

Concept note for Blockchain based Electronic Health Record (EHR) System

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1. Executive summary

Healthcare domain will see considerable and beneficial impact once Blockchain based systems are adopted across the Patient and healthcare provider ecosystem.

Though there is no panacea technology which can overnight transform healthcare, but blockchain is the fabric that will enable secure sharing of crucial medical data which is un/under-utilized within current silo healthcare systems.

The \$ 80 Billion healthcare industry observes medical error as 3rd leading cause of patient death caused due to unavailability of clinical history of patient as claimed by Johns Hopkins University researchers.

Protenus (leading health IT security firm) discovered that 5.579 Million patient records were hacked. The hackers now know lethal allergy or composition that the patient is prone to, that's a critical info.

2. Current system

Any individual's interaction with existing healthcare system starts once he visits any healthcare provider/doctor or Hospital. For the ailment or diagnosis, the patient provides his clinical data and laboratory results to the provider/hospital. But once he visits another hospital the already critical and crucial data is unavailable or can't be fully used for diagnosis or prescription, figure 1 depicts it.

Some providers/hospitals have IT systems to collect/store this data so that it can be referred to for future visits of the patients or to get clinical insights.

In context to India, majority of the hospitals doesn't have systems or has non-standard Health care IT system.

2.1 Issues in current system

2.1.1 Manual/Paper driven process: As the complete healthcare system is not digitized we still have complete patient to prescription cycle on paper on in bits and pieces.

2.1.2 Siloed non-interacting systems: Those healthcare providers/hospitals which has IT systems are designed such that they can't interact with other system in same hospital/network or with the affiliated labs.

2.1.3 In-accurate diagnosis/prescription: If the patient changes his healthcare provider/hospital then the chances of partial/in-accurate diagnosis and prescriptions are much as his clinical history is not easily available and if available not in the standard format to interpret it well.

2.1.4 Supply chain leakages: Pharmacies associated to particular healthcare provider/hospital doesn't have accurate and current patient data thus not able to predict what surgical/pharmaceutical inventory is needed and results in over/under stock.



2.1.4 Fraud prone ecosystem: Globally the total cost of insurance fraud is estimated to be more than \$40 billion per year. The fraud categories ranges in the form *fraudulent claims, subsidized medicines in sold in open market, patient data theft, counterfeited medicines/drugs.*

2.1.5 Delays/Frauds and lack of audit in Government schemes: Public healthcare system is most hampered because of not being able to identify the needed patient and providing him needed services. Current manual or disconnected system has very inefficient auditability.

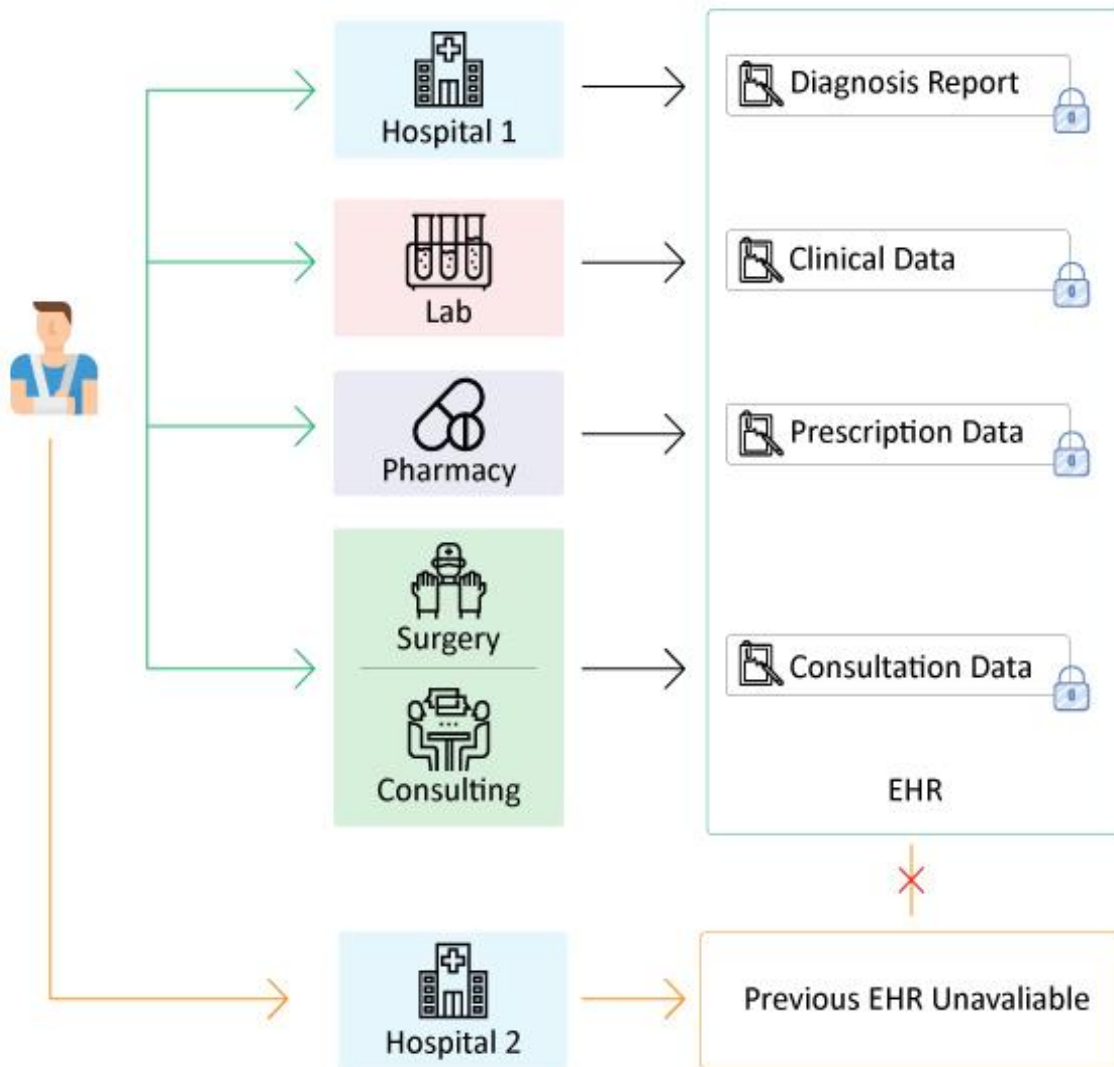


Figure1. Current System for Healthcare

3. Proposed EHR system over blockchain

With proposed new system for patient EHR, we prioritize patient as the most important beneficiary along with building trust and confidence in all other parties involved.

With proposed system every patient will have a unique identity over blockchain network and his clinical data generated at various stages will be associated to this unique identity as EHR digital asset.

Blockchain by definition is secure/shared auditable ledger to share digital asset associated with unique blockchain address, this fundamental is the core to the proposed system.

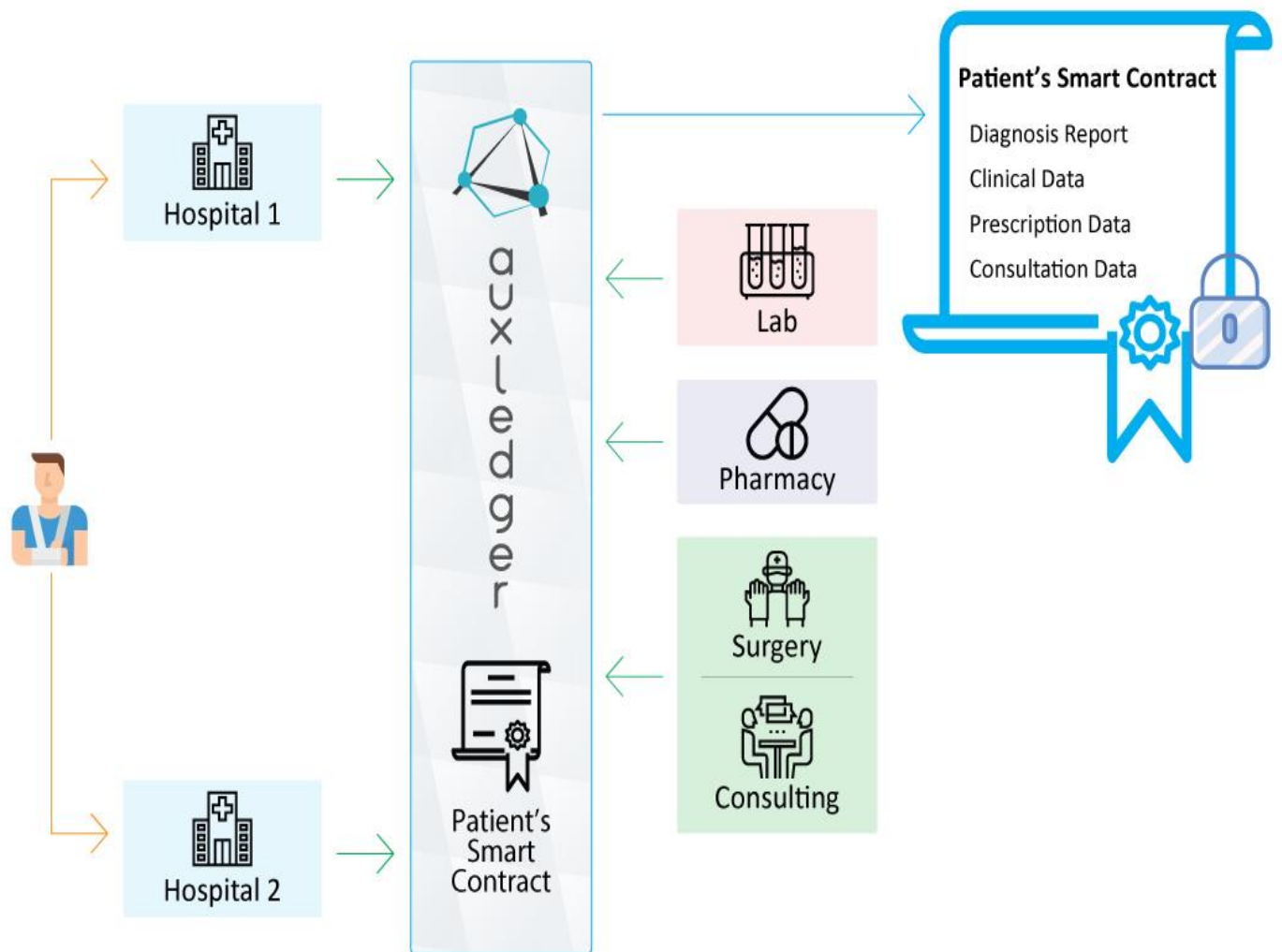


Figure2. Blockchain based EHR System for Healthcare



3.2 Advantages with Proposed system

3.2.1 Control access and EHR ownership with patient: Blockchain will contain references to the EHR data, while Smart Contracts will define and enforce access rules to EHR content. This will ensure that only authorized persons/entities access the EHR data. In addition, the blockchain provides an irrevocable record of all events that the data has undergone. All these will enable population health management and research.

3.2.2 Transparency and auditability in Government healthcare program: A integrated and synchronized EHR system will put power in Governments hand to efficiently and accurately involve the needed citizens in state sponsored schemes. Also, the participation of private players can be very will merged because of a transparent and auditable system.

3.2.3 Accurate and efficient diagnosis/prescription: The EHR will be a permissioned shared asset across thee EHR network healthcare providers/hospitals.

3.2.4 Reduced supply chain leakages: Real-time and accurate data about patients enables predictions and inventory management with higher efficiency and accuracy.

3.2.5 Fraud proof system: Real-time auditability and immutable nature of blockchain datasets will ensure the system is fraud proof and when implemented with operational checkpoints can be secured till last mile.

3.2.6 Clinical Trials: Clinical trials offer particular. Using blockchain could help make clinical trials reliable at each step by keeping track and time-stamping at each phase of the trial (trial protocol, patient enrolment etc). This can bring live saving drugs at reduced cost in short span of time to market.

3.2.7 Preventive healthcare: Current advanced AI or conventional analytics can be utilized to draw out valuable insights from huge and diverse datasets to help individuals/public institutions focus on preventive healthcare rather than curing the ailment.

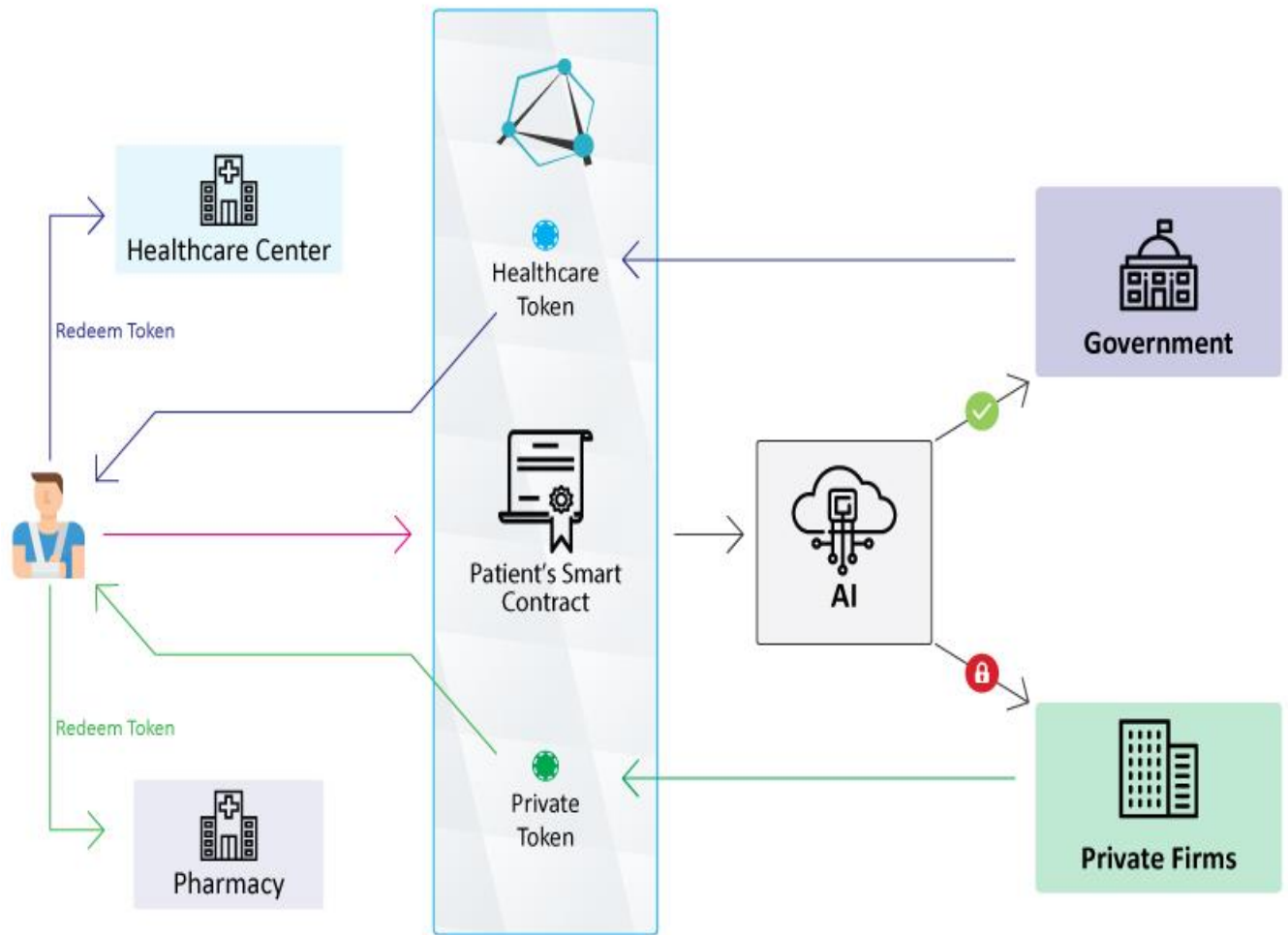


Figure3. Data and Benefit in single system

Figure 3 below pictorially shows how using a blockchain Government can get insightful data from Patients data and run various healthcare schemes over the same system from which data is extracted. Such an approach makes the scheme efficient and reach out till the beneficiaries for whom it is intended.

With the AI enabled analytics, Government can take preventive actions before the epidemic or trend becomes a national problem.

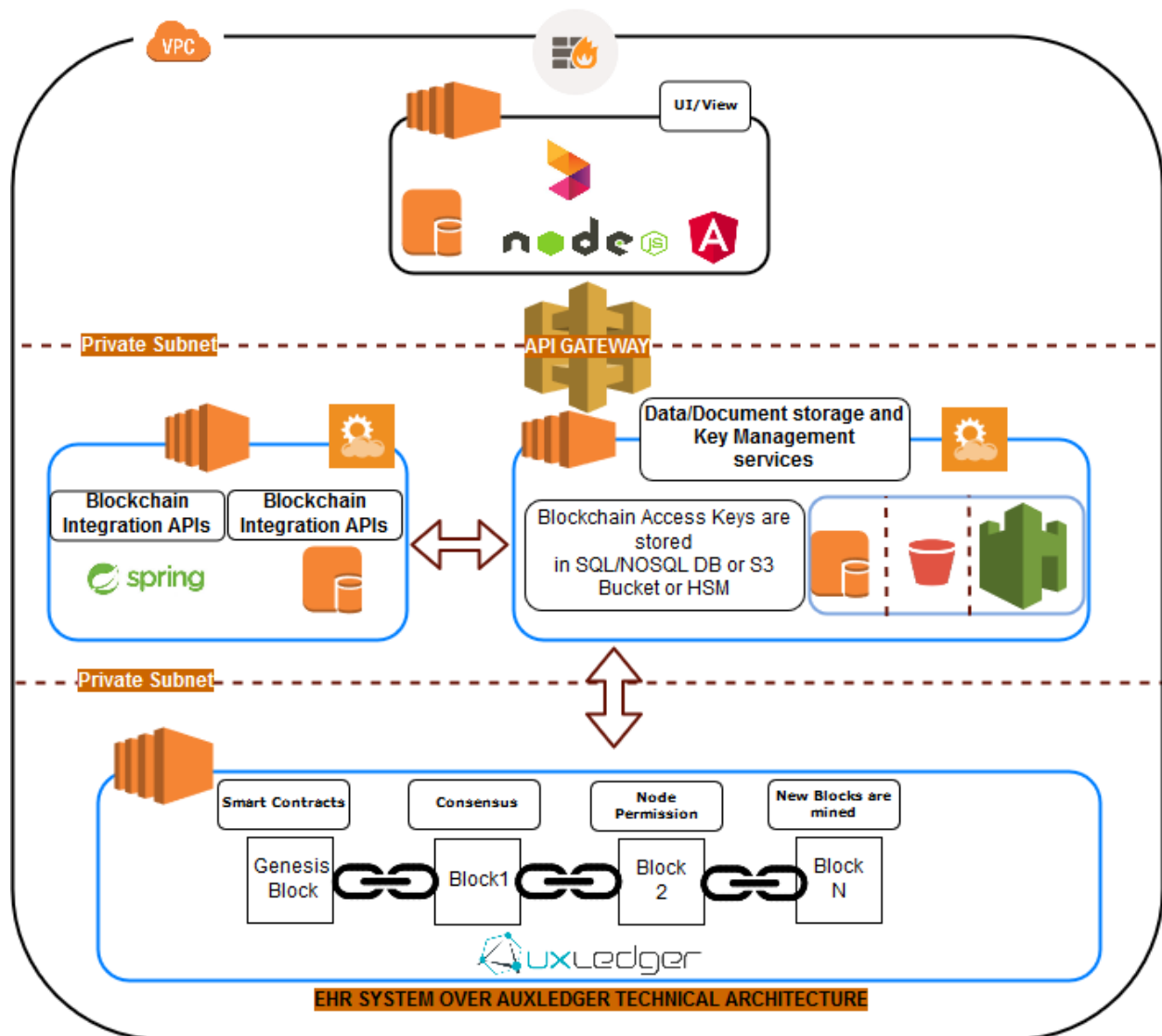
Similarly, the patient himself is the owner of the data and can capitalize on his clinical asset. He can offer his clinical data via patient smart contract to the clinical trials or Drug research companies.

There are many use-cases that can be built over a secure/shared blockchain based EHR system with the objective to keep patient first.



4. Implementation Architecture of Blockchain based EHR System

We propose a pluggable blockchain based EHR System that can be accessed by Restful APIs.



4.1 Major components in proposed EHR System

4.1.1 Auxledger: Enterprise ready secure and scalable blockchain solution having features as high TPS (Transactions per Second), highly secure private permissioned implementation with configurable permission and consensus management.

4.1.2 Backend EHR application service: Application layer to provide the user/business functionalities non-critical to blockchain e.g. role bases login service.



4.1.3 **Blockchain Integration service:** Proprietary Java application layer build on proven Spring-Hibernate framework to provide a reusable and versatile blockchain integration layer.

4.1.4 **Document/Database service:** The documents/data generated during treatment is stored in encrypted form in the SQL/NOSQL DBs or file storages.

4.1.5 **Key Management Services:** The blockchain access keys or Public/Private keys can be stored using SQL/NOSQL or S3 bucket or HSM (Hardware Security Module has cost involved).

5. Cost analysis for Prototype/POC Project

Below table depicts the pilot platform deployment requirements.

Sr no.	Application component	Software's/Frameworks that will be running on it	Infrastructure requirement
1.	Auxledger	Auxledger	1 AWS EC2 t2 medium OR 1 machines of 8 GB RAM 4 core CPU 300 GB Disk space
2.	Blockchain Integration layer And Backend App layer	Java 8, Spring 2.0.0 release, Hibernate 5.0.1, SQL DB – MySQL 5.5, Oracle 11g	AWS EC2 t2 medium OR 8 GB RAM 4 core CPU 1 TB Disk space
3.	Key Management Services	NOSQL DB (Mongo 3.0), SQL DB – MySQL 5.5, Oracle 11g	AWS EC2 t2 medium OR 4 GB RAM 4 core CPU 10 GB Disk space

Cloud Infrastructure cost: Approximate AWS VPC infrastructure cost per month will be around \$ 160 excluding HSM for Key storage.

On premise cost: for hospital/enterprise data-center we need 3 machines with above specifications.

Software Licenses: Software license if open-source is not approved. E.g. Oracle license 11g license for DB.

5.1 Rate card for development and consulting:

Auxesis will play two major roles development/deployment and support (as per the agreement) phase mentioned below.

Role	Cost/Hour
Blockchain developer	\$ 70
Full Stack developer/Dev-Ops	\$ 40
UX/UI Designer	\$ 30
Project Manager	\$ 45



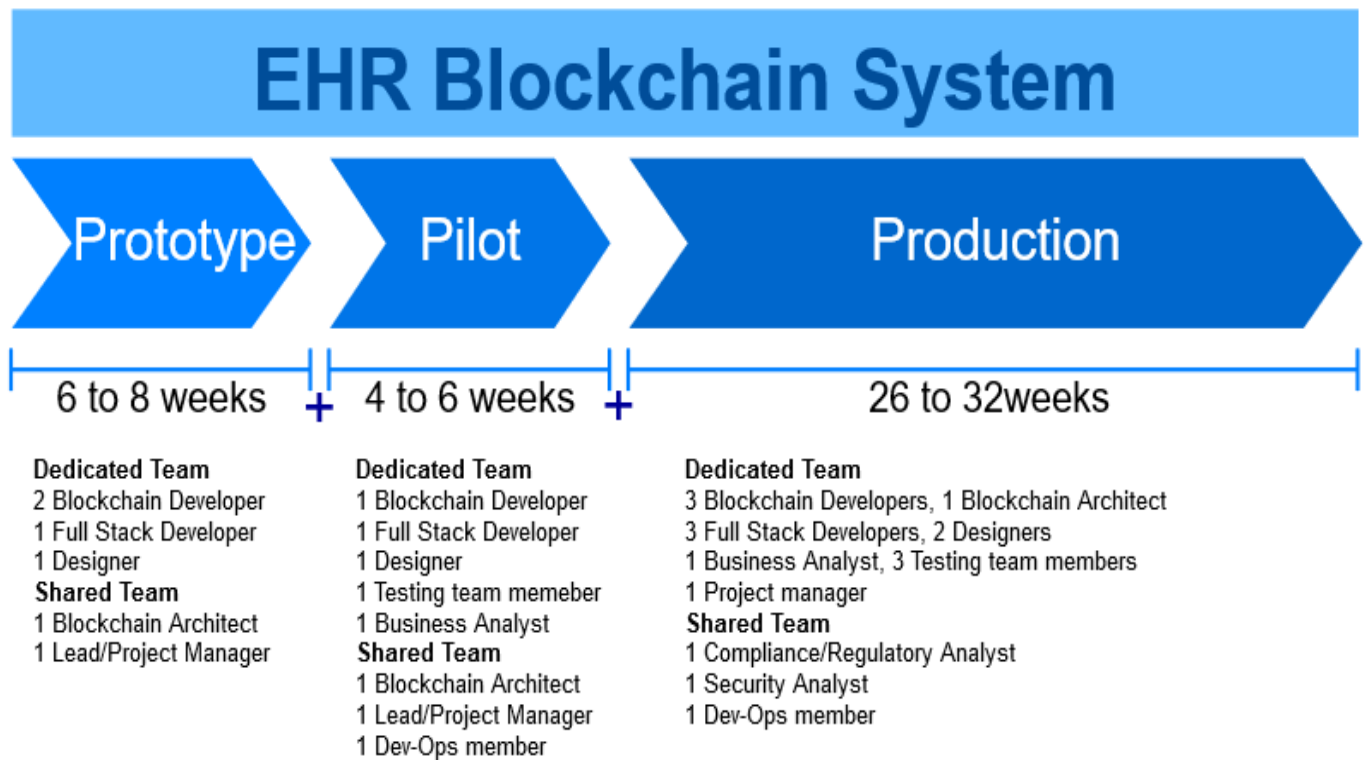
Business Analyst	\$ 50
Security/Compliance Analyst	\$ 55

5.2 Assumptions for Design/Implementation for Prototype

The proposed prototype/pilot solution is designed and will be implemented on below critical assumptions.

1. There will be only web-based responsive UI having 3 access roles patient/healthcare provider/Admin.
2. For Pilot Maximum 10000 patients each having all relevant data of not more than 100 MB(including clinical records/prescriptions)
3. Any licensed software to be used by client’s recommendation should be procured by client.

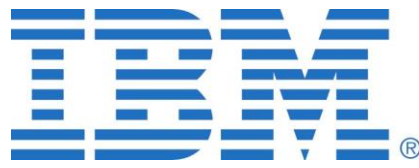
6. Timelines for prototype to production





OptiAux
Technologies Pvt.Ltd

7. Customers



सत्यमेव जयते

नीति आयोग

National Institution for Transforming India



सत्यमेव जयते

Government of Rajasthan

