AWS Architecture Monthly

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Healthcare

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Editor's Note

According to the Centers for Medicare and Medicaid Services (https://www.cms.gov), and under current law, national health spending is projected to grow at an average rate of 5.5 percent per year from 2018 to 2027 and to reach nearly $6.0 trillion by 2027.

Healthcare and life sciences organizations are looking for ways to lower costs and improve the quality of patient care. Intelligent, connected, and secure cloud-based solutions can help bring innovations to care delivery models, drug discovery, and genomics.

This month's magazine dives deep in what AWS offers for the healthcare industry, from HIPAA security and compliance to artificial intelligence in health monitoring and more.

We hope you'll find this edition of Architecture Monthly useful, and we'd like your feedback. Please give us a star rating and your comments on the Amazon Kindle page (https://amzn.to/Kindle-magazine). You can view past issues at https://aws.amazon.com/whitepapers/kindle/ and reach out to aws-architecture-monthly@amazon.com anytime with your questions and comments.

In February's issue:

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Annik Stahl, Managing Editor

What are the general architecture pattern trends for healthcare industry?

It's important to keep in mind that generally, IT technology in healthcare runs a little behind other industries. What we're seeing now—like the move towards SaaS and decoupled architectures—is only just beginning within healthcare. Right now, the biggest architecture pattern/trend is the adoption of serverless-within-healthcare data interoperability. True data interoperability in healthcare has long been a goal of almost every institution around the world; it gives clinicians better, more timely access to essential data needed for patient care and offers patients better visibility into their own journey. And like many things in healthcare, previous solutions that were based on block/monolithic architectures can't scale to accommodate all patients across the multitude of points for care. So, we have been working closely with industry bodies such as HL7 (https://www.hl7.org/) and strategic partners like Cerner (https://www.cerner.com/) to drive adoption of scalable (serverless) solutions to better serve our healthcare customers.

When putting together an AWS architecture to solve business problems specifically for healthcare customers, do you have to think it all differently?

Yes, absolutely. As I've been reminded by customers and clinicians many times, "move fast and break things" doesn't work when those "things" are necessary for saving lives. When working in healthcare right now, it's essential to recognize that the most critical systems that are central to patient care are massive, monoliths that have been in service for decades. These systems can't be easily modernized or migrated without careful consideration and planning. And while the cloud brings incredible promise for institutions needing the ability to scale, to better reach their patient population, and to quickly incorporate new advancements in research and robotics, it's going to be a years-long process. Woven throughout all of our efforts has to be patience, persistence, and an appreciation for the incredible responsibility on our customers' shoulders when they are providing healthcare for all of us.

Do you see different trends in healthcare in cloud versus on-premises?

Definitely! Providers who have the capacity for new development have enthusiastically adopted the cloud to better connect with their patients. Healthcare industry trends like direct-to-consumer (d2c) care delivery, telemedicine/telehealth, and the digital front-door

are all built on and for use with the cloud. All of the industry trends for on-premise are saddled with the focus on reducing costs and increasing the operational efficiency of the infrastructure. All the new, innovative trends in healthcare are happening in the cloud. The only thing happening on-prem is people trying to squeeze out everything they can from their remaining investment. On-premise infrastructure doesn't offer the scale or flexibility needed to address the challenges healthcare providers face.

What's your outlook for the healthcare industry and, what role will cloud play in future development efforts?

I'm incredibly optimistic that the cloud will play the central role in all future development efforts within healthcare technology. The cloud provides the best path forward for scale, for reaching vulnerable patients, for supporting the deployment of advanced surgical robotics, for more comprehensive and cheaper diagnostics in remote areas, for the development of advanced AI-based clinical decision support, and much more. There is hardly any area emerging in healthcare technology that doesn't utilize the cloud. Just think about some of the workloads running on AWS today:

- "Intelligent" inhalers for children with asthma that can measure the delivery dosage and relay that info to AWS. In turn, this information, when combined with environmental and prior health data, can be used to predict when those children are most vulnerable to potential attacks in the future and can help them avoid those episodes.
- Surgical robots that compile their operational plan on Amazon EC2 and then perform their post-op analyses by the microsecond of the surgery performed, carefully reviewing it for any anomalies or deviations from the plan.
- Diagnostic tools and scanners that can be attached to mobile phones and taken far afield, where they can be used with populations that wouldn't otherwise have access to sophisticated care in a hospital. These devices relay their data to AWS, where it is analyzed and returned to the physicians while they are with the patient and can then provide immediate treatment or guidance.
- Elastic computational support behind the small-scale therapeutic manufacturing needed for patient-specific immunotherapy.

These are all happening today on AWS! Imagine what tomorrow will bring as we develop more AI/ML services, provide more robust infrastructure, and build more capabilities at the edge.

Patrick Combes joined Amazon Web Services in April 2016 and is the Worldwide Technical Leader for Healthcare and Life Sciences (HCLS). He helps develop and implement the strategic plans to engage customers and partners in the industry and leads the community of technically focused HCLS specialists within AWS. Patrick has a B.S. in Computer & Electrical Engineering from the University of Illinois at Champaign-Urbana with additional graduate work focused on programming language design. He also holds several associate and professional certifications for architecting on AWS.

Real-World Example

Healthdirect Australia: Using AWS to Connect People with Healthcare

Peter from Healthdirect Australia walks us through a system that supports every health service, provider, and practitioner in Australia. The architecture is split into two sides—write-intensive and read-intensive—and leverages multiple AWS services including Amazon API Gateway, AWS Lambda, Amazon DynamoDB, Amazon Kinesis, Amazon S3, Amazon EMR, Amazon Elasticsearch Service, and Amazon Athena.

https://amzn.to/AWS-HC-TMA-Healthdirect

Blog:
Patient-Centered Health: How AWS Helps Patients Take Control of Their Own Health Data

By Dr. Taha A. Kass-Hout, Arun Ravi, Melanie Kaplan, and Pat Combes

Imagine: Transforming the patient and caregiver experience by streamlining health providers and administrative staff interactions and calculating risk score and clinical decision support systems to offer clinicians actionable insights at the point of care. Establishing healthcare data interoperability interfaces, like Fast Healthcare Interoperability Resource (FHIR), can help empower patients and improve their care.

Backed by the nonprofit HL7, the FHIR application programming interface (API) facilitates data exchange between enterprises, like health systems, and uses medical claims for analytics. FHIR helps software developers build applications to benefit patients and clinicians, like a secure application for patients to pull data into a portal of choice. This approach reduces friction, introduces automation, and provides new methods for delivering cost-effective services to close gaps in care. Patients become active, informed partners with their clinicians.

Last year, Amazon Web Services (AWS) worked with Fred Hutchinson to create a FHIR-enabled storage and APIs, enabling care coordination between oncologists and primary care providers. Fred Hutch used the APIs to provide patients with an application to support their regimes, including appointment follow-up and engagements with multiple providers, providing visibility into disease progression. This digital-therapeutic approach helped improve patients' mental health, health outcomes, and overall experience.

Technical integration: Achieving syntactic interoperability

Most electronic health record systems (EHRs) do not follow patients on their journey of care beyond the hospital walls. As a result, a patchwork of healthcare data emerges. The average health system in the United States (US) struggles with integrating data and coordinating care across as many as 18 different EHR systems among its various affiliated providers. FHIR can help integrate the fragmented pieces of patients' records. FHIR combines the features of existing standards specification – such as HL7 V2, HL7 V3, and CDA – while using the internet to exchange information and democratize the flow of information. Based on RESTful web services, the FHIR design uses multiple standards like HTTP, JSON, URL, or XML in contrast to the majority of IHE profiles, which rely on SOAP web services protocol (largely

based on HTML or XML). FHIR also migrates data to various messaging standards, such as from HL7 v2 messages and CDA documents.

In the US, the Office of the National Coordinator for Health Information Technology (ONC) and the Centers for Medicare and Medicaid Services (CMS) champion an open standard, generated by the user community to achieve greater interoperability and rapid exchange of data providing patients "safe, secure access to, and control over, their healthcare data." CMS advocates for Blue Button 2.0 adoption, with FHIR at its core, to benefit patients and their care teams (Mirth/Nextgen Connect for bi-directional exchange of messages). Consented information flows into the NIH All of Us Program to realize personalized medicine at the individual level.

Internationally, the United Kingdom National Health Service (UK NHS) selected FHIR as the standard for exchanging information, and the Nordic Council of Ministers' eHealth group published a report with guidance for setting up interoperable digital public services with open standards (technical and semantic) such as FHIR and openEHR.

SMART on FHIR

The SMART open specifications (https://docs.smarthealthit.org/) offer developers a framework to create, authenticate, and integrate a healthcare application with any organization regardless of the underlying EHR system. For example, to display a patient's blood pressure measurements from the past six months at home and in the clinic, you can build a provider view inside the EHR and a consumer application, exchanging data using the FHIR data model. FHIR supports data ingests (with patient's consent) from EHRs, patient generated data or devices (wearables, digital therapeutics), and applications (patient portals, health coaches).

An app could display data trends, highlighting anomalies at the individual or population level. SMART's inclusion in proposed federal rules will provide ways for patient-facing technology to better integrate with EHRs and for the bi-directional exchange of information. Over the past five years, Redox, an AWS customer, has enabled its healthcare customers to use SMART on FHIR to launch applications inside the EHR while exchanging patient-authorized data with Single Sign-On (SSO).

Read the full blog post at: https://amzn.to/AWS-HC-blog-patient-health

Real-World Example

Healthfirst: Building a Secure Analytics Platform for 1.3 Million Users on AWS

Steve from Healthfirst explains how they ingest data from various sources into Amazon S3 and RDS and then curate the date with Amazon Redshift and EC2. This data is then

published to work areas where they achieve analytical outcomes using Tableau and Machine Learning. You will also learn how they protect their members' data by account separation, VPC separation and encrypting data at transit and rest.

https://amzn.to/AWS-HC-TMa-healthfirst

Case Study:

Babylon Health

Founded in 2013, Babylon Health (https://www.babylonhealth.com/about) is a subscription health service provider that enables users to have virtual consultations with doctors and health care professionals via text and video messaging through its mobile application. Using AWS, the company can innovate using artificial intelligence and scale globally.

Watch Dr. Ali Parsa, CEO and founder at Babylon, discuss how AWS allows the company to innovate with artificial intelligence and scale globally.

https://amzn.to/aws-hc-babylon

Below are the five top announcements for healthcare, life sciences, and genomics from reinvent 2019. You can explore the full recap of the more than 75 launches and announcements we made here: https://amzn.to/AWS-HC-reinvent2019-healthcare-recap

1. Amazon Transcribe Medical

Amazon Transcribe Medical is a service that converts medical speech to text, making it easy for developers to integrate medical transcription into applications that help physicians do clinical documentation efficiently. In clinical documentation workflow, physicians can more efficiently capture medical notes, and bring focus back to their engagement with their patient. Moreover, physicians can leverage the transcribed notes after patient encounters to more quickly conduct medical data entry into electronic health record (EHR) systems.

Learn more about Amazon Transcribe Medical:
https://aws.amazon.com/transcribe/medical/

2. AWS Data Exchange

AWS Data Exchange makes it easy to find, subscribe to, and use third-party data in the cloud. Pharmaceutical companies, healthcare providers, and health insurers can better plan clinical trials, build insurance plans, support sponsored research for new drugs, and improve patient lives by combining their own data with products they subscribe to on AWS Data Exchange. Some relevant products contain data on simulated clinical data, drug switching patterns, fitness benchmarks, life expectancy benchmarks, aggregated claims data, and more.

Learn more about AWS Data Exchange:
https://aws.amazon.com/data-exchange/

3. Amazon SageMaker

Multiple new service features were launched for Amazon SageMaker, including Autopilot, Debugger, Experiments, Model Monitor, Notebooks, Studio, and Processing.

In healthcare and life sciences, we want to specifically highlight the following updates:

1. Amazon SageMaker Studio: Fully integrated development environment for machine learning, allowing you to build, train, debug, track, and monitor your models programmatically.
   Learn more about SageMaker Studio:
   https://amzn.to/AWS-HC-sagemaker-studio
2. Amazon SageMaker Notebooks: Spin up machine learning notebooks in seconds, and share notebooks with just a single click to simplify collaborations and reproducibility across your organization.
   Learn more about SageMaker Notebooks:
   https://amzn.to/AWS-HC-sagemaker-notebooks
3. Amazon SageMaker Debugger: Analyze and debug ML models in real time by automatically identifying complex issues developing in training jobs.
   Learn more about SageMaker Debugger:
   https://amzn.to/AWS-HC-sagemaker-debugger

Learn more about Amazon SageMaker: https://aws.amazon.com/sagemaker/

4. AWS Outposts

AWS Outposts is a fully managed service that extends AWS infrastructure, AWS services, APIs, and tools to virtually any datacenter, co-location space, or on-premises facility for a truly consistent hybrid. Easily apply analytics and machine learning AWS services to health management systems that need to remain on premises due to low latency processing or patient health information (PHI) requirements. Many pharma manufacturing companies use AWS services to run process control systems such as MES and SCADA systems and applications that need to run close to factory floor equipment. Seamlessly integrate these on-premises applications with services running in the AWS Region for centralized operations.

Learn more about AWS Outposts:
https://aws.amazon.com/outposts/

5. Amazon Kendra

Highly accurate and easy-to-use enterprise search service that's powered by machine learning. Kendra lets scientists use powerful natural language search capabilities to so they can more easily find the information they need within the vast amount of information spread across a biotech/pharma company.

Learn more about Amazon Kendra:
https://aws.amazon.com/kendra/

Be sure to read customer news and announcements as well as other important services for health care and life sciences: https://amzn.to/AWS-HC-reinvent2019-healthcare-recap

Solution:

AI-Powered Health Data Masking

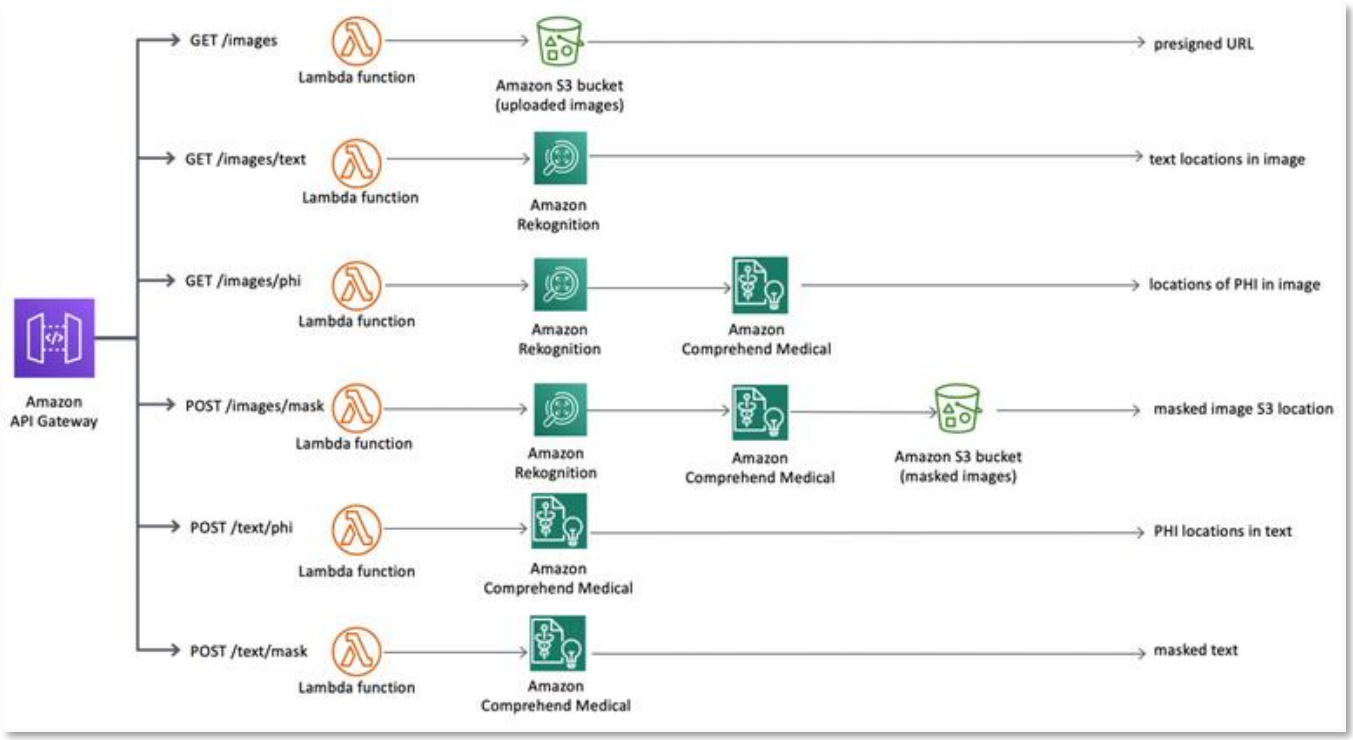
What does this AWS Solution do?

The AI-Powered Health Data Masking solution helps healthcare organizations identify and mask health data in images or text. This solution uses Amazon Comprehend Medical (https://aws.amazon.com/comprehend/medical/) to detect health data in a body of text, Amazon Rekognition (https://aws.amazon.com/rekognition/) to identify text in an image, Amazon API Gateway and AWS Lambda to provide an API interface for this functionality, and AWS Identity and Access Management (IAM) to authorize API requests.

This solution was designed for implementation as part of a set of mitigating controls in your environment, and does not guarantee alignment to any regulatory framework. It is your responsibility to ensure that the outputs generated by this solution comply with any legal requirements applicable to your organization. For more information, see the solution's implementation guide (https://amzn.to/AWS-HC-solution-data-masking-implement).

AWS Solution overview

AWS offers a solution that uses AWS artificial intelligence (AI) services behind a serverless API to identify and mask health data. The diagram below presents the architecture you can automatically deploy using the solution's implementation guide and accompanying AWS CloudFormation template.



AI-Powered Health Data Masking Architecture

The AWS CloudFormation template deploys an Amazon API Gateway to invoke the microservices (AWS Lambda functions). The microservices provide the business logic to manage preprocessing configuration and logic, and identifying and masking health data. The microservices interact with Amazon Rekognition to identify text in an uploaded medical image, and the Amazon Comprehend Medical protected health information data extraction and identification (PHId) API to identify health data in text.

Additionally, the template deploys an Amazon Simple Storage Service (Amazon S3) bucket for storing raw and masked images, AWS CloudTrail (https://aws.amazon.com/cloudtrail/) to log API actions, and AWS CloudWatch Logs (https://amzn.to/AWS-HC-cloudwatch-logs) to log errors within the AWS Lambda functions. By default, log files are encrypted over HTTPS.

See the full solution: https://amzn.to/AWS-HC-Solution-data-masking

Real-World Example

Innovaccer: Deriving Insights from Healthcare Data to Empower Care Teams

Ravi from Innovaccer talks about the company's Data Activation Platform that analyzes various clinical and non-clinical data sets and provides critical insights that enable patient care delivery.

https://amzn.to/AWS-HC-TMA-Innovaccer

Whitepaper:

Architecting for HIPAA Security and Compliance on AWS

This paper briefly outlines how companies can use Amazon Web Services (AWS) to create HIPAA (Health Insurance Portability and Accountability Act) compliant applications. We will focus on the HIPAA Privacy and Security Rules for protecting Protected Health Information (PHI), how to use AWS to encrypt data in transit and at rest, and how AWS features can be used to meet HIPAA requirements for auditing, back-ups, and disaster recovery.

Introduction

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) applies to "covered entities" and "business associates." Covered entities include health care providers engaged in certain electronic transactions, health plans, and health care clearinghouses. Business associates are entities that provide services to a covered entity that involve access by the business associate to Protected Health Information (PHI), as well as entities that create, receive, maintain, or transmit PHI on behalf of another business associate. HIPAA was expanded in 2009 by the Health Information Technology for Economic and Clinical Health (HITECH) Act. HIPAA and HITECH establish a set of federal standards intended to protect the security and privacy of PHI. HIPAA and HITECH impose requirements related to the use and disclosure of PHI, appropriate safeguards to protect PHI, individual rights, and administrative responsibilities. For additional information on HIPAA and HITECH, visit http://www.hhs.gov/ocr/privacy/.

Covered entities and their business associates can use the secure, scalable, low-cost IT components provided by Amazon Web Services (AWS) to architect applications in alignment with HIPAA and HITECH compliance requirements. AWS offers a commercial-off-the-shelf infrastructure platform with industry-recognized certifications and audits such as ISO 27001, FedRAMP, and the Service Organization Control Reports (SOC1, SOC2, and SOC3). AWS services and data centers have multiple layers of operational and physical security to help ensure the integrity and safety of customer data. With no minimum fees, no term-based contracts required, and pay-as-you-use pricing, AWS is a reliable and effective solution for growing health care industry applications. AWS enables covered entities and their business associates subject to HIPAA to securely process, store, and transmit PHI. Additionally, AWS, as of July 2013, offers a standardized Business Associate Addendum

(BAA) for such customers. Customers who execute an AWS BAA may use any AWS service in an account designated as a HIPAA Account, but they may only process, store, and transmit PHI using the HIPAA-eligible services defined in the AWS BAA. For a complete list of these services, see the HIPAA Eligible Services Reference page. (https://aws.amazon.com/compliance/hipaa-eligible-services-reference)

Read the full whitepaper: https://amzn.to/AWS-HC-whitepaper-hipaa

Real-World Example

Logicworks: HIPAA Compliance and SSL Termination with Thousands of Certificates

Jason from Logicworks explains how the company helped a customer migrate a three-tier, HIPAA-compliant application to the cloud. The solution had to be designed to handle tens of thousands of certificates for SSL termination. Learn how Logicworks used a combination of NLB, ELB, EC2, HAProxy, Auto Scaling, and more to make it happen.

https://amzn.to/AWS-HC-TMA-HIPAA