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RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VII, v.1 2026 | Submission: July 25, 2026 | Accepted: July 28, 2026 | Publication: July 31, 2026

The impact of 5G networks on digital transformation and the expansion of the Internet of Things. (IoT)

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Vinicius de Souza Silva

SUMMARY

The world is undergoing technological revolutions that bring about drastic changes and impact various areas and market segments. A wealth of information permeates many daily activities; electronic equipment, robots, and automation are increasingly accessible and integrated into the world, which, driven by a set of technologies, can transform people's lives in the era we live in. This new scenario allows for the identification and measurement of many activities, whether performed by humans or machines, in virtually any sector: personal, industrial, urban, or rural. However, for Internet of Things (IoT) solutions to be developed and implemented, the integration of different and complex technologies is necessary, involving people, processes, data, and things. This research presents the main technological components capable of enabling and integrating an IoT solution. In this context, the author presents a literature review on the Internet of Things (IoT), describes technologies and concepts that can compose a solution, and provides a workflow for implementation.

Integrated and connected.

Keywords: Internet of Things, workflow architecture, power source, sensing, networks, big data, and cloud computing.

INTRODUCTION

Currently, there is a boom in technological development, in which many technologies have the

The power to transform various aspects of different markets. This study addresses the context

This current topic presents the reasons for the adoption of the Internet of Things (IoT). This has become a

This is an important topic for detailing the coexistence between a large and growing human population.

and the gradual integration of technology and automation into daily life.

For a solution in any segment to be considered intelligent, that is, to offer

More complete and better information to help your user make decisions is

It is necessary to incorporate a range of technologies. Technological guidelines cover virtually everything.

all component solutions, such as power supply, sensing, infrastructure

networking, cloud computing, and big data.

The combination of different technologies, coupled with increased competitiveness and high volume.

The scarcity of available data leads organizations to seek ways to survive in the market.

For this to be possible, they need to invest in innovation and even rethink their business models.

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These actions are considered fundamental to a company's growth today.

Some researchers, such as Fernandes (2009) and Perez (2010), state that the development
The success of a business is due to innovation. Nowadays, companies must improve their...
knowledge, experience, and processes to satisfy their customers, increasing the
productivity, reducing costs and adapting to the changes resulting from this scenario in
constant evolution. According to Bastos (2003), from the moment a new
When technology starts being used in a market, it can be said that innovation has occurred.

In this context, it can be stated that technological innovation consists of a combination of
societal needs and market demands, transforming knowledge into
Products, processes, and services that can be introduced to the market.

Innovation activities involve all scientific, technological, and organizational steps.
financial, commercial and social, including investment in new knowledge, that leads
to the introduction of technologically advanced or substantially new products or processes
improved.

Technological innovation is one of the factors that most represents a competitive advantage.
Companies that develop technologies are currently the ones that stand out the most. It should be noted that...
that innovation demands knowledge, adaptation, time, practice, and investment, in addition to a
A range of technological and marketing skills, thus bringing competitive advantages.
for companies in the medium and long term, with positive effects for society (SAES, 2012).

Development does not derive solely from the growth of economic activities, but resides...
fundamentally in a qualitative process of transformation of the productive structure,
Incorporating new products and processes, aiming to add value to production through the use of knowledge
and information. This is where IoT solutions come in to capture,
to intermediate and process data and transform it into relevant information, thus causing,
A technological disruption in various sectors.

Disruptive innovations began to be better defined from the 1990s onwards, because
Clayton Christensen, who presented, in his book, the types of innovation: disruptive and
supporting (CANDIDO, 2011).

Sustaining innovations result in products and services that meet the needs of
customers, allowing the company to increase its profit margin and sell higher-value products.
Quality, without taking greater risks. This type of innovation is achieved through innovations.
incremental, focusing primarily on the most demanding consumers in the market.
(CANDIDO, 2011).

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Disruptive innovations, on the other hand, give rise to new markets and business models, with solutions.
more efficient than the current ones, generating a disruption of an old business model and altering
The basis of existing competition. Disruptive innovations bring performance to the market.
superior to what is offered up to now. (CANDIDO, 2011).

THEORETICAL FRAMEWORK - INTERNET OF THINGS (IoT)

The Internet of Things is a paradigm that aims to connect everything that can be connected to the Internet.
where "everything" refers to people, processes, things (cars, televisions, cameras,
refrigerators, airports, cities, among countless other possibilities) and their respective data.
Therefore, IoT solutions have been widely promoted in various sectors, due to...
its enormous market prospects and associated benefits. This paradigm has
It has received a great deal of attention from governments, businesses, and universities around the world.
Playing an important role and aiming to facilitate the integration of sensor networks by
mobile communication means, private networks or the Internet, for the management and control of
processes and data, typically correlated with Return on Investment calculations
(ROI).
For any IoT solution, it is necessary to apply the knowledge and processes of the segment.
to obtain crucial data, for example:
For an IoT solution in the automotive industry, or a "connected car," it is necessary...
to understand traffic and its rules, the vehicle, its components and onboard technologies,
Passengers and cargo. Now, for an IoT solution at the airport, it is necessary
knowledge about flight operations, airlines, the time a passenger spends
delays in boarding, baggage and aircraft logistics processes, procedures
related to security, the services offered, among others. All this information can
to help the user be in the right place, at the right time, with the right tools or information.
available for a specific action.
So, IoT isn't just about connectivity, but about how to use the data obtained by it.
through devices, in a context that assists a process, supports a decision or
Automate a command. The real importance of the solution is directly linked to how...
The data obtained can generate value for products, services, or processes.

IoT solutions can include various technological components, since there are countless...

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variables in solutions designed for different segments. However, the author listed, according to
In his view, as shown in Figure 1, are the components that should be present in most solutions.
IoT, namely: Power source, Sensors, Networks, Cloud and Big Data.

2.1 Networks

Network infrastructure is the oldest technological pillar among those listed for solutions of
IoT. It began during the third industrial revolution, in the 1960s, based on new
Technologies that would make activities more creative and require a more skilled workforce. It is a
technological and scientific revolution, and the characteristic technologies of this period are...
Microelectronics, computer science, and telecommunications.
The network architecture that predominated in the early 1970s consisted of a single host.
(mainframe), to which terminals and printers were connected. At this time, the architecture
The current system was served by low-speed circuits, and all processing was done on the...
mainframe.

The introduction of the PC (Personal Computer) in the early 1980s revolutionized the market by...
Bringing processing closer to the user. The most user-friendly PC interface, combined with low
cost contributed to greater computerization, initially in companies. This process was
quite accelerated due to the rapid growth in the number of applications for this.
environments, such as word processors and spreadsheets.
In the late 1980s, LANs (Local Area Networks) gained importance.
providing the interconnection of PCs and having as its initial objective to allow
Sharing resources that were expensive at the time, such as printers and disk space.
The importance of LANs was quickly recognized by companies, which began using them.
primarily for departmental applications, such as databases and email. This
contributed to increased productivity and made LAN a differentiating factor for the
competitiveness. The main technologies used were Ethernet, Token Ring, and FDDI.
In the 1990s, corporate networks spurred a re-engineering of applications, which
They began to utilize data distribution and processing resources. This increase in
The demand for internet traffic has stimulated the development of new technologies.
WAN (Wide Area Network) telecommunications, such as Frame Relay, ISDN (Integrated Services Network).
Digital Network) and ATM (Asynchronous Transfer Mode).
Local traffic also grew, leading to the development of local area network technologies.

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High-speed networks like Fast Ethernet and Gigabit Ethernet. Studies show that networks
Corporate companies in the late 1990s not only made increasingly intensive use of distribution
data, as well as integrating voice and image into this traffic.
Currently, network and telecommunications infrastructure in general has a wide reach.
especially in large urban centers, where there is a wide variety of access to the Internet and to
data networks.

In order to reduce complexity, network communication was divided into layers.
These layers, when stacked, form a suite of communication protocols or, in short...
In other words, a stack of protocols.
Each layer of a communication stack implements a protocol which, in turn, is
responsible for certain tasks in the network communication process, abstracting the
details of these tasks for the upper layers. The TCP/IP protocol stack is the standard for
This is a fact for communication on the Internet. Each layer of the TCP/IP stack is responsible for encapsulating
and to decapsulate the output and input data, respectively.
Encapsulation refers to the addition of information from the protocols in question, commonly in
a header containing this information, followed by the transfer of this encapsulated data to
lower layer. Decapsulation is the reverse process, in which the information from
The protocol is removed and the remaining data is passed to the upper layer.
The evolution of telecommunications reached a new milestone with the implementation of networks.
fifth-generation (5G) mobile technologies, considered one of the key enabling technologies of
Industry 4.0 and the Internet of Things (IoT). Unlike previous generations of networks.
In the mobile sector, 5G was developed not only to increase data transmission speed,
but also to meet the demands for mass connectivity, low latency and high
reliability required by intelligent applications.
5G networks can achieve significantly higher speeds than 4G, reaching...
transmission rates on the order of gigabits per second, in addition to reducing latency to values
less than 10 milliseconds in certain applications. This feature allows for
Near real-time communication between devices, an essential factor for applications.
such as autonomous vehicles, telemedicine, smart cities, industrial automation,
Remote monitoring and critical control systems.

Another relevant aspect of 5G is its ability to support high density of
devices connected simultaneously. While previous generations featured
Given the limitations on the number of devices per geographic area, 5G networks were designed to...

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to support up to one million devices per square kilometer, making it a
Ideal infrastructure for large-scale IoT ecosystems.
Furthermore, the 5G architecture incorporates advanced technologies such as Network Slicing and Edge.
Computing and Massive MIMO (Multiple-Input Multiple-Output). Network Slicing allows you to
creation of independent virtual networks within the same physical infrastructure, enabling
Different performance levels for specific applications. Edge Computing, on the other hand, offers different levels of performance for specific applications.
Bringing data processing closer to where it is generated reduces response time.
and improving operational efficiency. In turn, Massive MIMO uses multiple antennas.
to increase the network's spectral capacity and efficiency.
In this context, 5G networks represent a natural evolution of the infrastructure of
telecommunications, significantly expanding the capacity for communication between people,
intelligent systems and devices. Their implementation strengthens digital transformation and creates
The foundations for the expansion of innovative applications based on IoT, Artificial Intelligence,
Cloud computing and cyber-physical systems are consolidating themselves as one of the pillars.
Technological aspects of the connected society.
Relevant characteristics and network architecture:

1. Fault Tolerance:

A resilient network is the ability to operate even after one or more failure events. This
This factor is very important for business continuity. Resilience can be relative to
Hardware or software components that make up the solution, such as:
Hardware: physical connections via copper, fiber, or radio frequency, elements such as routers,
switches, firewalls, access points, repeaters and servers.
Software: rapid convergence mechanisms, dynamic protocols, service migration by
virtualization medium.

2. Scalability

Scalability indicates the network's growth potential. We can consider this factor to be...
This can directly influence network performance, since scalability is...
compromised, negative impacts on new services or instability may occur in
Services already in operation.

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3. Service Quality

The term Quality of Service (QoS) refers to the guaranteed statistical performance that a
A system or application can offer advantages in terms of loss, delay, throughput, and jitter.
Quality of service is fundamental and aims to prioritize the traffic of certain types of vehicles.
applications considered critical, to the detriment of others. This planning aims to provide
a better user experience for those using an application or service provided by
through a specific infrastructure.

The central question is utilization: when does a network have sufficient resources for all the
traffic, QoS restrictions are unnecessary; when traffic exceeds the total capacity of the
On the network, user demands will be compromised. In other words, a network with 10% utilization...
There would be no need for QoS, and a network with 101% utilization would prioritize the most critical traffic.
IP networks support various services, such as data, voice, and video, each with...
specific characteristics and service levels.

By default, IP networks operate using the First In First Out (FIFO) standard, which treats packets
according to the order of arrival in the network elements, without taking other considerations into account.
characteristics, such as traffic relevance, can thus cause instability in
critical applications.

To propose a QoS policy, it is necessary to understand the application and demand requirements.
services and to understand the infrastructure. From this point on, mechanisms can be...
developed.

Network applications must be classified so that they can later be marked in
Different levels of priority are considered and they are dealt with as needed.

Classification:

Classification refers to the inspection of one or more fields of a package to identify the type.
traffic that this packet carries. Once identified, the traffic is forwarded to the
specific policy mechanism in which it receives predetermined, preferential treatment or
differentiated. This treatment may include remarking, queuing, policing, shaping, or some other procedure.
a combination of these.

Marking:

There are different ways to perform this marking; the most common are done in
Ethernet link header, via the Class of Service (CoS) field, or in the header

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IPv4/IPv6, via the Type of Service (ToS) field.

The classification and marking of packages can be done by examining:

- Physical Layer: Physical Interface, Subinterface, PVC or Port
- Data Link Layer: 802.1Q (CoS) or MPLS EXP
- Network Layer: Preceding IP, DSCP, source or destination address.
- Transport Layer: TCP/UDP Ports
- Application Layer: Using identification mechanisms.

Once the marking is done, the confidence limit is established from which the tools...
QoS is based on this. Marking is only necessary at the network's trust boundaries and not
It can be performed without prior classification. If the marking is done as close as possible to
The user, that is, in the network access equipment, the subsequent elements through which it passes.
Regarding traffic, there's no need to reschedule packets; simply trust the assigned marking.
previously.

Of the six bits addressed to DSCP, we have the following characteristics:
Bits 0, 1, and 2 are responsible for addressing Service Classes; bits 3 and 4 define the...
Priority for discarding packets; while bit 5 is used as the Default Action and remains
Always zero.
Table 1 converts the binary values of the ToS field to the DSCP service classes.
corresponding, in ascending order; that is, the first classes are intended for applications
or services with lower priority, while the latter are used for applications or
services with higher criticality.

4. Security

However, a network only achieves its full performance efficiently and reliably when it is...
completely safe. In this way, all the principles highlighted above work.
with efficiency and success, generating a productive, efficient and secure network that only brings good things.
Results for the user and, most importantly, for the company.

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5. Availability

Availability is measured by network uptime. Network connectivity tests.
They can be used to verify if services are operational, using tools.
Simple methods like ping and traceroute. Optionally, more critical environments opt for...
network management tools that check devices using the protocol
management standard, the Simple Network Management Protocol (SNMP).
There is a very simple formula for calculating Availability: subtract the time from
The total unavailability of time is calculated, and the result is divided by the total time.
To illustrate, let's calculate the availability of a router over a period of 1 year, which
This equates to 8760 hours, since it was unavailable for 48 hours. Therefore, its availability
It was: (8760 – 48) / 8760 = 99.45%.

6. Response Time:

Response time or Round Trip Time (RTT) is defined as the time required for
A packet travels throughout the infrastructure to provide communication between two hosts.
Several factors can influence this response time between client and server, such as...
physical distance, the technology used, network throughput, overload on network elements,
Access failures to the medium and failures in network devices. The request and response time of
A packet on the network can be seen using the ping and traceroute commands, which return the time.
total and cumulative time per host to destination, respectively.

7. Network Usage:

The utilization of each network segment is an important factor in network performance.
Network utilization is a percentage value that represents the amount of information transmitted.
and received within a specific period of time (BLUM, 2003).
Calculating network utilization in a segment is relatively simple; however, determining this
Usage can become more complex. Therefore, most performance tools
This calculation uses different elements, such as the flow rate and transmission capacity of the network.

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8. Flow rate:

The flow rate, also called throughput, is the rate at which requests are fulfilled by the system. In computer networks, this rate is measured in packets per second (pps) or in bits per second (bps). Determining the throughput consists of measuring the amount of bandwidth. available for application at the moment. This rate is directly linked to the characteristics of Physical access and capacity of network elements and available links; this scenario may be influenced by overloads. Even if the client and server have high Connection speeds, this will not always be replicated across the entire network.

2.2 RFID

IoT solutions largely require flexibility and mobility. Radio-Frequency RFID (Radio-Info) is a technology that uses a system of tags and... radio frequency, enabling the development of solutions that meet these needs. According to Bernardo (2004, p. 03), RFID, "unlike the light beam used in the system "It uses radio frequency instead of barcode scanning for data capture." This tool has It has been widely used by various types of organizations due to its high potential. to significantly simplify and increase efficiency in the identification process. automated product processing.

In this way, the use of labels on goods or assets helps to ensure that each item is identified. be tracked in an optimized way, providing monitoring and, consequently, the Real-time management of company inventory levels, whether on shelves or in stores. warehouses, presenting detailed automated and up-to-date data from the Information obtained from sales outlets or from points of entry and exit of goods. Beuren (2000) considers that RFID allows the time spent on identification actions to be reduced. The number of products in a distribution center can be reduced, since it is possible to update them. only with the passage of products through the docks or forklifts, provided they are equipped with readers, always considering the automation of activities, which facilitates location. of goods and cargo.

RFID (Radio Frequency Identification) is a technology that uses radio frequency waves. to transfer data between a reader and a mobile device, for identification, categorization, Tracking, etc. The range of objects identifiable by RFID covers virtually everything.

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what exists on the planet. Therefore, RFID is an example of Auto-ID (Automatic Identification) technology.
Identification), through which a physical object can be automatically identified.

RFID is fast, reliable, and requires neither line of sight nor contact between the reader and the object being tracked.
read (PASSARETTI, 2008, p. 09).

Based on these principles, RFID technology is considered to make use of "electronic tags,
with an implanted microchip, which are attached to objects or living beings. The microchip has
an internal antenna that communicates, via radio frequency, with a specific reader when it reaches
"its range" (FRANCO et al, 2009, p. 11). Thus, through software, the data is
collected by readers and transmitted in turn to a database that stores
The same in real time, being able to transmit this information to everyone or specific audiences.
sectors of the organization.

According to Lopes (2011), RFID technology is classified as the most comprehensive technology.
automatic identification, not intended to replace the barcode in
all its applications, but above all as a methodology that delivers results.
more efficient when other methods are not sufficient to meet the needs of
enterprise.

The antenna is responsible for activating the tag by means of a radio signal that it sends and exchanges.
information during the reading or writing process. According to Bernardo (2004, p. 04) “as
Antennas are manufactured in various sizes and shapes, with different configurations and...
distinct characteristics, each for a specific type of application. It should be noted that when the
The antenna, *transceiver ,* and decoder elements are located in the same housing and receive the signal.
reader designation.

The reader's function is to emit radio frequencies that are dispersed across various...
senses in space, being able to maintain a distance of a few centimeters and even meters. A
Emission is carried out through an electromagnetic field, that is, radio frequency.
considered the source that provides energy to the transponder, which then provides responses to the reader with the
Necessary information. Various types of materials can be read, such as paper, cement,
plastic, wood, glass, among others. In this way, "when the Tag passes through the area of
The antenna coverage, the magnetic field is detected by the reader, which decodes the data.
encoded in the Tag, passing them to a computer to perform the processing"
(BERNARDO, 2004, p. 04).

Transponders, also known as RF tags, can be found on the market.
in various formats such as cards, tablets, rings and in different types of materials. Emphasizes-

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I know that tags have 2 categories:

- active: they are powered by an internal battery that assists in the inscription process and reading.

- Passive: These only have a reading function, which is used for short distances.

involving storage potentials between 64 bits and 8 kilobits.

Regarding frequency bands, it's worth mentioning that RFID systems maintain low rates.

Frequencies ranging from 30kHz to 500kHz aid in reading at short distances. Therefore:

The lower the frequency range, the slower the transfer rate. Low frequency is

Used for short-distance reading and generally for reading passive labels.

Higher frequencies are used for reading at medium and long distances and at high speeds.

supported by active tags (PRADO, PEREIRA, POLITANO, 2006, p. 03).

They have a relatively low operating cost, which is why they are used to control access.

to identify and track goods, among other applications. According to Bernardo (2004) the

High-frequency systems range from 850MHz to 950MHz; and from 2.4GHz to 2.5GHz, and their reading

It occurs at high speed over medium or long distances, typically benefiting vehicles and

Automatic data collection procedures. The table below presents the variations of

Frequency, characteristics, and typical applications of RFID technology:

Table 2 – Frequencies of RFID technology

Frequency band	**Features**	**Typical applications**
Low: 100 to 500 kHz	- Short to medium range reading; Low cost; Low speed reading.	- Access control; Animal identification; Inventory control.
Average: 10 to 15 MHz	- Short to medium range reading; - Potentially low cost; Average speed of reading.	- Access control; Smart card.
High: 850 to 950 MHz and 2.4 to 5.8 GHz	- Wide reading range; - High cost;	- Vehicle monitoring in roads.

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	- High reading speed; Line of sight required.	

Source: Bernardo (2004)

2.3 SENSING

The recent development and success of cloud services have boosted sensing,
Since all the collected data can be stored, it can be easily accessed in real time.
realistic and have the technological resources scaled according to the platform's needs.
of sensing; for example, an application that generates a larger amount of data demands
a proportional increase in disks for storage.
Big Data, Cloud, and Sensing technologies, combined, have great potential for
forming what is known as the Internet of Things (IoT), thus promoting an integrated solution.
Remote sensing plays a fundamental role in acquiring data in the field.
Using objects or things equipped with sensors to detect and collect data in real time.
Real. After this data is collected, it is necessary to absorb and interpret it in order to...
To find vital business information, answer a question, or guide the company, cloud services
become essential.
Information can be shared and used by all interested users or with
access.

Data centers designed to operate 24 hours a day, 7 days a week, with systems
of logical and physical redundancy, accompanied by a series of standards. Here are the locations
with greater scalability for storing, making available, and accessing all of this data.
Integrated sensing solutions for obtaining critical data are becoming increasingly common.
increasingly commercially viable, they are encouraged and adopted, in many cases, by
issues of company or industry survival in a high-demand global environment
high productivity and quality are required.
Cloud-assisted sensing can be useful in many real-world applications and if
It falls within different sectors, including industrial, agricultural, social, and environmental sectors.
doctors, to name a few. Unlike the previously conventional methods, or often,
With analog technology, sensing now offers decentralization in data detection and collection.
where sensors can be spread throughout the plant and sensory data can be
detected from any location and then analyzed.

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According to YADAV, SWARNKAR, CHAUHAN and JAIN, the agricultural environment equipped with Sensors have the potential to remotely monitor vegetation and combat pests that affect it. They threaten and improve the productivity of the agricultural system. Connected cameras are being used for remote monitoring through the collection of images of vegetation and fields in real-time, thus enabling the generation of performance reports, which subsequently They are sent to the cloud. These mechanisms can help in making appropriate decisions. to improve food security and the productivity of the agricultural system.

These steps include mapping agricultural production and creating comprehensive databases through... monitoring water resources using high-resolution radiometers and Moderate-resolution imaging spectrometers, typically installed on board aircraft. and satellites. Relevant information can be distributed via the Internet or stored on so that other farmers or consumers can stay informed.

Given this scenario, we will see various sectors adopting technologies of Automation and sensing, all in pursuit of the right information at the right time.

According to ABDELWAHAB, HAMDAOUI, FELLOW and RAYES, once they come into existence Given the numerous sensor networks in different domains, a common architecture should be considered. for the sharing of resources and information. The architecture is divided into four Layers: Fog, Stratus, Alto-Cumulus and Cirrus.

A. Fog Layer

This encompasses all physical objects, machines, and anything that is equipped with computing, storage, networking, sensors, or other computing resources that can to connect to the Internet. The elements of this layer are those that collect and send data from Sensing for the next layer, the stratus. In this way, the main functions of the layer Fog are:

1) To provide homogeneous network and communication infrastructure to connect billions of things;
2) Unambiguous identification of all things through IPv6;
3) Data aggregation points to serve as clusters.

Although the capabilities of devices in this layer may vary depending on their type and For this purpose, it is feasible to consider that they have scarce resources in terms of energy, memory, and... processing, primarily relying on wireless connections.

The sensors that make up the Fog layer are segmented as follows:

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Machine Translated by Google
RCMOS - Multidisciplinary Scientific Journal The Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year VII, v.1 2026 | Submission: July 25, 2026 | Accepted: July 28, 2026 | Publication: July 31, 2026

1) Fixed sensors: These are stationary, and the network connectivity is known and controllable;
2) Mobile sensors: These are known sensors that are mobile and operate in various locations.
known and the network connectivity is known and can be controlled;
3) Participatory sensors: These are private devices that, of their own volition, can or
Do not opt out of participating in detection tasks. Network connectivity may be intermittent and
It may or may not be known, but it is definitely not controllable.

B. Stratus Layer:

It is an intermediate layer consisting of the aggregation of thousands of clouds composed of
Sensory devices from the same domain. Each Stratus cloud manages and operates in conjunction.
with a different group of sensors that share similar characteristics or do
part of the same context or property. The functions of the Status layer include:
1) Virtualization of physical sensors;
2) Sensor handling and management;
3) Ensure the operation and functionality of sensor instances;
4) Sensor configuration to ensure network connectivity;
5) Control of operations and functionalities to guarantee service levels;

Thus, the Stratus layer provides an abstraction of the physical world, represented by the Fog Layer.
This layer does not interact directly with customers, but serves them through orders.
received from the upper layers.

C. Altocumulus layer:

It is a middle layer that serves as a connecting point between the Stratus and Cirrus layers. This
facilitates negotiations related to costs, policies, regulations, and service levels between
the Stratus and Cirrus layers.

While the Stratus layer belongs to specific domains (medical, environment,
agriculture), a high-cumulus cloud can map and orchestrate multiple stratus clouds.
different domains.

This can allow for resource sharing between environments, increasing elasticity.
and resource scheduling. The main functions of High Cumulus are as follows:

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1) It serves as a link between the Cirrus and Stratus layers, translating policies,
regulations and requirements expressed by the Cirrus layer.
2) It allows commercial transactions;
3) To enable and facilitate service level negotiations between Cirrus and Stratus;

4) Coordinate and facilitate interactions between clouds.

D. Cirrus Layer:

Cirrus is the highest layer in the sensing architecture, and its main function is to interact.
with the service customers and fulfill their requests with the help of the lower levels. He
It doesn't deal with resource virtualization, nor does it need to know which sensor cloud each one is in.
The resource is executed; it only needs to communicate the customer requests, specifying the level of
Service for the High Cumulus layer. The main functions of this layer are as follows:
1) It acts as a user access point for sensing systems, allowing them to specify
your services;
2) It allows users to establish their detection requirements and create their service model;
3) Negotiate service levels with users and communicate them to the high-cumulus layer;
The goals of cloud-assisted remote sensing are to offer customers access
Flexible to data and detection services and enabling the sharing of physical resources between
the clouds.

Security is another fundamental attribute of wireless sensor networks. The main ones
The objectives for security within the WSN are:
• Confidentiality: Data transmitted over the network cannot be read by just anyone.
only by the intended recipient.
• Integrity: Any message received is confirmed as being exactly the message.
which was sent without any additions, deletions, or modifications to the content.
• Authenticity: A message that claims to be from a particular source is, in fact, from that source.
If time is used as part of the authentication scheme, authenticity is also...
It protects against the recording and playback of a message.

Several critical safety technologies must be incorporated into a sensor network without
A key approach to address these goals is using encryption and access control lists (ACLs) to allow or...

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Deny explicit access to specific devices.

4. Power source for sensors

After identifying the sensors, assess the type of energy they use.

2.4 **Cloud Computing**

Since Information Technology (IT) is widespread and part of everyday life...
people and the strategy of companies and universities, with a large part of their transactions or
With information based on digital technology, it became clear that the content stored in Data Centers...
It became far more valuable than all of his material assets.
Google Trends is a tool that expresses interest in specific keywords.
over time, using as a basis the history of research carried out through their
extremely popular search engine. According to this information, the interest in the term
Cloud computing emerged in mid-2008 and can be considered a relatively new technology.
According to Marcon Junior (2011), in general, cloud computing can be
used for hosting software in internet computing environments. With this, the
Consumers can communicate with numerous servers simultaneously and share...
data between themselves.

In technical topologies, cloud drawings are often used to hide details.
specific to infrastructure, connectivity, or implementation, with the aim of retaining the
Attention should be paid to the overall function of the system under discussion. Often, this may not be of interest.
to present certain complex details that make up a scenario, such as: Servers,
IP addressing, Operating Systems, among others, in an executive presentation that
Involve managers and directors.
Through simplification and objectivity in the information conveyed, the concept of
Cloud computing now connects users directly to the applications they need.
necessary, concealing all the lower layers.
Sousa et al (2010) states that cloud computing is one of the key concepts for
Information Technology industry. This concept is an evolution of services and products,
of on-demand information, where data storage is vital.
Cloud computing service is recognized as the set of enabled networks,

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enabling scalability, quality of service, and low computing costs, generating a simple and efficient access (ARMBRUST et al, 2009).

According to Santana, the infrastructure that enables Cloud Computing is located in the Data Center. In summary, a data center is a specialized facility designed to host, manage, and To support critical computing resources for one or more organizations. An entity particularly complex, encompassing special construction structures, energy storage, cooling systems, equipment racks, structured cabling, network elements and storage, servers, data security systems, mainframes, software of Applications, physical security devices, cameras, monitoring centers, among others. systems. All these resources and their interaction are managed, locally or remotely, by specialized personnel.

According to WANT, SCHILIT, and JENSON, the advantages of cloud computing for a solution of IoT includes energy savings for peripheral devices, and scalability gains with the... The use of data centers, in addition to backup and physical security policies. With the service Centralized, it's possible to run it on a simple client. Based on these observations, it seems to be a good idea for IoT architecture.

IT service providers (SPs) are a fundamental part of cloud application development, as they are able to offer a range of Technologies or services provided to an organization for a period of time stipulated in a contract. The choice of service provider can be made for various reasons, such as the need for intensify efforts in the organization's business, the technical inadequacy for the development and maintenance of technological solutions, the unavailability of resources technological, among others. Many organizations also opt for a mixed strategy, Having internal resources and tools, while aggregating services from providers. Quality levels are established for contracting these services; the metrics used They generally encompass availability, performance, and failure recovery time.

The National Institute of Standards and Technology (NIST) describes the cloud model and its composition through five characteristics, three service models and four models of implantation.

Essential Features:

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1. On-Demand Service: A consumer can provision computing resources, such as Storage, as needed, without requiring human interaction with the provider. of services.

2. Easy Access: Products must be available online and accessible through Standard mechanisms that promote use across heterogeneous platforms, for example: phones. cell phones, tablets, laptops, and workstations.

3. Resource Grouping: The provider's computing resources are grouped together to serving multiple consumers, with different physical and virtual resources allocated. dynamically adapts to demand. There is a sense of location independence, in meaning that the customer generally has no control or knowledge over the exact location. of the resources provided; however, it can specify the location at a higher level of Abstraction, oriented towards the positioning of its resources, for example: country, state or date. Center.

4. Elasticity: Capacities can be provisioned and released elastically, in In some cases, automatically, according to demand. For the consumer, the capabilities Available for supply often seem unlimited and may be appropriate in any amount, at any time.

5. Measured Service: Cloud systems automatically control and optimize usage. of resources, leveraging a measurement capability at some appropriate level of abstraction. to the type of service, for example: storage, processing, and bandwidth. The use of Resources can be monitored, controlled, and reported, which provides transparency to both parties. service provider in relation to the consumer.

Service Models:

1. Software as a Service (SaaS): Provides the consumer with the ability to use the Provider applications, running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface, such as a web browser (for example, web-based email) or a program interface. The The consumer neither manages nor controls the underlying cloud infrastructure, including the network.

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servers, operating systems, storage, or even application resources
individual settings, with the possible exception of specific application settings for users.

2. Platform as a Service (PaaS): The capability offered to the consumer is
To implement, within the cloud infrastructure, applications developed by the consumer themselves.
The consumer does not manage or control the cloud infrastructure, but does have control over the...
Deployed applications and hosting environment settings.

3. Infrastructure as a Service (IaaS). Processing is provided to the consumer,
storage, networks, and other fundamental computing resources, with which the
The consumer is able to deploy and run arbitrary software, which may include systems.
Operational and application-related aspects. The consumer does not manage or control the cloud infrastructure.
underlying, but has control over operating systems, storage, and applications.
deployed and possibly limited control over selected network components, by
For example, host firewalls.

6. Big Data

Nowadays, it's common to use our smartphones from the moment we wake up.
These devices can also notify us in advance about the time of a meeting.
to schedule services, such as transportation and home deliveries, and to provide access to numerous media of
communication, among hundreds of other functions. Decades have passed and, currently, we have a
a variety of solutions capable of facilitating our daily activities, transforming the way
How we communicate and generate new business strategies.
To aid in this understanding, the following items show how technology exerts influence.
directly impacting how we carry out our activities. Whether for leisure, shopping, or work,
It provides us with previously unimaginable conveniences.

- **Shopping:** E-commerce; price comparison; online order tracking;
Online customer service; internet banking; product tracking;
- **Leisure:** Video and music streaming services; social networks; online games; access to
e-books;
- **Job Description:** Online scheduling; video and audio conferencing; file storage on
Cloud computing; seeking opportunities through corporate social networks; online training;

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All these services generate a large volume of data to be processed. The recent
Advances in hardware, software, and infrastructure were fundamental to getting us to...
current moment. Two decades ago, all data was stored in analog formats,
such as vinyl records, cassette tapes and VHS tapes, and later CDs and DVDs. These resources
They could not withstand widespread dissemination because their sharing was restricted and not
It added resilience to the data. They gradually disappeared from the scene with the adoption of...
new digital resources.

NATHAN and WARREN (2015) mention that Big Data is used commercially for the
analysis of large volumes of data, in order to make decisions based on behavior and
in consumer preferences.

According to Stifel, this catatonic state of the inanimate world is about to change shape.
dramatic. The internet is allowing the inanimate world to create "consciousness" and, in this
In this context, it's interesting to note that the Internet and TCP/IP were born just over 30 years ago.
which means that the evolution of the Internet has existed for 0.00135 of the time that we have existed.

Several factors were fundamental to the development of the data age in which we live.
Currently. Certainly, the Internet has been one of the most powerful drivers of...
transformation for the growth and dissemination of data, coupled with evolutions in
storage capacity and more accessible computing resources, as foreseen by
Moore's Law, according to which it was observed that the processing capacity of
The number of computers would roughly double every 18 months. In this way, widespread access generated...
an exponential growth of data. Anyone carrying such a device can
generate a video, audio, or text that will be shared through various applications. They are
Examples of widespread adoption: Twitter, Instagram, Pinterest, Facebook, LinkedIn, and Flickr.
All of this data can be generated from numerous sources today. Let's classify it into...
Two categories: data generated by humans and data generated by machines.

1. Human-Generated Data:

These are the ones in which the content was generated from intellectual priority and individuality.
human; its particularities are directly linked to the data. We can also
to interpret them as data that reflect the interaction between people in the digital world. Currently,
A large portion of human-generated data comes from social media, where users...
They can share their opinions, generate debates, and express their preferences and feelings.

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According to Brenner and Smith, the use of social networks is an important activity for users of
The internet is accessible to a wide range of demographic groups. Adults and younger people are...
especially adept; however, social networks continue to grow in popularity among them.
Older people too. Six out of ten internet users between the ages of 50 and 64 are users of
social media, as well as 43% of people aged 65 or older. Although online seniors are
Less likely to use social networking sites, adoption rates among those aged 65 or older
But they tripled in four years.
Besides social media, whenever we are connected to the internet, we can generate different
Data types via emails, spreadsheets, blogs, and product and service reviews.
commerce, to name a few.
The examples cited so far are data generated by users who have
knowledge, opinion, or emotion. However, many services are already capable of capturing data.
Human data is collected covertly, meaning without the user's knowledge. This includes websites visited, locations, etc.
Travel itineraries, device descriptions, and contact lists are some of the ways in which...
What systems are available to abstract data generated by humans?

2. Machine-generated data:

These are digital data generated through computer processing, applications, and other means.
systems that do not require human intervention in the collection process.
The data generated by machines has increased significantly with the evolution of...
Machine-to-Machine (M2M) communication technology. A technology directly linked
to the Internet of Things (IoT) paradigm that enables direct communication between devices.
In this paradigm, in addition to computers, other objects become part of the infrastructure.
Internet communication, generating, consuming, and interacting with other people and objects.
Examples include RFID tags, sensors, and wearable devices. Intel estimates
that each person will have 7 connected devices by 2020.
This new global phenomenon is driving the massive growth of unstructured data and
It is expected to intensify in the coming years.
As illustrated in the Hewlett-Packard image below, other drivers, which include data from
mobile web, social media, clickstream, GPS, video and photos, among other content, both
Generated by both machines and humans, data will dominate the network at the expense of data itself.
corporate.

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According to ZANELLA, BUI, CASTELLANI, VANGELISTA and ZORZI, mobile devices
The most common current technologies, such as smartphones, tablets, and laptops, have great potential to strengthen
This scenario offers new forms of interaction. For example, Near Field Communication.
(NFC) integrated into smartphones allows interaction with other devices, simply
By bringing the cell phone closer, eliminating the need for wires to exchange information, it can also...
enrich the information with location data. Furthermore, mobile devices
They can provide various access points in different ways, such as through a phone call.
IP provided by the cellular data service or through a direct connection to objects, by
through other short-range wireless technologies, such as Bluetooth Low Energy.
With the exponential increase in data that the new world is expected to generate, there will be changes in
various sectors, both from a technological and social perspective.

3. Locating Data:

For the development of a Big Data project, it is necessary to define what answers will be...
you want to obtain it from the data; therefore, we need to locate and collect the data to begin the process.
analysis. With this, we will identify whether the data already exists or if it needs mechanisms,
sensors or other tools to be generated. This step is fundamental for the
Development of an IoT solution.
Once we know what data is desired, it is necessary to verify that it is under the control of...
Whether a corporation or not, characterizing data ownership and considering them as internal.
or external, in addition to identifying its shape.

Internal data:

They can be obtained from two of the company's systems, usually through systems such as
ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) or areas
internal departments, such as engineering, human resources, marketing, support, among others, added to
Production of files and documents generated by collaborators.
Data obtained through internal sensors are also considered internal and become
vital in IoT solutions; they add the desired sensing capability and enable...
Interaction between devices and humans, providing relevant information in the scenario.
desired. To meet this demand, it is necessary to identify the type of sensor that exists and

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The transmission technology allows data to be sent to a server and,
subsequently processed, adding value to the solution.
IoT solutions with Big Data can fit into various segments, for example: a
A transportation company can monitor its bus fleet using sensors to...
to identify the need for preventive maintenance, map the use of components or the form
driver's driving, evaluating components such as the engine, the braking system, the
doors, the braking system, the lights, the average speed, the route taken, among others.

External data:

They originate from sources external to the corporation; not all are relevant to the characteristic of desired solution.
We can obtain data from public sources that provide information about, for example, the climate and finances.
and traffic, or from third-party websites. However, the largest amount of external data may be
found on social media, with its vast range of options, such as Facebook, Twitter,
Instagram, YouTube, LinkedIn, and others. Here, you can find information about your...
brand, product or service directly from the end customer.

Data obtained through sensors will be the most suitable for IoT solutions.

5. Processing Data

IoT solutions are composed of hundreds or thousands of objects that generate, transmit, and...
They receive data. Different types of sensors, actuators, wearable devices, and smartphones.
They will be present and will bring innovation to their segment.
Common examples of connected homes, smart cities, and smart solutions for...
Agriculture and livestock farming, to name a few, require real-time data processing.
real to be effective.
Smoke and temperature sensors can send alerts to residents near forests.
industries or volcanoes. In healthcare settings, cardiac monitoring can provide information.
Immediately alert the medical system to an emergency.
For data from an IoT solution to be processed, it needs to reach the
Cloud servers. A limiting factor in data processing time in the context of
IoT is the connectivity of sensors, since transmission technologies can be...

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intermittent or slow-speed transmissions, which cause delays, retransmissions, or...

Eventually, data loss.

A structured solution with a Fog Computing layer and cluster functionalities can

to help improve agility and availability.

6. Visualizing Data

To demonstrate the mechanisms of the real-time data processing tool.

To illustrate how easy it is to present the large volume of data to the client in a clear way.

Relevant information.

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