Dealerships usually have a menu of these services available to the customer (see Tables 2 and 3). After discussing the necessary servicing with the client, the customer manager should log the average time required in the proper service or technical category.

For the repair category, it is absolutely critical to get as much information about symptoms and conditions as possible to make the best estimate. It may be necessary in most of the cases to consult with the technicians before logging the duration of the required activities.

Finally, for diagnosis, we have to distinguish between complicated repairs and minor ones (the first type involving many symptoms and conditions, the second being those that are time consuming and could take several days). Based on the diagnosis and the need to order special parts, the consumer should be informed on how much time the shop will need to complete the repair.

Table 2: Offered services

Car Care	Brake Systems	Cooling & Heating	Drive Train Systems	Fuel Systems	Electrical Systems	Suspension Systems	Exhaust Systems
Lube/Oil Filter	Diagnosis	Diagnosis	Clutch Assembly	Diagnosis	Diagnosis	Diagnosis	Diagnosis
Transmission	Pads & Shoes	Radiator	Drive Shafts	Carburetors	Drivability	Shocks/Struts	Manifolds
Wheel Bearings	ABS repairs	Cooling System Flush	Axle & Bearings	Gas Fuel Injection	Alternators	Ball Joints	Mufflers
CV Joints	Brake Hoses	Heater Cores	Transaxle	Diesel Fuel Injection	Starters	Leaf/Coil Springs	Header Pipes
Differential Service	Brake Caliper	Thermostats	Differentials	Glow Plugs	Lights	King Pins	Catalytic Converters
Power Steering	Wheel Cylinders	Hoses/Belts	Standard Transmission	Fuel Lines/Hose	Power Accessories	Control Arms	Gaskets
Brake Fluid	Parking Brakes	Fan Clutches	Automatic Transmission	Fuel Tanks	Heat/AC Control	Drive Axle	
Windshield Washer	Brake Drums	Electric Fans	U-Joints	Fuel Gauges	Instrumentation	Air Ride System	
Windshield Wipers	Brake Rotors	Water Pumps	4X4 Service/Repairs	Fuel Pumps	Electrical Wiring	Steering Racks	
Battery Service	Power Boosters	AC Svc/Repairs		Fuel Filters	Computer Systems		
Inspections	All Hydraulics	AC Compressor		Emission Controls			
Scheduled Maintenance	Master Cylinder	R-134A Retrofit					

Table 3: Example of a more detailed service activity

Electrical Systems
Lights
Heading Aim (visual)
Headlight Units Hi-Lo Indicator
Parking Lights
Turn Signals
Turn Cancellation
Tail Lights

When dealing with a walk-in or an emergency, experts suggest the repair should be scheduled as any regular repair appointment. So, to choose the best day and time for a customer to leave their vehicle, the repair order should be pre-written as much as possible so as to allow descriptions of common and frequent types of problems.

Effects of environmental factors also need to be taken into account when building a schedule of service activities. Punctuality is a factor affecting an Appointment Scheduling System. As pointed out by Ho et al. (1995), one expects punctuality to depend very much on norms and cultures, which vary considerably with time and locality, so it is difficult to model punctuality in a real work environment. Therefore, customers shall be assumed punctual in this study.

Repair and maintenance services in the automobile industry take both regular appointments and customers that arrive at any time. These walk-in customers typically have a lower priority than those clients scheduled for appointments. The service times required to serve walk-in customers would definitely increase the waiting time of subsequent customers and therefore they have to be scheduled in the 20% portion of the schedule that is intentionally left unplanned. There could be as well a seasonal pattern within a business day, week, or year. There tend to be more customers around noon-time for certain services. During these peak periods, the utilization of the service workstations should increase considerably.

Once an overall view of the main steps to schedule an appointment has been presented (see Figure 3), we propose an insertion activity algorithm in order to help the dealership with its daily dynamic scheduling.

2.2 Elements characterizing an appointment scheduling system for a dental clinic

“Effective scheduling is a little bit of science and a whole lot of art” (Nasser, 2005).

Populations in developed countries have shown improved oral health in recent years. Demographic changes are projected a stabilizing of the pool of children and young adults and an increase in the pool of middle-aged and senior adults. As was stated by Brennan et al. in 2004, “with more people retaining their teeth and the age structure of the population changing, shifts in service provision have been observed among dental patients in private general practice” and so, it is important to improve efficiency in order to provide customers with high quality services.

Scheduling is the single most important administrative function in a dental clinic. “Too often clinics allow themselves to be controlled by the appointment book rather than through the appointment book.” (Nasser, 2005) A well-organized appointment system is a source of increased patient satisfaction and reduced team frustration. It is very important to have a clear scheduling strategy based on the clinical abilities of the dentists, the skills of the team, and most significantly, the needs of the patient. Creating this schedule format is, in Nasser’s opinion, the first step in organizing the appointment system. Dental personnel

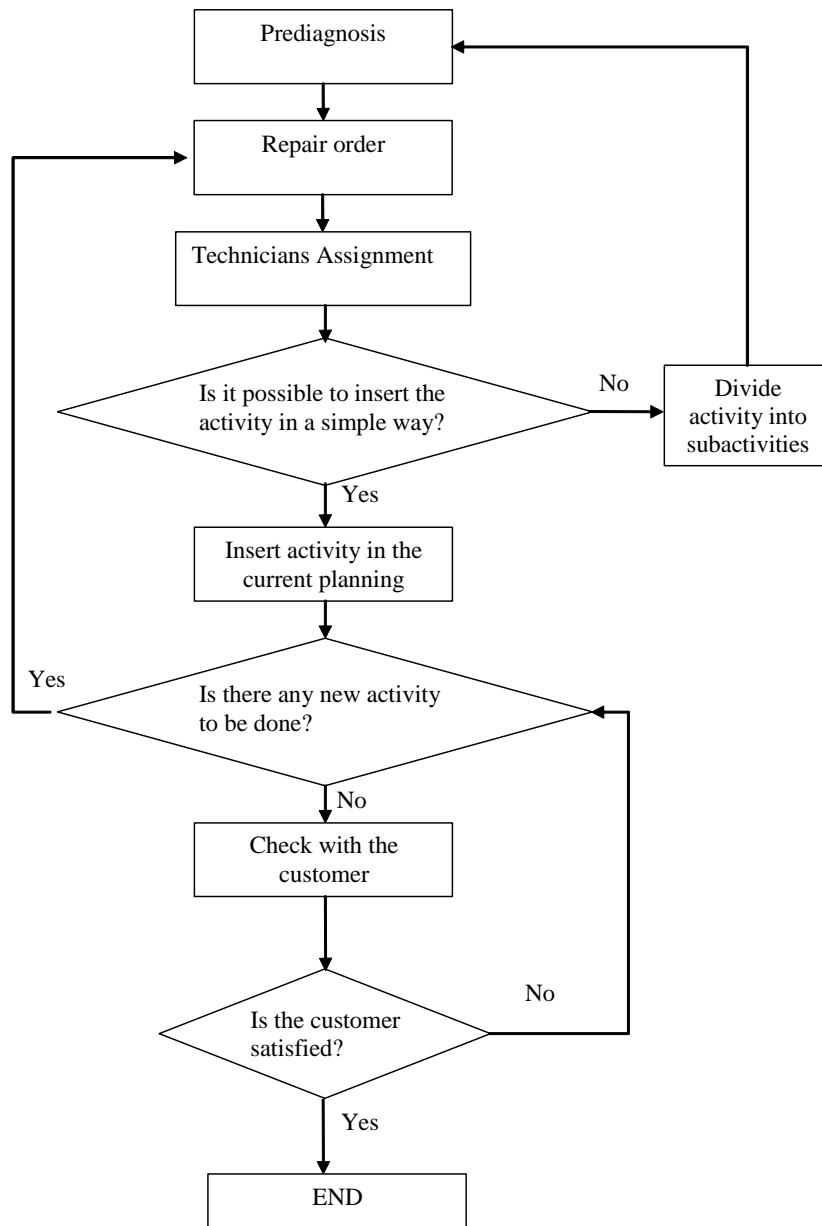


Figure 3: Flow chart of a repair service on demand

(usually organized in teams around a dentist) should work together in developing the scheduling format because some adjustments may be necessary over time and therefore, the schedule format should be reviewed as needed during periodic staff meetings. “The important things to consider when creating a schedule format are the types of procedures to be performed, the length of time required for each procedure, the need for performing certain procedures at a specific time or day, lunch hours, holidays, time off and over all, maintaining flexibility on the scheduling.” (Nasser, 2005)

In Table 4, some of the steps for the establishment of an appointment system in a dental clinic are summarized. They resemble that of the car dealership.

Table 4: Steps for setting up an appointment system

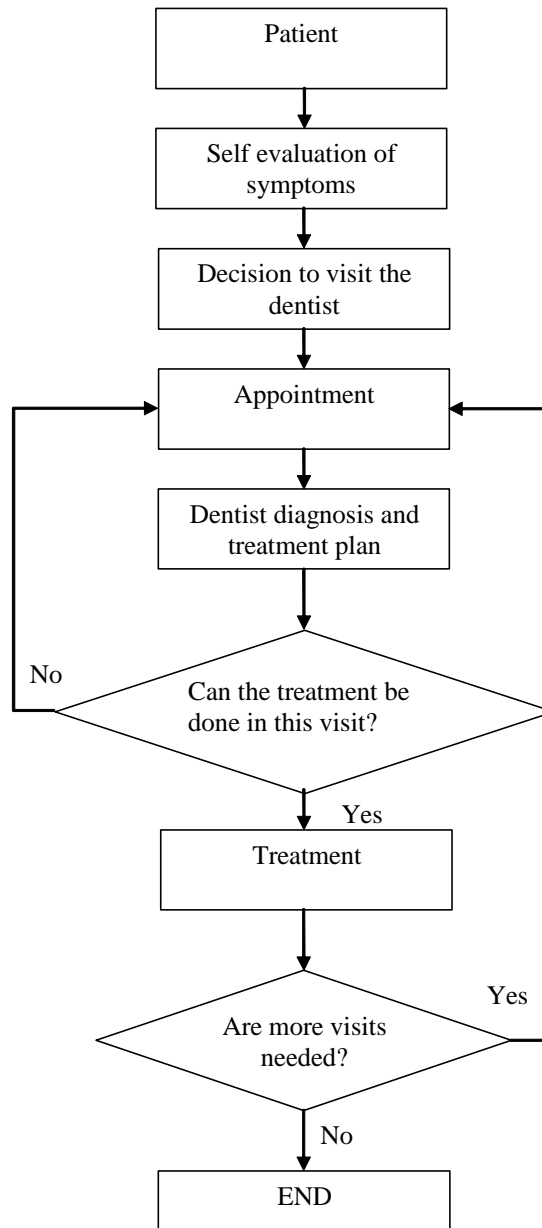
Step One	Organizing activities into categories in an appointment tracking form
Step Two	Determining daily clinic capacity and dental teams' capacity
Step Three	Determining the percentage of the clinic capacity that will be used for scheduling
Step Four	Choosing the best day and time for the patient to visit the hygienist and/or the dentist
Step Five	Estimating and logging the approximate time for patients with an appointment, walk-in, and emergencies

Source: Own elaboration.

In the dental services case we cannot identify two levels, aggregated and detailed, as for the dealerships because there is usually no active cooperation between the patient and the person giving the appointment at the dental clinic. Dental care processes and customer reaction to this care are different as can be seen in Figure 4. There is no first prediagnosis made by the patient in order to help determine the nature of the required dental service. Usually, emergencies or walk-in patients call or come to the clinic with different levels of pain and very general symptoms, while other patients come to regular and periodic revisions without symptoms or pain just to check if there are any problems. Prediagnosis is needed in dental clinics but cannot be done before the date of the appointment because it requires the presence of the patient, and for that an appointment for a first visit has to be scheduled. In this sense, dental services are different from vehicle maintenance services because the customer's requirements usually cannot be specified before the service is rendered. The dental clinic does not depend on the patient's information about all the treatments needed.

For regular visits to the dental clinic, patients are usually asked what their appointment preferences are, namely preferred their date and time. Another difference with dealerships is that patients can usually visit the clinic at any hour in the working day.

Dental clinics are often organized in teams with a dentist, some dental assistants, and some hygienists. Patients are always assigned to the same team. Within the team, members



Source: Adapted from Bedos et al. 2003.

Figure 4: Model of dental care process

of the personnel have particular and well differentiated profiles, so the task consisting of assigning actors to activities does not represent a real problem as in the case of the car dealership.

Contrary to the dealerships, dental clinics do long term scheduling (6 or more months in advance) for regular and periodic maintenance services. Dental clinics also have the dental history of each patient and a system ensuring that regular visits are scheduled. Dealerships usually do not use this kind of reminder system.

Finally, as it happens with dealerships, there are some environmental factors to be taken into account when scheduling dental appointments. If punctuality of the customers is an important factor affecting the scheduling in dealerships, it has even more importance in dental services where the duration of the different activities is shorter and in some ways more imprecise and less standardized.

3 Real cases studies

In this section, several real cases with different scheduling methods will be presented and analyzed to try to find their weaknesses. At the end of the section will be proposed some scheduling solutions in order to improve the services' efficiency.

3.1 Repair and maintenance services in a dealership

Two different vehicle dealerships have been visited in the Quebec region. Data has been obtained by means of a questionnaire which was filled in by the authors of the paper in a nearly two hour interview with the manager of each dealership. The questionnaire is presented as an appendix.

In Table 5, answers to the questionnaire by both dealerships are organized into three groups: general data, information related to the actual scheduling system, and information related to activities and resources in the dealerships.

Both dealerships use the same appointment system: *SERTI Information Solutions* developed by SDSwin. Currently, more than 290 dealerships in Canada use this system which includes not only an *Appointment module*, but also an accounting service; a *Follow-up module* for generating personalized mailings to stay in touch with customers and thereby improve customer retention thereby increasing; a *Parts Management module* related to inventory management; a *Service Management module* which allows technical advisors to make sure that the work required is completed within the time frame promised to the customer; and finally a *Point of Sale Invoicing module* which allows the dealership to create part invoices and close work orders so that users from all departments have access to the components of the invoice (<http://www.sdswin.ca>).

The *Appointment module* allows dealerships to make appointments immediately while taking into account the availability of shop resources. It allows the user to open work orders containing a description of the jobs entered during the creation of the appointment.

Table 5: Data from the dealerships

	DEALERSHIP 1	DEALERSHIP 2
GENERAL DATA		
Average number of customers	2,000	1,400
Maintenance of all kinds of vehicles	Yes, but 90% are from the dealership's brand	No, only Subaru and Mercedes Benz
Maintenance only under warranty	Lifetime warranty	Lifetime warranty
Main type of maintenance activities	General maintenance and electronic problems 20% of total activity are warranty revisions 50% of total activity are maintenance activities 30% of total activity are revisions previous selling a vehicle	65% of total activity are warranty revisions 25% of total activity are maintenance activities 10% of total activity are revisions previous selling a vehicle
Different kinds of customers	Single, enterprises, fleets, ambulances	Only single customers
Customer prioritization	1° Ambulances, 2° emergencies, 3° enterprises with contract, 4° particular customers	No prioritization
Online appointment system	Yes, based on e-mails	Yes, based on e-mails and phone calls
Distribution of appointments	Continuous	
SCHEDULING SYSTEM		
Actual Scheduling System	Appointment system Software SERTI Schedule using a 15 minutes Grid attending phone calls and e-mails and giving appointments on the basis of a board on the wall	Appointment system Software SERTI Schedule using a 15 minutes Grid attending phone calls and e-mails Customers are allowed to choose preferred technician to do the service
Percentage of total shop capacity scheduled	70%	80%
How to deal with emergencies	Within the 30% of the day not scheduled	Within the 5%-15% not scheduled
How to deal with walk-in customers	Within the 30% of the day not scheduled	Do not admit walk-in customers
How to deal with late customers		They handle a late customer at the end of the current activity
Scheduling Periodicity	Civil year	15 days
Prediagnosis with customer	Yes, questions related to certain routines	They have data files and from this information they make suggestions to the customer related to the maintenance of their vehicles

Table 5: Data from the dealerships (continued)

Detailed repair order in cooperation with activities manager after prediagnosis	Yes, when an activity is started and not finished	
Determination of drop off and picking up time	Working day: 7 AM to 6 PM Drop off: 8 AM to 12 AM Pick up: 1 PM to 5 PM 15 minutes in advance	Working day: 8 AM to 5 PM Drop off: all the day Pick up: no constraints
Courtesy vehicle	Yes	No
Seasonal patterns	Yes, autumn and first snow fall	December- February and June-July No special changes in scheduling
Main difficulties when making an appointment	Diagnostic (intermittent problems)	Customers being in a rush
Ideal characteristics of a scheduling system	Duration times incorporated with assignment of technicians	
ACTIVITIES		
Groups of activities	Agree with groups and activities in Table 2	Agree with groups and activities in Table 2
Percentage of total shop time spent in each maintenance activity	Maintenance Service 1: 50% Maintenance Service 2: 15% Maintenance Service 3: 10% Maintenance Service 4: 17% Maintenance Service 5: 5% Other repair/maintenance activities: 3%	
Processing times for the activities	Maintenance Service 1: 30 minutes Maintenance Service 2: 45 minutes Maintenance Service 3: 120 minutes Maintenance Service 4: 240 minutes Maintenance Service 5: 240 minutes Super duty Service : 45 minutes Platinum plugs and electrodes: 120 minutes Gear box : 120 minutes Service before selling a vehicle: 2 hours	They cannot give us the data because they are really variable depending on the customer. (The marketing guideline: "selling time to the customer".) They use Automatic Data Processing a registered trademark of ADP of North America Inc (ADP).
Logic sequences for activities	Same	
Activities which can be done by different techs	Car care by all techs Brake systems by all techs Cooling & heating almost all (10 of 13 techs) Suspension Systems almost all (10 of 13 techs) Exhaust Systems almost all (10 of 13) 3 techs which work with fuel systems can work with drive train systems	

Table 5: Data from the dealerships (continued)

Human technical resources	13 technicians (3 of them apprentices) Professional profiles car care: 13 techs brake system: 13 techs cooling & heating: 10 techs drive train systems: 5 techs fuel systems: 3 techs electrical systems: 6 techs suspension systems: 10 techs exhaust systems: 10 techs	4 general technicians (1 of them is a technician specialized in transmission systems)
Specific Machines	2 specific brake systems machines 2 specific cooling & heating machines 2 specific drive train system machines 3 specific fuel system machines 2 specific electrical system machines 2 specific suspension system machines 1 specific exhaust system machine	All machines are mobile
Allocation of jobs to technicians	Directly during the phone call. The secretary or receptionist handles the assignment using the grid (times versus technicians) with the SERTI system	They sell time with SERTI and at the end of the previous day the manager does the allocation

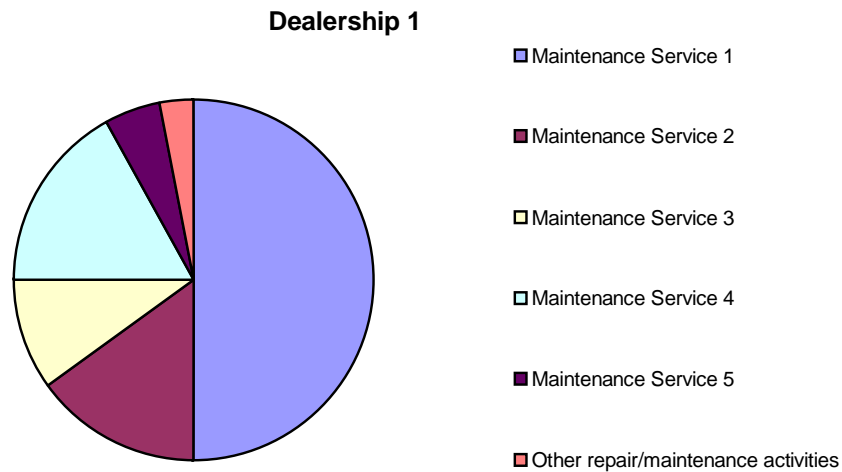


Figure 5: Daily percentages of total shop time spent on each maintenance activity for dealership 1

Table 6: Maintenance Services Dealership 1

Services	Description
Maintenance Service 1	<ul style="list-style-type: none"> - Change engine oil - Replace oil filter - Verification of all filling levels - Inspect tires for wear, air pressure (including spare) - Inspect exhaust system to detect leaks, damage, loose parts and remove any obstructing component - Battery verification - Verification of horn, headlights, flashers, and hazard lights - Inspect radiator, cooler, heater and AC - Check wipers and washer fluid - Inspect secondary component belts to verify the tension and to detect tears - Inspect air filter - Inspection des gaines de demi-arbre - Check and lubricate steering, suspension, ball joints, drive shaft U-joints and slip yoke (if serviceable)
Maintenance Service 2	Same activities of Maintenance Service 1 plus : <ul style="list-style-type: none"> - Inspect tires for wear regularly and rotate every 10,000 km
Maintenance Service 3	Same activities of Maintenance Service 2 plus : <ul style="list-style-type: none"> - Replace cabin/pollen air filter (if equipped) - Brake Service: inspect brake pads, shoes, rotors, drums, brake lines and hoses, and parking brake system - Lubricate hinges, latches, locks, sliding door tracks and weather-stripping - Clean battery terminals - Inspect wheels - Replace “green” engine coolant every 36 months or 60,000 km (whichever occurs first) - Replace “yellow” engine coolant at 60 months or 100,000 km (whichever occurs first) and then every 36 months or 60,000 km thereafter
Maintenance Service 4	Same activities of Maintenance Service 2 plus : <ul style="list-style-type: none"> - Replace engine air filter and engine crank case filter
Maintenance Service 5	Same activities of Maintenance Service 3 plus : <ul style="list-style-type: none"> - Replace engine air filter and engine crank case filter
Other repair/maintenance services	<ul style="list-style-type: none"> - Valve - Platinum spark - Non-platinum spark - Automatic transmission/transaxle service

Possible improvements in the actual dealerships' appointment systems

1) **Pre-diagnosis:** Who makes the pre-diagnosis with the customer?

In most cases, the pre-diagnosis is made based on collaboration between a receptionist and the customer. However, receptionists cannot always diagnose with the customer what is required by the vehicle, and in most of the occasions the help of a technician is required. In these situations, the customer is asked to come into the dealership for a pre-diagnosis, implying a time commitment from both the dealership and the customer. Following suggestions presented in Kiff (2000), each customer should have a customer-personnel technician linked to him so that these personal technicians could be involved with the customer in ensuring a successful prediagnosis. This will surely lead to fewer visits to the dealership for a repair/maintenance services.

2) **Drop off and pick-up times:**

To have the vehicle returned at the time expected by the customer is essential but it is also important not to have *over-production* in the sense of inappropriate service delivery timing. In most of the dealerships, the customer drops off the car in the morning for a repair service which does not takes place immediately, and picks up the car at the end of the afternoon.

3) **Assignment of technicians to activities:**

It does not seem to be a good idea to let customers choose their preferred technician as is the case with dealership 2. An online assignment system could be a complementary tool for an appointment system on the basis of well qualified technicians with the adequate profile.

In this sense, there can usually be a match between a service and a customer and a customer with a vehicle. Only one technician is assigned to a vehicle, one who normally has the qualifications required to handle the various necessary repairs. So, the real case study show us how activities are always inserted at the first available time in a simple way with each customer or vehicle regarded as representing one activity and assigned to only one technician who works on the vehicle without interruptions.

Sometimes there is more than one technician with the adequate profile to handle the required task. An open question which has not been answered by the dealerships is: how are technicians assigned to vehicles? Interviewed dealerships do not have explicit strategies. Dealerships schedule activities in advance. A way of improving efficiency by increasing the number walk-in customers and emergencies (and therefore reducing daily customer rejections) could be to follow a certain scheduling rule or strategy. For example, if two technicians with the same profile are available and customers are not allowed to choose the method for dropping off their vehicle, the two following strategies could be followed.

The notation below should be used.

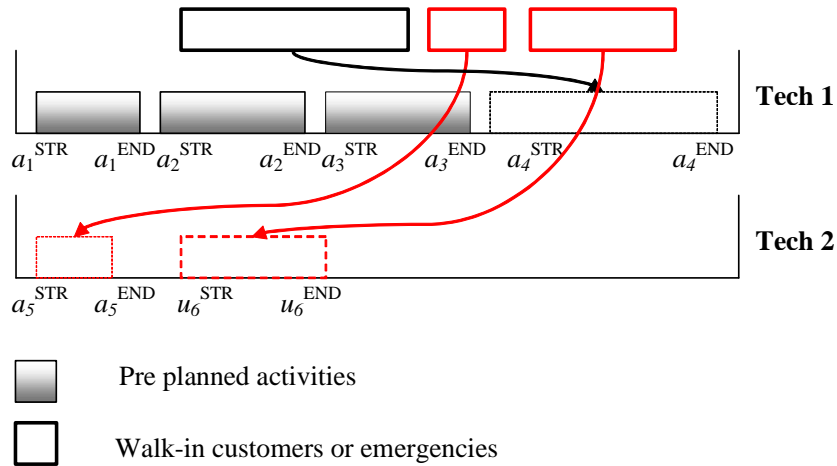
Indices

$i(i - 1, \dots, n)$	Customers, vehicles or activities
$t(t - 1, \dots, m)$	Technicians

Parameters

a_i^{STR}	start time for activity i
a_i^{END}	end time for activity i
pa_i^{STR}	customer's preferred start time for activity i
pa_i^{END}	customer's preferred end time for activity i
u_i^{STR}	start time for emergency activity i
u_i^{END}	end time for emergency activity i
r_i	arrival time for vehicle i . This is the time at which the vehicle is dropped off at the dealership. It is the earliest time that processing of the service activity could begin.
p_i	due date or pick-up time for vehicle i . This is the time at which the vehicle is picked up by the customer. It is the latest time that processing of the service activity could finish.
$d_i = a_i^{END} - a_i^{STR}$	estimated duration of a standard activity i
$du_i = u_i^{END} - u_i^{STR}$	estimated duration of an emergency activity i

First strategy:



1. Assign vehicles to one technician, leaving the second technician free for dealing with emergencies and supporting other technicians with their activities in case some complications which can delay services arise.
2. When the capacity of technician 1 is full, start assigning new vehicles to technician 2.

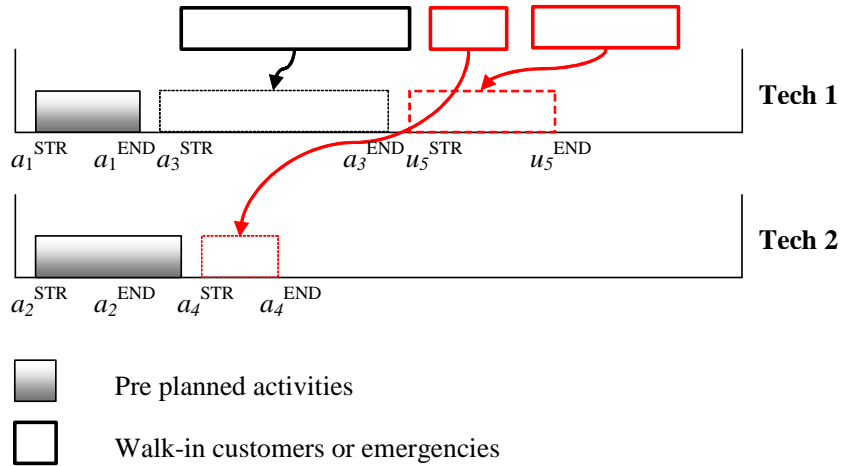
3. Always schedule from the beginning of the morning without letting great empty time periods between activities: $a_{i+1}^{STR} \approx a_i^{END}$.
4. Try to assign technician 2 short or easy activities in order to leave him free time for emergencies or walk-in customers. So, if there is a new complicated activity to be done, assign it to technician 1 and reassign the necessary short activities to technician 2.

This scheduling corresponds to a model in which customers drop off their vehicles at the beginning of the morning period and pick them up in the afternoon (dealership 1). Dealership 2 accepts vehicles at any time during the working hours so the first strategy could be more difficult to follow by this dealership.

Dealership 1 accepts vehicles from 9:00 AM to 12:00 PM. In order to follow this strategy, the customer manager has to offer clients the first hours in the morning following previous activities. If this is not possible because the customer has a different preferred time for bringing the vehicle to the shop, insertion in the ongoing plan has to be done such that between the last planned activity and the new one, there is potentially enough time to insert a new activity. For this, the customer manager has to take into account the average duration of the most common activities in the dealership:

$$|pa_i^{END} - a_{i-1}^{STR}| \geq d_i.$$

Second strategy:



1. Assign vehicles with an appointment to both technicians at the same time starting from the beginning of the morning.
2. Try to insert new activities (emergencies, walk-in customers, and other reassigned activities) when planned activities are finished. If there is an emergency and

$p_i \geq a_i^{END}$ and, $du_{i+1} \leq p_i - a_i^{END}$, then the emergency activity $i + 1$ can be inserted in the place of the ordinary activity i .

3.2 Dental Clinic

A dental clinic has been visited in the Lachine borough of Montreal. A specific questionnaire was elaborated for collecting different data in a two-hour interview.

The dental clinic has three different teams each composed of one dentist, two hygienists, and a dental assistant. Each team has three different types of rooms: an operating room, two hygienists' rooms, and a common office that all teams share for the secretary, reception, payments, waiting room, and the different laboratories and X-ray rooms. There is another operating room shared by all and used for long treatments only when necessary.

This clinic has three different scheduling strategies with three different schedule formats at the base of its appointment system. Dental teams work together in developing the scheduling format and required adjustments are made each week during staff meetings.

The clinic's regular working hours are from 8:00 AM to 9:00 PM from Monday to Thursday and from 9:00 AM to 4:00 PM on Friday, but not all teams have the same hours. Usually two teams work simultaneously and another team works on a differed schedule.

This clinic does not use appointment management software. For each day of the work week and for each dental team, the clinic has an appointment sheet with a particular colour. Each day of the week has a different schedule and each team has a different scheduling model.

On the sheet, each hour is divided into 6 ten-minute periods. One hour is left unscheduled, the lunch hour, which may vary from one day to the other. Teams must schedule the dentist, the hygienists, the dental assistant, as well as the rooms needed.

100% of the clinic capacity is scheduled.

Possible improvements in the actual dental clinic appointment system

An important difference with the dealership case is that dental clinics usually do not accept walk-in customers or patients, so the only kind of non pre planned customers to be scheduled are emergencies.

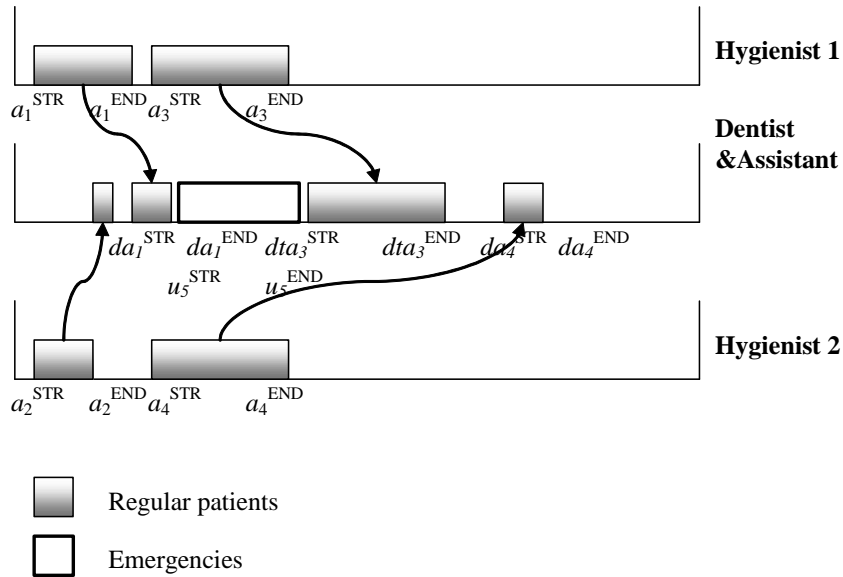
Another important difference with dealerships is that in a dental clinic, each dental service is usually composed of several different activities with different assigned dental professionals. There are two main dental services: regular revisions and specific treatments. When a patient arrives at a clinic for a regular revision, he is first received by the hygienist. Then the dentist with his assistant visit the patient in order to make a diagnosis and to plan a treatment, if it is required. So in the case of a dental clinic, additional unexpected activities could appear within the visit of a patient.

How do dental clinics deal with this situation? Normally they give the patient a second appointment to start the treatment. Several strategies such as the one described below can be followed to improve efficiency in dental clinics.

First strategy:

Once the hygienist has finished with the patient, the dentist comes in to make the diagnosis and if some treatment is necessary, he can decide to do it at that moment or to give the patient another appointment. We shall denote as:

da_i^{STR}, da_i^{END} start and finish times only if a diagnosis is made by the dentist.
 dta_i^{STR}, dta_i^{END} start and finish times if the diagnosis is followed by a treatment carried out by the dentist and the assistant.



1. As patients are usually able to select the dentist's team but not the hygienist within the team, assign patients to both hygienists but attach the longer activities to one and the shorter activities to the other.
2. Always try to schedule from the beginning of the morning without letting significant empty time periods between activities: $a_{i+1}^{STR} \approx a_i^{END}$. If this is not possible because dental clinics usually accept patients during the whole day, try to insert the new activity such that there is enough time to insert a potential emergency between the last patient with an appointment and the new one.
3. Try not to schedule the total clinic capacity in order to allow emergencies coming in and some treatments to be done after the diagnosis. Currently, the dental clinic depends only on patient problems to decide whether to prolong the treatment time

in order to avoid a second visit. But this strategy, however, presents a considerable problem, namely the length of activities such as hygiene and treatment. While a dealership can spend all the time required on a vehicle, it is not the same with a patient who, after a certain period of time, depending on whether he is an adult or a child, cannot stay in the operating room more than a reasonable period of time. It is for this reason that it is not easy to continue treating patients even if there is enough time in the dental clinic's schedule.

Table 7: Data from the dental clinic

I/ QUESTIONS RELATED TO THE APPOINTMENT SYSTEM		
1	Average number of patients	25 per day 1800 active patients per year (two or more visits) 5500 total patients in the clinic
2	Difficulties in the appointment system	Failed appointments Late arrivals
3	Preplanning dental appointments	They write a schedule outlining the plan of treatment for each appointment needed to complete the total treatment plan. For each patient they write the name, the dates for the future procedures, the estimated time for each procedure, the description of each procedure and their cost. They delegate to the assistants appropriate tasks. They try to schedule sufficient doctor time for the procedure to be completed. They prepare and process the minimum number of instruments and materials to accomplish treatment: 4 boxes per room (12 kits). They include in the appointment the time for clean up and transition over the operatory room.
4	Appointment software	No, manual appointments with sheet (different colour for each team and 10 minutes periods).
5	Flexible appointment system	Yes. Emergencies, for example are treated simultaneously to long treatments.
6	Running of appointment book	For certain hygienist procedures: 1 year in advance. For the rest: they accept appointments 6-9 months in advance.
7	Periodicity of appointments in the appointment book	10 minutes periods
8	Distribution of phone appointments	Yes. High picks: Monday morning and Thursday especially after or before long weekends. 3 telephone lines and fax for each team.
9	Categories of patients	With or without insurance, Welfare Government, Welfare (child from 0-10), Indian welfare
10	Patient prioritization	None, but is left to the discretion of the scheduler.
11	Diagnosis of appointments	Yes, check up and for emergencies.
12	Clinic capacity scheduled	100%
13	Emergencies	They accept them in the online plan and they try to give them a treatment for the short-term.

Table 7: Data from the dental clinic (continued)

14	Walk-in patients	They do not accept usually walk-in patients.
15	Appointment prioritization rules	Not, but workers have priority on choosing first or last hours.
16	Confirming appointments	Yes, always. Two days before by phone and by mail (they send reminding cards).
17	Dealing with failed appointments	Approximately 4 patients fail per week, but usually they advise in advance.
18	Procedure for unfilled appointments	If there is a patient in the chair they offer her to extend treatment if it is necessary.
19	Late arrivals	They accept 10-15 minutes of delay especially if there is a good reason. In any case, they always give an appointment 10 minutes before the real starting time. If it is not possible to insert the patient that moment they usually try to insert her in the ongoing daily plan.
20	Seasonal patterns	High season: December and June Low season: January
21	Modification of scheduling in seasonal patterns	Not so much
22	Ideal characteristics for an appointment system	It has to be clear. Daily, weekly, monthly, year in advance. Flexible. Modifiable online: allow rescheduling if unexpected events happen.
II/ QUESTIONS RELATED TO SERVICE ACTIVITIES		
1	Principal activities	See Table 8
2	Length of time for each procedure	See Table 9
3	Performance of procedures at specific times	Yes, difficult or large interventions in Friday mornings
4	Standardized procedures and repeatable patterns	Yes
5	Instrumental placement on the tray	Yes, and they have prepared trays (4 boxes per room with 12 kits)
III/ QUESTIONS RELATED TO AVAILABLE RESOURCES		
1	Existence of working teams	Yes, usually two or three teams at the same time
2	Professionals in each team	1 dentist +1 dentist assistant 2 hygienists
3	Shared professionals	1 clean-up assistant once per week Sometimes if it is required they can share a hygienist or a dental assistant
4	Technical resources	7 rooms
5	Operating rooms	4 (one for each team) and another to share
6	Secretary	1 shared room
IV/ QUESTIONS RELATED TO PATIENT SATISFACTION		
1	Waiting room	Sometimes two patients
2	Phone appointments	Sometimes patients have to wait more than 30 seconds over the phone but it is not usual because they have 3 phone lines and a fax

Table 8: Dental procedures

Dentist	Dental assistant	Dental hygienist	Secretary
Examinations	Assist doctor	Oral prophylaxies	Scheduling of appointments
Treatment of emergencies	Initial follow-up	Sterilization procedures and infection control	Record Patient workload data
Treatment of cavities	Sterilization procedures and infection control	Oral hygiene instructions	Payments
Making diagnostic models	Gathering data for risk assessment to verify medical history	Exposing and processing X-rays	
Replacements	Delivering post-operative instructions	Typical fluoride application	
Periodontal maintenance	Placing rubber dam	Bleaching	
	Production of temporary restorations	Pre-booking	
	Follow-up and estimate insurance payment plan		

Table 9: Duration times for some procedures

Dental Procedure	Minutes
Annual exam without hygiene	15
Hygiene	45
Simple restorative	30
Complex restorative	60
C&C (single unit)	60
C&C (complex)	120
Endo (single canal)	45
Endo (multiple)	90
Extraction (simple)	30
S&RP (1 quadrant)	60
Prophy (simple)	30
Prophy (complex)	45
Room preparation	5
Instrument Sterilization	5

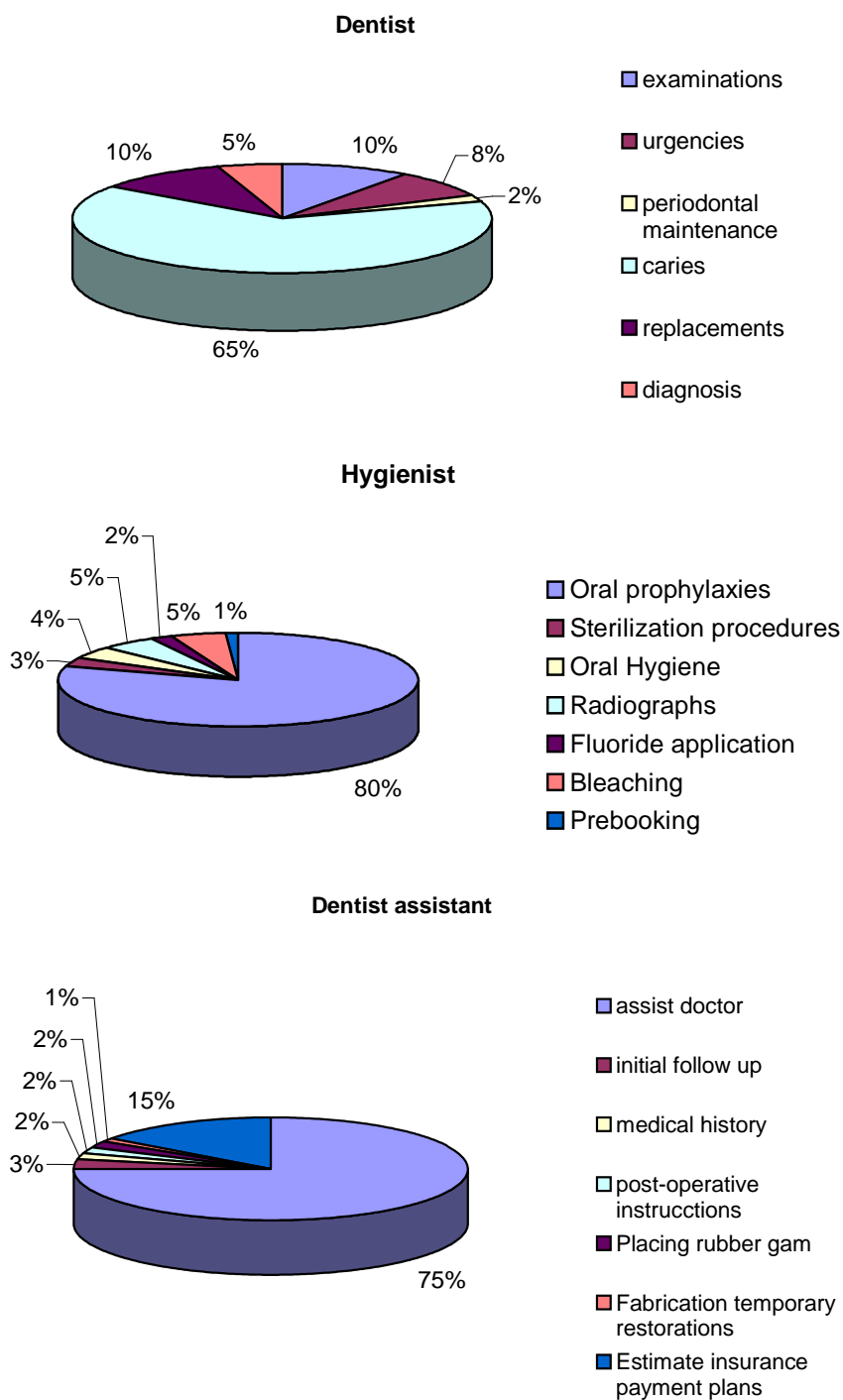


Figure 6: Daily percentages of total time spent on clinical procedures by type of professional

4 Conclusion

Two different services have been studied in this work in order to improve their scheduling systems. From the data obtained from the interviews with the managers of the services, we can conclude that the scheduling needs in both services are not the same. Rescheduling in dentist services is more difficult than in dealerships due to the nature of the service. As dental services are characterized by a direct action on the customer's person (the patient), all kinds of modifications in the ongoing plan have numerous repercussions over daily scheduling. This does not happen in vehicle maintenance services because customers usually drop off their vehicles at a certain hour in the day and usually do not wait for the service to be completed. Normally, a due date is provided to the customer so he can come to the shop to pick up the vehicle after several hours, often at the end of the afternoon. This situation allows easy rescheduling and does not lead to customer dissatisfaction. In dental services, a delay due to rescheduling could highly decrease customer satisfaction.

From the real case studies we have found that a more dynamic tool is needed in dealerships in order to reassign technicians to activities when rescheduling is necessary. In the case of the dental clinic, scheduling rules are needed in order to plan appointments in an optimal way. The maintenance of two appointment books simultaneously (one for the long term for appointments with the hygienist in the back and another one for the short term with the secretary in the front desk) requires a more sophisticated scheduling system in order to coordinate appointments. In this sense, efficiency could also be improved if they had an online appointment system because this would allow the clinic to easily schedule long and short term appointments simultaneously.

Nevertheless, this work is just preliminary research and the starting point to a more in depth study of scheduling systems in the services field.

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Appendix DEALERSHIP QUESTIONNAIRE

GENERAL DATA

DEALERSHIP:

ADDRESS:

TELEPHONE:

FAX:

WEBSITE:

I/ QUESTIONS RELATED TO SERVICE ACTIVITIES

Activity Groups:

- Car care
- Brake systems
- Cooling & Heating
- Drive Train Systems
- Fuel Systems
- Electrical Systems
- Suspension Systems
- Exhaust Systems
- Other groups:

List your repair and maintenance activities trying to classify them into different groups. You can reclassify activity groups and add other activities not included in Table reftab1 if you consider it necessary.

CAR CARE

- Lube/Oil Filter
- Transmission
- Wheel Bearings
- CV Joints
- Differential Service
- Power Steering
- Brake Fluid
- Windshield Washer
- Windshield Wipers
- Battery Service
- Inspections
- Scheduled Maintenance
- Other activities:

BRAKE SYSTEMS

- Diagnosis
- Pads & Shoes
- ABS repairs
- Brake Hoses
- Brake Calipers
- Wheel Cylinders
- Parking Brakes
- Brake Drums
- Brake Rotors
- Power Boosters
- All Hydraulics
- Master Cylinder
- Other activities:

COOLING & HEATING

- Diagnosis
- Radiator
- Cooling System Flush
- Heater Cores
- Thermostats
- Hoses/Belts
- Fan Clutches
- Electric Fans
- Water Pumps
- AC Svc/ Repairs
- AC Compressor
- R-134A Retrofit
- Other activities:

DRIVE TRAIN SYSTEMS

- Clutch Assembly
- Drive Shafts
- Axle & Bearings
- Transaxle
- Differentials
- Standard Transmission
- Automatic Transmission
- U-Joints
- 4X4 Service/Repairs
- Other activities:

FUEL SYSTEMS

- Diagnosis
- Carburettors
- Gas Fuel Injection
- Diesel Fuel Injection
- Glow Plugs
- Fuel Lines/Hose
- Fuel Tanks
- Fuel Gauges
- Fuel Pumps
- Fuel Filters
- Emission Controls
- Other activities:

ELECTRICAL SYSTEMS

- Diagnosis
- Drivability
- Alternators
- Starters
- Lights
- Power Accessories
- Heat/AC Control
- Instrumentation
- Electrical Wiring
- Computer Systems
- Other activities:

SUSPENSION SYSTEMS

- Diagnosis
- Shocks/Struts
- Ball Joints
- Leaf/Coil Springs
- King Pins
- Control Arms
- Drive Axle
- Air Ride System
- Steering Racks
- Other activities:

EXHAUST SYSTEMS

- Diagnosis
- Manifolds
- Mufflers
- Header Pipes
- Catalytic Converters
- Gaskets
- Other activities:

Complete the processing times of previous activities indicating if they are exact or approximated data. In the last case, please, indicate if the estimation is the most possible, minimum processing time estimation or maximum processing time estimation marking the right cell with a cross.

Car Care	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Lube/Oil Filter					
Transmission					
Wheel Bearings					
CV Joints					
Differential Service					
Power Steering					
Brake Fluid					
Windshield Washer					
Windshield Wipers					
Battery Service					
Inspections					
Scheduled Maintenance					

Brake Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Pads & Shoes					
ABS repairs					
Brake Hoses					
Brake Callipers					
Wheel Cylinders					
Parking Brakes					
Brake Drums					
Brake Rotors					
Power Boosters					
All Hydraulics					
Master Cylinder					

Cooling & Heating	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Radiator					
Cooling System Flush					
Heater Cores					
Thermostats					
Hoses/Belts					
Fan Clutches					
Electric Fans					
Water Pumps					
AC Svc/ Repairs					
AC Compressor					
R-134A Retrofit					

Drive Train Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Clutch Assembly					
Drive Shafts					
Axle & Bearings					
Transaxle					
Differentials					
Standard Transmission					
Automatic Transmission					
U-Joints					
4X4 Service/Repairs					

Fuel Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Carburettors					
Gas Fuel Injection					
Diesel Fuel Injection					
Glow Plugs					
Fuel Lines/Hose					
Fuel Tanks					
Fuel Gauges					
Fuel Pumps					
Fuel Filters					
Emission Controls					

Electrical Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Drivability					
Alternators					
Starters					
Lights					
Power Accessories					
Heat/AC Control					
Instrumentation					
Electrical Wiring					
Computer Systems					

Suspension Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Shocks/Struts					
Ball Joints					
Leaf/Coil Springs					
King Pins					
Control Arms					
Drive Axle					
Air Ride System					
Steering Racks					

Exhaust Systems	Processing time (minutes)	Exact (Yes/No)	Most possible estimation	Minimum estimation	Maximum estimation
Diagnosis					
Manifolds					
Mufflers					
Header Pipes					
Catalytic Converters					
Gaskets					

Is there any logical sequence for the activities to be done in a repair or maintenance service?

.....

Is there any delay required for an activity before continuing with the following one?

.....

Is there any activity which has to be finished before starting the following one?

.....

II/ QUESTIONS RELATED TO AVAILABLE RESOURCES

Human resources

List below the different categories of human resources related to repair and maintenance activities in the dealership:

.....

Technical requirements

List below the principal technical resources required by repair maintenance services:

.....

Are all the technical resources allowable in a sufficient number to be available at any time?

- Yes
- No

If not list below the technical resources which can not be used in two different activities at the same time:

.....

III/ ASSIGMENT OF TECHNICIANS TO ACTIVITIES

Fulfil the following table with the required human and technical resource for each activity:

Car Care	Technician	Machine
Lube/Oil Filter		
Transmission		
Wheel Bearings		
CV Joints		
Differential Service		
Power Steering		
Brake Fluid		
Windshield Washer		
Windshield Wipers		
Battery Service		
Inspections		
Scheduled Maintenance		

Brake Systems	Technician	Machine
Diagnosis		
Pads & Shoes		
ABS Repairs		
Brake Hoses		
Brake Callipers		
Wheel Cylinders		
Parking Brakes		
Brake Drums		
Brake Rotors		
Power Boosters		
All Hydraulics		
Master Cylinder		

Cooling & Heating	Technician	Machine
Diagnosis		
Radiator		
Cooling System Flush		
Heater Cores		
Thermostats		
Hoses/Belts		
Fan Clutches		
Electric Fans		
Water Pumps		
AC Svc/ Repairs		
AC Compressor		
R-134A Retrofit		

Drive Train Systems	Technician	Machine
Clutch Assembly		
Drive Shafts		
Axle & Bearings		
Transaxle		
Differentials		
Standard Transmission		
Automatic Transmission		
U-Joints		
4X4 Service/Repairs		

Fuel Systems	Technician	Machine
Diagnosis		
Carburettors		
Gas Fuel Injection		
Diesel Fuel Injection		
Glow Plugs		
Fuel Lines/Hose		
Fuel Tanks		
Fuel Gauges		
Fuel Pumps		
Fuel Filters		
Emission Controls		

Electrical Systems	Technician	Machine
Diagnosis		
Drivability		
Alternators		
Starters		
Lights		
Power Accessories		
Heat/AC Control		
Instrumentation		
Electrical Wiring		
Computer Systems		

Suspension Systems	Technician	Machine
Diagnosis		
Shocks/Struts		
Ball Joints		
Leaf/Coil Springs		
King Pins		
Control Arms		
Drive Axle		
Air Ride System		
Steering Racks		

Exhaust Systems	Technician	Machine
Diagnosis		
Manifolds		
Mufflers		
Header Pipes		
Catalytic Converters		
Gaskets		

IV/ QUESTIONS RELATED TO THE APPOINTMENT SYSTEM

Do you make a prediagnosis with the customer?

- Yes
- No

How do you exactly determine the drop-off and picking up time for each customer?

.....

Do you make a detailed repair order after the prediagnosis and in cooperation with the activities manager?

- Yes
- No

Which is the periodicity for your scheduling?

- Daily
- Weekly
- Monthly
- Yearly
- Other:

What percentage of the shop capacity do you schedule?

- 50%
- 75%
- 80%
- 100%
- Other:

How do you deal with emergencies?

- You have a percentage of the shop capacity left to emergencies.
- You try to insert the emergency service in the ongoing plan.
- Other solutions:

How do you deal with walk-in customers?

- You have a percentage of the shop capacity left to walk-in customers.
- You try to insert the service in the ongoing plan.
- Other solutions:

Which are your prioritization rules?

- First in first out.
- Short time process activities first.
- Special customers first.
- Other:

How do you deal with unpunctuality of customers for dropping off their vehicles?

.....

Do you perceive some seasonal patterns?

- Yes
- No

In the case of an affirmative answer, at what time of the year?

.....

How do you modify your scheduling in high and low seasons?

.....

V/ OTHER QUESTIONS RELATED TO CUSTOMERS SATISFACTION

Do you repair vehicles of all trademarks?

.....

Do you do only maintenance services under warranty?

.....

Your main type of repair/maintenance service is:

- Post-Sales services.
- All type of repair and maintenance services in Ford vehicles.
- All type of repair and maintenance services in all trademarks vehicles.

Do you have different categories of customers?

.....

Are they prioritized in any way?

.....

DENTAL CLINIC QUESTIONNAIRE

I/ QUESTIONS RELATED TO THE APPOINTMENT SYSTEM

1. Which is the average number of patients per day in the clinic? And per week? And per month?
2. What kind of difficulties do you find when making an appointment with a patient?
3. Do you have a preplanning of dental appointments in order to:
 - Delegate duties to the lowest skill level appropriated to the task being performed,
 - Schedule sufficient doctor time for the procedure to be completed,
 - Prepare and process the minimum number of instruments and materials to accomplish treatment,
 - Allow for operatory clean up and turn over?
4. Do you have an online appointment system? How does it work? Is it similar to the one presented in Table 1? See next questions.
5. Do you have a flexible appointment system? That is, do you have alternative Work Schedules? Do you modify the appointment book to match the hours of new operations?
6. How long do you run your appointment book? One week? Two weeks? One month?
7. Do you have one hour generic appointments?
8. Do the telephone calls or the online appointments follow any distribution?
9. Do you have different categories of patients?
10. Are they prioritized in any way?
11. Do you make a first appointment with the patient just for diagnosis of the problems?
12. What percentage of the clinic capacity do you schedule?
13. How do you deal with emergencies?
14. Do you accept walk-in patients?
15. Usually patients want to get the first appointment in the day or the last one Which are your prioritization rules in these cases? "First come, first serve", for example?
16. Do you confirm appointments, specially those lengthy appointments? How do you do it, by phone, by mail?
17. Which percentages of patients do not come for their appointments? Do they usually advise you in advance? How do you deal with patients cancelling appointments? Do you have a list of patients available on short notice?
18. When you suddenly have unfilled appointment time due to a failed appointment, do you extend treatment to patients already in the chair?
19. How do you proceed with late patient arrivals?
20. Do you perceive some seasonal patterns? In case of an affirmative answer, at what time of the year?
21. How do you modify your scheduling in high and low seasons?
22. In your opinion, which could be the ideal characteristics for an appointment and scheduling system?

II/ QUESTIONS RELATED TO SERVICE ACTIVITIES

1. Which are your principal procedures or activities? See Table 2.
2. Can you give us the length of time required for each procedure? See Table 3.
3. Do you perform certain procedures at specific times?
4. Do you use standardized (consistent and uniform) procedures? Do you have repeatable patterns?
5. Do you have a technique for simplifying instrument placement on the tray? In this sense, do you have prepared trays?

III/ QUESTIONS RELATED TO AVAILABLE RESOURCES

Human resources: Personnel

1. Do you have working teams?
2. How many professionals do you have? If some of them are shared please specify:
3. **Dentists**
Dental Assistants
 Shared between dentists: YES NO
- Hygienists**
 Shared between dentists: YES NO
- Dental Therapy Assistants**
 Shared between dentists: YES NO
- Sterilization Technicians**
 Shared between dentists: YES NO
- Treatment Coordinators**
 Shared between dentists: YES NO
- Other**
4. Are the dental assistants always related to the same dentist?

Technical resources and equipment

5. Can you give us a list of the principal technical resources in the clinic?
Dentist offices
Operating rooms
Other
6. Has each dentist her operating room?
7. Instruments that are frequently used are packaged and sterilized together in order to reduce the number of instrumentation, removing instruments that are never or seldom used?
8. Can you give us the required human and technical resource for each activity?

IV/ QUESTIONS RELATED TO PATIENTS SATISFACTION

- 1. Are patients usually left to wait for long periods in the reception area?
- 2. In case of appointments over the phone:
 - a. Is there always someone available to answer calls during duty hours?
 - b. Do you keep patients on hold for more than 30 seconds?

Table 1: Appointment system

	Team Dentist 1	Team Dentist 2	Team Dentist 3
8:00			
9:00			
10:00			
11:00			
12:00			
13:00			
14:00			
15:00			
16:00			
17:00			
18:00			

If your appointment system is like this, how do you schedule operating rooms? How do you assign technicians to dentist?

Table 2: Dental Activities

Dentist	Dental Assistants	Dental Hygienist	Dental Therapy Assistant	Sterilization Tech.	Treatment Coordinator
Examinations	Assist doctor	Oral prophylaxis		Sterilization procedures and infection control	Scheduling of appointments
Treatment of urgencies	Assist hygienist	Periodontal maintenance		Clean up and operatory preparation	Record Patient workload data
Hygiene	Delegated functions from doctors: Oral hygiene instructions Initial follow-up Taking and recording blood pressures Gathering data for risk assessment to verify medical history Exposing and processing radiographs Making diagnostic models Topical fluoride application Placing rubber dam Delivering post-operative instructions Fabrication of temporary restorations				
Oral Prophylaxis					
Periodontal maintenance					
Treatment of caries					
Dental restorations					
Replacements					

Table 3: Duration times for some procedures

Dental Procedure	Minutes
Annual exam	15
Simple restorative	30
Complex restorative	60
C&C (single unit)	60
C&C (complex)	120
Endo (single canal)	45
Endo (multiple)	90
Extraction (simple)	30
S&RP (1 quadrant)	60
Prophy (simple)	30
Prophy (complex)	45
Room preparation	5
Instrumental Sterilization	10