EP-JOURNALS

GLOBAL JOURNAL OF ENGINEERING AND TECHNOLOGY REVIEW

Available on: http://gjetr.ep-journals.org/ E-ISSN: 3051-3782, P-ISSN: 3051-3774

Global Journal of Engineering and Technology Review

Volume: 02 Issue: 02 February 2026

Livestock Management Using IoT-Enabled Smart Intelligent

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Published Date: February 20, 2026 **Article DOI : 10.65150/EP-gjetr/V2E2/2026-04**

ABSTRACT: With the advent of Internet of Things (IoT), RFID and communication mechanisms, livestock management has become smart and intelligent. As a result, livestock and their end-products are being systematically monitored from their birth to their final destination on the dining table. This paper describes the use of IoTs and sensor network towards addressing various issues in livestock management. The architecture of an IoT-enabled intelligent livestock management (iSILM) is described and its performance evaluated through parametric modeling technique. The iSILM system runs over a private cloud so that all information can be gathered, processed and what-if questions answered using a variety of historical and current data along with an embedded intelligent decision support system. The performance indices indicate that the iSILM system is viable and will value-add to intelligent livestock management programs.

KEYWORDS: Sensor network, IoT, Livestock management, Smart & Intelligent Information, Asset registry, Private cloud and Parametric performance evaluation.

1. INTRODUCTION

Livestock management is now a big industry, wherein a variety of sensors, computers and software systems are being used widely [1]. Livestock and their end-products are being systematically monitored from their birth to their final destination on the dining table [2]. Livestock enhancement through appropriate feeding, nurturing and disease control has also become a intensive research and development arena. This paper describes a Internet of Things (IoT) based livestock management system, which runs over a private cloud computing environment.

The rest of the paper is organized as follows: section 2 provides an overview of Internet of Things (IoTs) and the sensors therein for smart livestock management, while section 3 details issues in livestock management. Section 4 describes the IoT-enabled intelligent livestock management (iSILM) architecture, followed by its performance evaluation through parametric modeling technique in section 5. The conclusion summarizes the paper, besides offering pointers for further R&D work in this arena.

2. INTERNET OF THINGS (IoT) & SENSORS

Internet of Things (IoT) are devices that contain a processor, variety of sensors, wireless modem, energy source and sometimes GPS (Fig.1) [3] [4]. Sensors are available in IoTs include those for monitoring weight, height, femur length, temperature and other details needed for livestock control. IoTs have an operating system and other associated programs so that most processing requirements are met locally. Networking systems over IoTs allow them to cooperate with each other so that a complete coordinating system can be built rapidly in order monitor a livestock in real time. The concept underlying this paper is based on such a mechanism that fosters livestock – from their birth to their final destination.

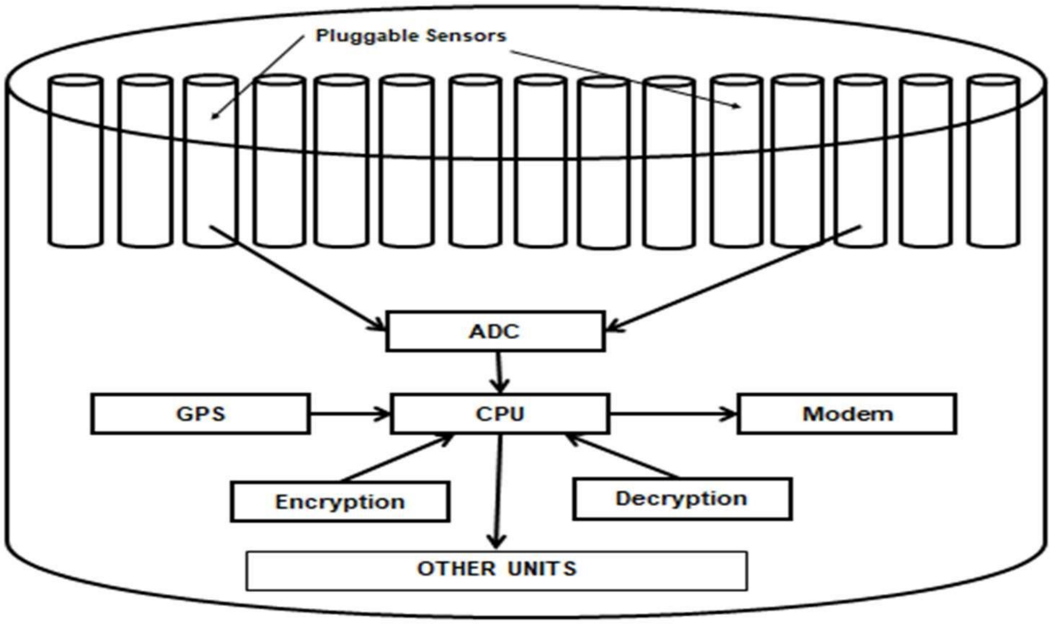

Fig.1: Configuration of an IoT

3. ISSUES IN LIVESTOCK MANAGEMENT

There are many important issues in livestock management [5] [6] some of which include: i) classification of a given animal to a particular category or sub-category, ii) category re-classification after nominal period of observation post birth, iii) animal feed adjustment, iv) animal weight management and v) animal disease management with a species and across species. Closely related to these issues are the price of feed, time to grow to maturity and price to market and Time-To-Market-Growth (Time-ToMarket-Growth – TTMG).

In many tropical countries farmers grow a variety of animals and their sub-species. So several questions arise naturally as to how to value-add to the growth of their livestock – e.g., can growth be hastened through appropriate feed management?, how to produce products, instead of export livestock valuecreate added Meat with stamp of station and how to create value added products such as Honey dipped, or chilly dipped or cheese dipped jerkins. Similarly, instead of just milk, value-added milk products (e.g., chocolate, flavored milk, etc) provide better return on investment, however, storage costs, processing costs and packaging costs are also there in such cases.

The questions that average farmers are interested are: “Optimality” for sale-Food consumption, their cost, timeliness for sale and correct choice of “Culling time” so that Productivity does not drop below 3db point. Similarly the set-up, operating and marketing costs involved in total livestock lifecycle management. This paper will address some of these issues through systematic information collection and their timely usage.

4. IoT-ENABLED INTELLIGENT LIVESTOCK MANAGEMENT (iSILM) ARCHITECTURE

Under the IoT-enabled Smart Intelligent Livestock Management (iSILM) management program, all livestock are fitted with RFID and IoT devices so that their activities can be monitored (and later recorded) [7] [8]. At sunset, when they return to paddock, their weights (and hence the weight of their consumption), femur length, duration of sun shine on them and other details will be collected. Specially designed pits will be used to measure several parameters, which also give them a good wash, including underbelly wash. In addition, RIFD tagging will open appropriate gates for additional special food supplements, based on the category an animal belongs to. For example, a milk cow will be provided with protein rich food, while a mean cow will be provided with fat rich food.

The Asset Deployment architecture of a typical IoT-enabled smart livestock management is provided in Fig.2 using C-COM[1] model of representation [9], while Table-2 details various entities therein. The private cloud-based IT architecture [10] underpinning the software system is provided in Fig.3, which offers a number of software services that can be downloaded and upgraded readily. The service also provides anywhere anytime monitoring and control functionalities. The cloud also offers a good degree of privacy and safety control through encryption and decryption mechanisms.

[1] C-COM is an enhancement on UML.

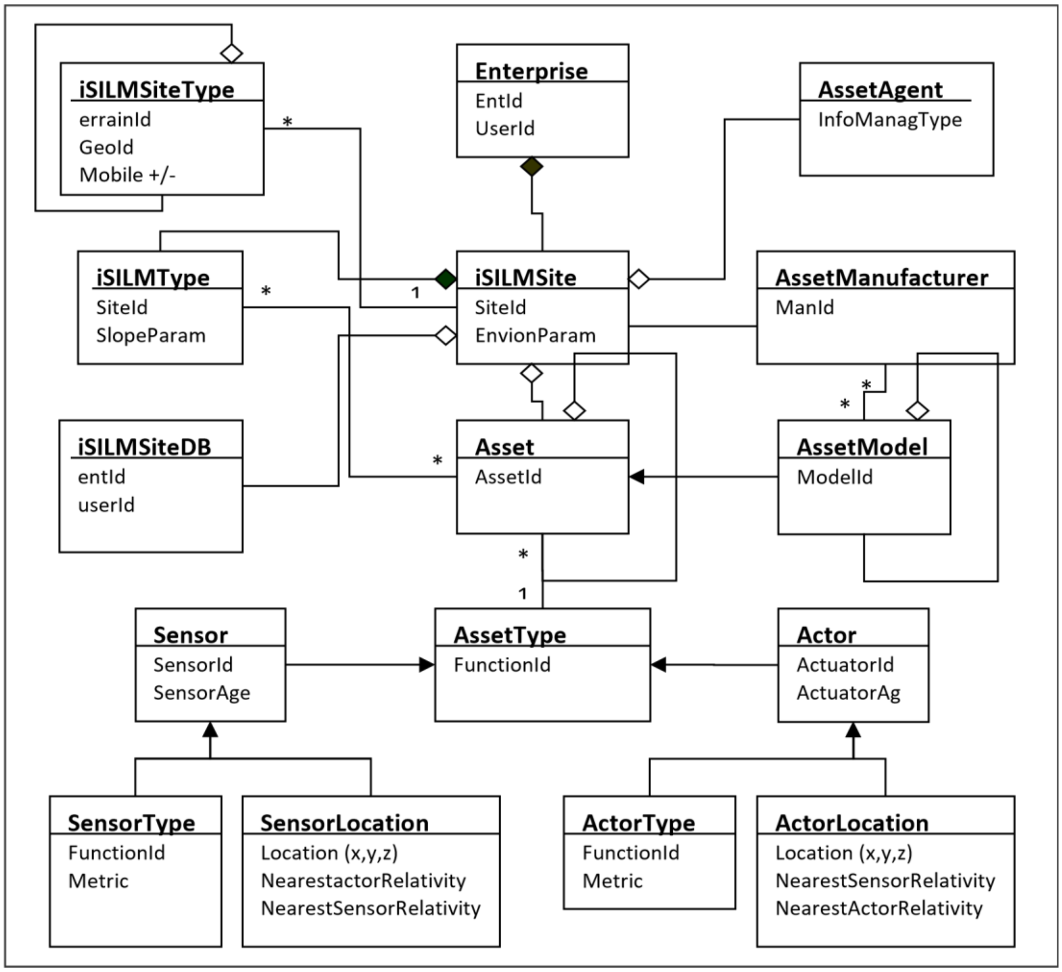

Fig.2: C-COM Based Asset Deployment Architecture of an IoT-Enabled Smart Livestock Management

Table-1: Description of Entities in iSILM Platform

Item	Description
Enterprise	Describes the smart home/building environment network as an ensemble entity
SILMSite	Describes each smart home/building sensor site and its characteristics
SILMSiteType	Describes a smart home/building sensor site types
Asset	Describes assets
AssetType	Describes asset functionalities
Sensor	Describes sensors
SensorType	Describes sensor types and their characteristics
SensorLocation	Describes sensor location
Actor	Describes actors
ActorType	Describes actor types and their characteristics
ActorLocation	Describes actor location
AssetModel	Describes asset models and their characteristics

Asset Manufacturer	Describes asset manufacturers
AssetAgent	Describes asset agent (for maintenance at a given SHABSite)
SILMSiteDB	Describes marine sensor database at a given SILMSite
Controller	(not provided in figure) Controls one or more parameters in conjunction with the corresponding sensor/s

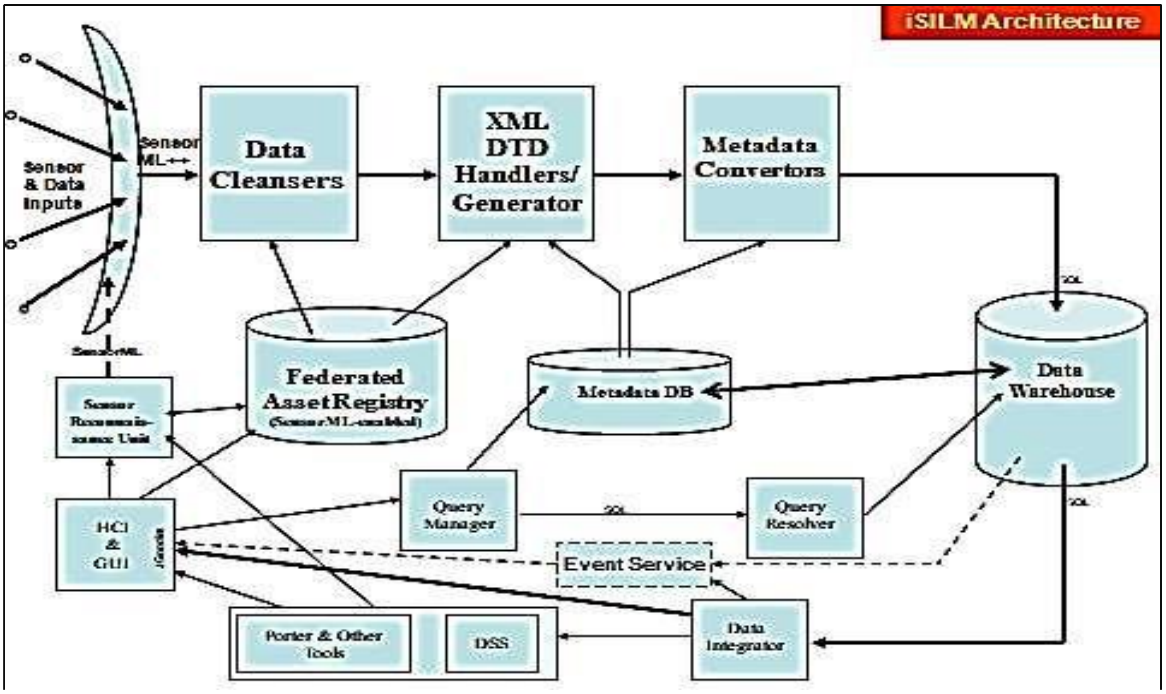

Fig.3: Private Cloud-Based IT Architecture for Smart Intelligent Livestock Management

5. PERFORMANCE EVALUATION OF PRIVATE CLOUD-BASED iSILM

A parametric model based evaluation of the iSLIM Cloud system has been carried out. Table-1 provides typical parameters used for the evaluation of the iSLIM Cloud, which have been obtained after discussions with several experts. Table-2 provides a list of performance indicators and their values, wherein the values are calculated using Relative Cost Unit (RCU) so that depending on the actual cost of individual companies a suitable multiplier can be employed to calculate the corrected values of various performance indices. It is hoped that these indicators will provide the way forward for the advancement of such systems in various marine sensor network R&D centers around the world.

Table-1: Smart Live Stock Private Cloud Information Systems Architecture

S.No.	Explanation	Symbol	Average Value	Max. Value
1.	Size of iSLIM PDF file (data or image)	a	0.001 GB	1 GB
2.	Number of Sensors per livestock	b	4	7
3.	Number of livestock per paddock	c	20	200
4.	Average Number of Messages per sensor	d	3	5
5.	Number of Gateway nodes	e	5	7
6.	Average sensor message size per message	f	5	10
7.	Number of Services in iSLIM	g	4	10
8.	Number of Maintenance calls per day	h	4	6

9.	Number of To-Act-On messages per day	i	2	20
10.	Number of Upgrade requirements per day	j	2	6
11.	Number of Internal low-end service calls per day	k	10	18
12.	Number of Internal medium-end service calls per day	l	5	8
13.	Number of Internal high-end service calls per day	m	3	5
14.	Number of Reports to be generated per day	n	40	60
15.	Number of Knowledge query management per day	p	20	70
16.	Number of Help line management--simple call per day	q	20	30
17.	Number of Help line management--medium call per day	r	10	15
18.	Number of Help line management--complex call per day	s	5	8
19.	Number of Compliance requirements per day (if any)	t	1	3
20.	Average viewing time per report	u	4 min.	7 min.

S.No.	Explanation	Symbol	Relative Cost Units
1.	Data storage cost per GB per month	C1	25
2.	Data access cost per GB	C2	2
3.	Internal low-end service cost per service call	C3	1
4.	Internal medium-end service cost per service call	C4	3
5.	Internal high-end service cost per service call	C5	8
6.	Maintenance cost per service call	C6	15
7.	Upgrade cost per service call	C7	10
8.	Encryption cost per file (1 MB)	C8	5
9.	Decryption cost per file (1 MB)	C9	5
10.	Air conditioning costs per day	C10	200
11.	Average Downtown costs for services upgrade per day	C11	400
12.	Compliance Management costs per compliance requirement (if any)	C12	500
13.	Average Report generation cost per report	C13	10
14.	Average Knowledge query management cost per query	C14	2
15.	Help line management per simple call	C15	1
16.	Help line management per medium call	C16	5
17.	Help line management per complex call	C17	10

Table-2: Smart Live Stock Private Cloud Information Systems Architecture Performance Indicators

S.No.	Metric Name	Symbol	Formula	Typical Average Value	Max. Value
1.	Average Execution time per paddock	PI-1	(a * b + d * e * g) * h*i	480.03	42,840
2.	Average bandwidth used per day	PI-2	a * b * c * i	016	28,000
3.	Average Downtime Management per paddock	PI-3	C11/ (b * c)	5	026

4.	Average Cost of Security per paddock	PI-4	(C8 + C9) * b * e * d	600	2,450
5.	Average Ease of Use per acre == Average Execution time per paddock + Weighted average service call time + Weighted average Help call time	PI-5	{(a * b + d * e * g) * h*I} + {C3 * k + C4 * l + C5 * m} + {C15 * q + C16 * r + C17 *s}	633.03	43,107
6.	Average report generation cost per day	PI-6	C13 * n	400	600
7.	Average compliance requirement cost per day (if any)	PI-7	C12 * t	500	1500
8.	Average network usage cost == Average Execution Time paddock cost + Visit cost + Specialty related cost + InfoSec cost + Data access & storage cost	PI-8	(a * b * c) + (d * f) + (g * i) + (C8 + C9) * i + (C1 + C2) * b * c * i	4,320	4,480,000
9.	Average iSLIM cloud usage cost == PI-18 + Knowledge query cost + upgrade cost + maintenance cost + Aircon cost	PI-9	PI-8 + (C14 * p) + (C7 *j) + (C6 * h) + C10	4,680	4,480,490
10.	Average Cost of Ownership per paddock	PI-10	PI-9/c	234	22,402.45

6. CONCLUSIONS

This paper describes a wireless sensor network environment, called iSILM, for managing livestock in real time, which runs over a private cloud environment the management of livestock. A CCOM model of the sensor network system has been developed. In addition, private cloud contains modules that collect and clean data, an integrated asset registry, tools & technologies for information exploitation and output management in order to handle various types of customer requirements. Excellent software tools also exist in iSILM to process both historical and current data using intelligent decision support systems so that what-if scenarios can be answered. An important feature of this architecture is the use of ISOcompliant federated asset registry [11], which ensures all data, metadata and information can be stored and exported in a standardized manner. We are currently working on following up on the MIMOSA Standards [12-13] and ISO Standards [14] and enhancing them to suit marine information management. The issues to be addressed include, conditional monitoring and facilitation for diagnostics and prognostics of various asset types inside a marine sensor network, including sensors, thrusters and others. The performance of the iSLIM private Cloud has been evaluated using parametric modeling technique and the results indicate that iSLIM private Cloud system can successfully enhance the performance of the scientists and technical people involved in this field; the details are also provided in this paper. We intend to develop operational IT systems, in addition to developing international Standards in these areas – for example as in [15-17].

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