

1. Executive Summary

Our dental clinic has a mission of improving patient care satisfaction, efficiency of staff operations, and an increase in the overall net income with the use of IoT technology. Key measurable goals that have been established include the reduction in patient wait times/consulting, higher ratings seen through patient reviews, as well as positive cash flow statements. According to the Dental Defense Union, some of the chief complaints from dental patients include long wait times, quality of services, use of old technology/methods, and delays in diagnosis. Our practice will be utilizing various aspects of IoT technology to help address these complaints and have an overall smoother flow of operations.

2. Business Situation/Context

As a business, our dental clinic will look at how IoT can help patient care overall. The main factors we will be looking at are how to achieve efficiency while also saving costs. We are seeking a competitive advantage over surrounding dental clinics through improving our overall patient satisfaction and a smoother flow of operations.

3. Motivation for IoT Technology

The world is constantly evolving through the use of various technologies such as sensors, internet of things, and artificial intelligence. With these tools, our clinic will be able to benefit our customers and staff members in various ways. Communication and connection through IoT will give our clinic an edge against competing clinics.

Transparency and clear communication is something we value highly in our dental practice, because it strengthens our relationships with our patients and staff as well as creates a healthy environment and smoother flow of operations. Cloud technology will not only increase productivity, but also will aid in clinical ways such as effective treatment. Overall, an increase in workflow operations will inherently lead to an increase in profits due to IoT allowing for more patients to be seen daily.

4. IoT Technology

a. Sensors and Actuators

No.	Sensors/Actuators	Data/Units	Potential Use of Data
1	Temperature Sensor	Fahrenheit	Aids in Covid-19 defense
2	Touch Sensor	Patient Identification	Expedites check in process and preps dentists and assistants on patient
3	Pressure sensor	Liters per minute	Automates drug infusions and monitors oxygen intake during procedures
4	Electric actuators	Found in dental xray equipment	Detection of cavities and problem areas
5	Linear actuators	Dental chair adjustments	Helps dentist quickly adjust patient in order to treat areas of concern

We chose the sensors and actuators above for our dental clinic. Although these sensors make small changes, they have a large pay off in terms of increasing efficiency. Covid-19 has changed the way our world operates and there are certain procedures put in place in order to preserve the health of as many individuals as possible, including our dental staff. For this reason, we are putting a temperature sensor in place at the front desk check-in kiosk that will register the temperature of the patient upon entering and determine whether or not the patient is in the safe zone to proceed with the appointment. If not, the kiosk will direct them to a screen which will display upcoming available appointment dates and time and allow them to choose whichever works with their own schedule the most. This system also helps increase profit due to the lack of needing a human to operate the front desk.

If the sensor concludes the patient is in the safe zone, the kiosk will eject a key card and assign the patient to a waiting room. Upon entering the waiting room, the patient will insert the key card into the provided slot. This touch sensor will immediately send a notification to the tablets carried by the dental clinic staff. The notification will provide the staff with the patient's information and electronic health records. They will also summarize the patient's reason for visitation, allowing the staff to increase their efficiency by being prepared for their next case.

In the cases that patient will need to be under anesthesia and need the use of an oxygen machine, our pressure sensors will provide an automation that will determine the oxygen intake needed for the patient as well as monitor their oxygen

intake throughout the procedure. This automation further increases profits of the clinic, because the automation is taking the place of a human staff member. The two main actuators in our clinic are electric and linear. The electric actuator can be found in our x-ray equipment and aids the machine in detecting cavities and other problem areas in a small amount of time. This directly increases the efficiency and improves the accuracy of the dental office which leads to an increase in revenue, as well as patient satisfaction. In addition to this, the linear actuator can be found in the patient chairs and help the doctor adjust the patient to different positions with the help of a touch sensor by his feet for convenience so he or she can operate the chair hands-free.

- *Communication (OT network / IT network)*

OT network/IT network convergence is a major necessary step if a dental practice wants to establish a tech-based future. Successful convergence of these networks can lead to cost savings, higher patient satisfaction, and an increase in operational standards/flexibility. In our clinic, the data collected from our sensors throughout our equipment within the clinic will be able to be stored and analyzed in Edge and AWS cloud. It is so important for our clinic to have our informational and operational technology working with each other in order for our clinic to truly see any positive results from IoT integration.

- *Cloud/Data Storage*

Healthcare practices rely on various servers and networks in order to store and keep track of patient records. Cloud-based technology aids in the protection and security of data, patient charts, tasks of employees, and the overall flow of the dental practice.

Typically, a traditional dental clinic will use electronic health records that are housed on client-owned servers. This puts the clinic at a disadvantage, because the clinic will then have abundant costs when factoring in hardware/software, installation, maintenance, licensing, and upgrades. It also needs to be backed up regularly and runs a risk of the clinic losing data, the system not functioning properly, and human error.

Due to the concerns listed above, our clinic will choose to use cloud-based dental software. This is also known as Software-as-a-service (SaaS). With the use of this software, our clinic will be able to utilize all records with web-based tools and access all our data from anywhere in the world on multiple different devices.

The main benefits of cloud-based dental practices:

- Fast and convenient data management, reliability, and scalability
- Cost savings
- Competitive advantage
- Improved security and compliance
- Overall improvement in patient satisfaction

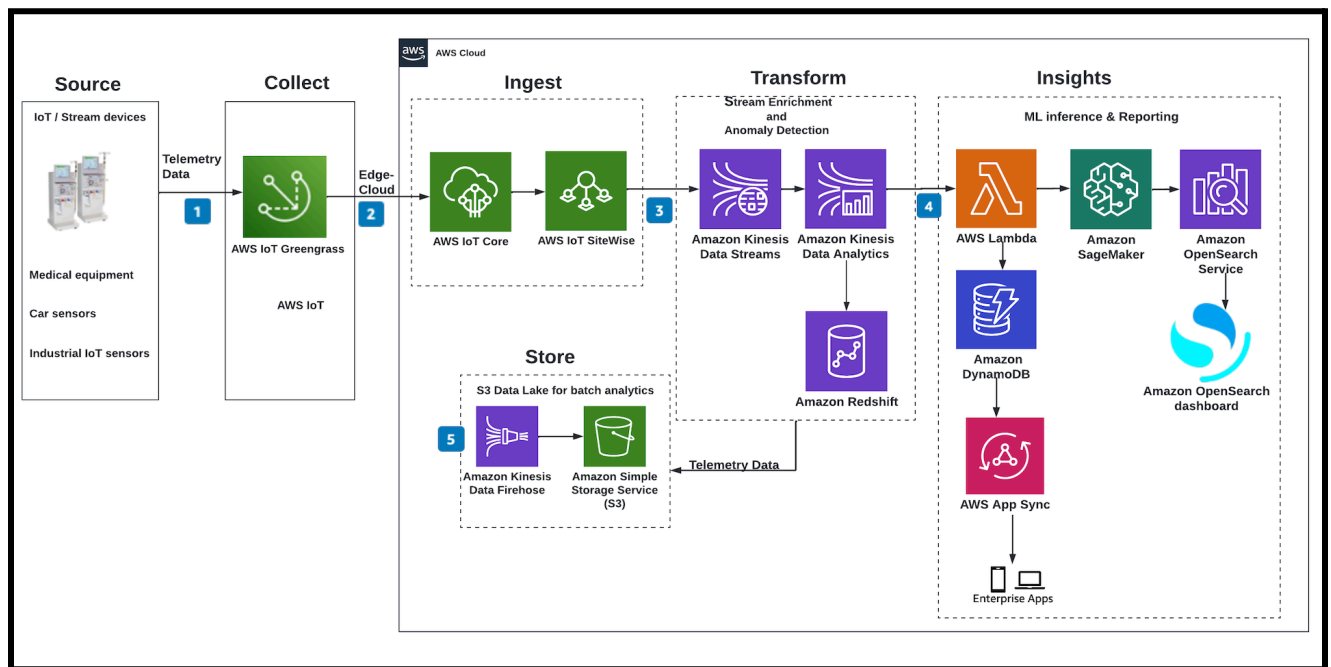


Figure above demonstrates the architectural structure of the development of IoT services

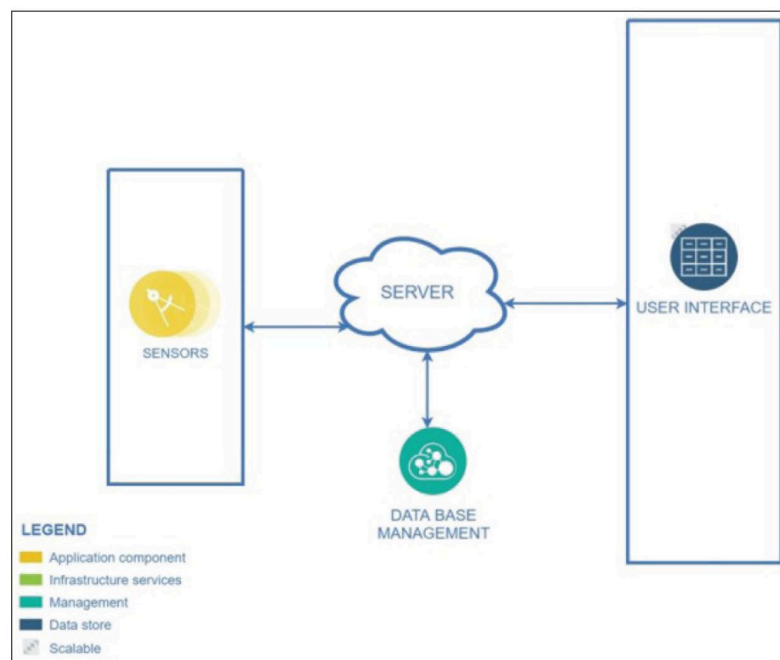
Architecture flow:

1. IoT devices, such as medical devices or industrial sensors, produce data. One of the IoT data collection methods we will be utilizing is AWS IoT Greengrass. This is an open-source IoT edge/cloud service that aids in data generation, as well as the analyzing of this data. During our day to day operations, AWS IoT Greengrass is activated in order to receive and filter data in order to communicate securely with the cloud and other local devices in our network to send the data.
2. Our data will then be sent into the cloud with AWS IoT Core, a managed cloud platform that connects, manages, and scales devices easily and securely. We also plan on utilizing AWS IoT SiteWise, a managed service that will help us collect, model, analyze, and visualize data from industrial equipment within our clinic.
3. AWS IoT Core will then filter our data into Amazon Kinesis Data Streams. The major benefit of this is that our clinic's data will be able to be analyzed nearly in real time.

Furthermore, data warehouses, such as Amazon Redshift enable searching data once patient data has been integrated into our systems.

- **Architecture**

A basic IoT system constitutes the sensors, cloud server, database and the user interface. The cloud system allows for our clinic to be able to access server data from anywhere in the world. We will be using the intraoral sensor as an example and breakdown of the architecture of IoT for our practice. This type of sensor can be placed by the mucous membrane within the oral cavity in order for a dentist to observe a patient's daily functions and intake without any discomfort for the patient. This data will be logged and then stored within the AWS cloud where it will be secure and privately kept. Within IoT, the edge and cloud are used as computing technologies. Edge is typically used to process data in real time while the cloud is more so used to process and store long term data. When a patient of ours uses a device that contains a sensor for tracking their vitals and health, it transfers the data from examination within the clinic to the patient's phone or tablet. In summary, IoT devices that will be used in our dental practice are typically used to monitor and transfer patient data to the cloud and edge for further analysis.



(Basic IoT Architecture pictured above)

Data Security -

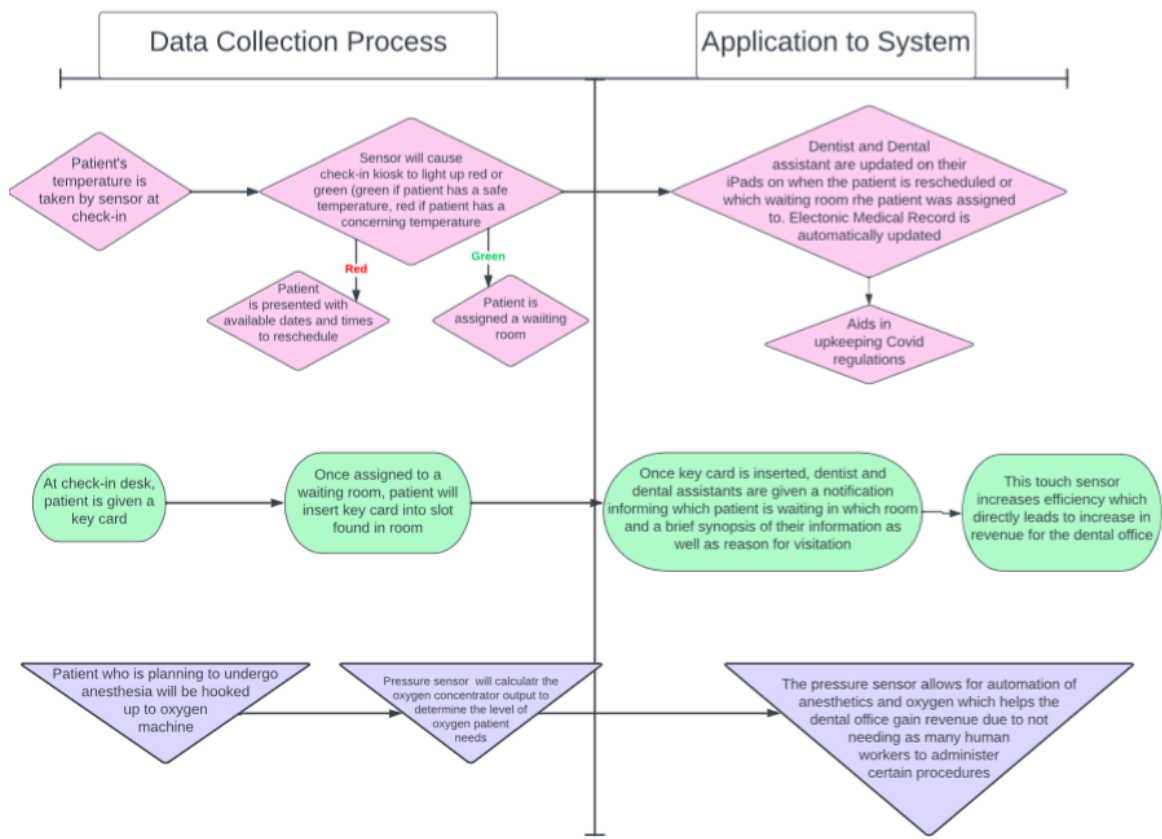
When discussing the sharing of data and data communication as a whole, it is really important to also look at the security risks and how to maintain privacy with the use of IoT. This is especially important due to our dental practice dealing with personal identifiable

information. Risks that are more unique to our business include HIPAA. This is the Health Insurance Portability And Accountability Act, which protects sensitive patient health data to be protected and not shared without their consent or knowledge. We will be looking at features that are built into cloud platforms that were created for the purpose of protecting data. '

Cloud software was created with safeguards put in place in order to protect a patient's personal data and privacy. These safeguards include the encryption of data, 2-factor authentication, restrictions on who has access to these data, and a variety of other software safety solutions. The encryption within the system will be stored in AWS cloud, which will have even more security systems put in place.

5. Data and Analysis

Temperature Sensor Mock Data				
Patient Name	Temperature Registered by Sensor (degrees Fahrenheit)	Do they meet Covid-safe regulations?	Light indicator	
Keerthi Raja	98.9	Yes	Green	
Andrew Varghese	101.4	No	Red	
Blake Burris	97.2	Yes	Green	
Devon Jackson	98.6	Yes	Green	
Touch Sensor Mock Data				
Patient Name	Age	Gender	Reason for Visitation	
Keerthi Raja	24	F	Cavity filling	
Andrew Varghese	53	M	Teeth Cleaning	
Blake Burris	19	M	Root Canal	
Devon Jackson	31	F	Experiencing discomfort, potentially due to wisdom teeth	
Pressure Sensor Mock Data				
Patient Name	Oxygen Concentration Output (liters per minute)			
Keerthi Raja	0.75			
Andrew Varghese	2.5			
Blake Burris	2.1			
Devon Jackson	1.3			
Electric Actuator Mock Data				
Patient Name	Cavity or problem area detected by Sensor?	Tooth with Concern		
Keerthi Raja	Yes	Second premolar		
Andrew Varghese	Yes	Canine		
Blake Burris	No	N/A		
Devon Jackson	Yes	Lateral Incisor		



6. Business Value derived from IoT data

A major way in which our business will benefit from the integration of IoT technology and the data it derives is through the transformation that will occur in our business design as well as the evolution of our equipment. This evolution will elevate our current systems in place in order to derive more data than we were originally able to before. Additionally, through digital automation, our clinic will be able to operate more swiftly and retrieve more data from our patients in less time. In conclusion, our patient consultations will take a fraction of the time, giving our clinic time to take in more patients on a day to day basis. The automation of several services will also give our clinic the opportunity to operate with less staff members, further benefiting our clinic monetarily.

7. Summary/Discussion

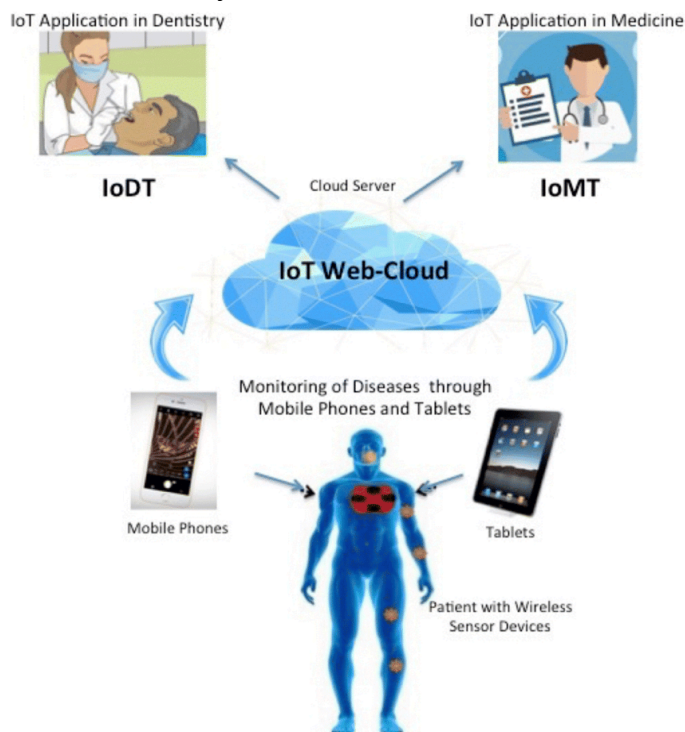
Our clinic's mission is to strive to have high satisfaction ratings and truly make the process of going to the dentist as effortless as possible for our patients, while simultaneously giving them quality care and aid in the prevention of dental issues. In our current world, technology is the answer to evolution in patient care. We plan on utilizing sensors/actuators, OT/IT convergence, and AWS cloud in order to achieve our goals moving forward. These tools will help our clinic reduce patient wait times,

help patients be more involved in their dental journey via accessible electronic health records, aid in an increase of cash flow in operations, and an overall more seamless experience for both patients and staff. The application of IoT services to our clinic is bigger than just us when it comes where the world is heading in terms of rapid advancements of technology. IoT is rapidly growing, and we will continue to see this happen in healthcare environments all around the world.

Always a scope for improvement:

We know there will be some growing pains as we start to integrate IoT into our clinical operations, but this investment will have a payoff worth any complications that will need to be worked through. Furthermore, we know some staff members or patients may present resistance to our changes in operations, but we hope to show all that are involved how IoT will do more good than harm for the clinic.

Visual summary:



8. References

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