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Secure Radio Resource Management in Cloud Computing using CRN

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Abstract: *Limited processing power in Cognitive Radio Networks (CRNs) creates challenges for secure radio resource management, particularly in dynamic spectrum access environments. This paper proposes a novel cloud-assisted CRN framework that addresses this limitation. By offloading spectrum sensing and allocation tasks to the cloud's vast computational resources, CR users can achieve a more secure and efficient spectrum utilization. The cloud platform prioritizes robust security protocols to safeguard spectrum information and communication, ensuring confidentiality, integrity, and user trust. This innovative approach optimizes spectrum usage, improves Quality of Service (QoS) for CR users, and strengthens the CRN's defense against unauthorized access and malicious attacks*

Keywords: Cognitive Radio Networks

I. INTRODUCTION

Data demands soar, pushing the limited radio spectrum to its limits. Traditional static allocation leaves valuable resources underutilized, creating a bottleneck. Cognitive Radio Networks (CRNs) offer a dynamic solution, allowing unlicensed users to access unused portions of licensed bands. However, CRNs face a processing power hurdle, hindering secure radio resource management (RRM) in ever-changing dynamic environments.

This paper proposes a groundbreaking solution: a secure RRM framework for CRNs that leverages the power of cloud computing. By integrating cloud processing, CRNs unlock a new era of spectrum efficiency. CR users offload spectrum sensing and allocation tasks to the cloud's vast resources, enabling them to efficiently identify and utilize available bands. This empowers CRNs to perform complex computations for dynamic spectrum allocation, leading to significant improvements in Quality of Service (QoS)for users.

Security remains paramount. The cloud platform prioritizes robust security protocols to safeguard spectrum information and communication, ensuring confidentiality, integrity, and user trust within the CRN. This innovative cloud-aided CRN framework promises to revolutionize wireless communication by optimizing spectrum usage, ensuring secure communication, and delivering superior user experience. The following sections will explore the framework's architecture, security mechanisms, and performanceevaluation.

II. NEED OF THE STUDY.

This study tackles this gap by proposing a groundbreaking secure RRM framework for CRNs that leverages cloud computing. By offloading spectrum sensing and allocation tasks to the cloud's vast resources, CRNs can overcome their processing limitations. This unlocks a new era of spectrum efficiency, enabling CR users to identify and utilize available bands more effectively. Additionally, cloud processing empowers CRNs to perform complex calculations for dynamic spectrum allocation, leading to significant improvements in Quality of Service (QoS) for users. Security remains paramount. The cloud platform prioritizes robust security protocols to safeguard spectrum information and communication, ensuring confidentiality, integrity, and user trust within the CRN.

Population and Sample

According to Cisco, global mobile data traffic is projected to reach 222 exabytes per month by 2027 . This immense data traffic translates to a vast population of users and devices demanding wireless resources. Quantifying the exact number of CRN users is challenging as the technology is still evolving. However, research suggests CRNs have the potential to support millions ofusers in a given geographical area. Depending on the research goals, pilot studies could involve a few dozen to a few hundred CRN users and a limited spectrum range to test the effectiveness of the secure RRM framework. Studies show that licensed spectrum utilization can be as low as 15% to 85% depending on location and time. For instance, Amazon Web Services (AWS) boasts instances with hundreds of CPUs and thousands of GBs of memory

Data and Sources of Data

For this study secondary data has been collected. From the website of International Journal of Science. And Research themonthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2023. And from the website of amazon web service the data for the macroeconomic variables are collected for the period of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years.

Theoretical framework

Cognitive Radio Networks (CRNs) represent an advanced form of wireless communication where radios can dynamically adjust their transmission parameters based on the environment to optimize spectrum use. Integrating CRNs with cloud computing introduces a flexible and efficient approach to manage radio resources, leveraging the cloud's extensive computational power and storage capabilities. However, this integration raises significant security challenges. This theoretical framework aims to provide a comprehensive structure for secure radio resource management (RRM) in cloud-based CRNs.

III. RESEARCH METHODOLOGY

Secure radio resource management in cloud computing using cognitive radio networks involves leveraging cloud-based resources for dynamic spectrum access, optimized spectrum utilization, and robust security mechanisms. This integration enhances spectrum efficiency and protects against threats like primary user emulation and data falsification, ensuring reliable and secure communications.

Statistical tools and econometric models

In Secure Radio Resource Management within cloud-based Cognitive Radio Networks, statistical tools and econometric models are vital for optimizing spectrum utilization and ensuring security. Descriptive statistics, including mean, variance, and correlation analysis, help understand spectrum usage patterns and relationships between variables. Inferential statistics, such as hypothesis testing and confidence intervals, assess the significance of observed effects. Time series analysis with ARIMA models and seasonal decomposition identifies and forecasts trends in spectrum availability. Cluster analysis, like K-means and hierarchical clustering, groups similar usage patterns to improve resource allocation. Regression models, including linear, multiple, and logistic regression, analyze relationships and predict outcomes related to spectrum efficiency and security. These tools collectively enable robust, data-driven decision-making for secure and efficient radio resource management in cloud-integrated cognitive radio networks.

Descriptive Statistics

Descriptive statistics play a pivotal role in Secure Radio Resource Management within cloud-based Cognitive Radio Networks (CRNs), offering valuable insights into spectrum usage dynamics and resource allocation. Metrics like mean, median, and mode provide a comprehensive overview of central tendencies in spectrum utilization, aiding in the identification of optimal frequency bands for communication. Measures of dispersion such as standard deviation and variance help assess the variability of spectrum availability, enabling CRNs to adapt dynamically to changing environmental conditions. Moreover, correlation analysis facilitates the exploration of relationships between different variables, such as spectrum availability and network performance, informing strategic decision-making processes. By leveraging descriptive statistics, stakeholders can gain a nuanced understanding of the complex interplay between radio resources and cloud computing infrastructure, thus enhancing the efficiency and security of CRNs.

Clustering Algorithm

Cluster-based algorithms are used to organize nodes into groups or clusters to improve network efficiency and scalability.

- **Cluster Formation**: Initially, nodes self-organize into clusters based on certain criteria such as proximity, energy levels, or communication quality. This can be achieved through algorithms like LEACH (Low-Energy Adaptive Clustering Hierarchy). Nodes autonomously form clusters based on specific criteria such as signal strength, proximity, or energy levels. This process reduces the complexity of network management and facilitates efficient data aggregation.
- **Cluster Head Election**: Each cluster selects a cluster head (CH), which is responsible for managing intra-cluster communication and relaying data between the cluster members and the base station. Each cluster elects a cluster head responsible for coordinating intra-cluster communication, aggregating data from member nodes, and forwarding it to the base station or other clusters.
- **Data Aggregation**: Cluster heads can aggregate data from member nodes before forwarding it to the base station. This reduces the amount of data transmission and prolongs network lifetime by reducing energy consumption. Cluster heads aggregate data from member nodes before transmitting it to higher-level nodes or the base station. This reduces the amount of data traffic in the network, conserving energy and bandwidth.
- **Routing within Clusters**: Cluster heads can use protocols like AODV or other suitable routing protocols to route data within the cluster or towards the base station

Cluster-based algorithms often incorporate mechanisms for dynamic cluster reconfiguration in response to node failures, energy depletion, or changes in network topology. This ensures robustness and adaptability in the face of evolving network conditions. By dividing the network into clusters, cluster-based algorithms reduce the overhead associated with global routing and communication. This improves scalability and prolongs network lifetime by distributing energy consumption more evenly among cluster members.

Module:

- **Cluster Formation**: Nodes self-organize into clusters based on certain criteria like proximity and energy levels.
- **Cluster Head Election**: Each cluster selects a cluster head responsible for managing intra-cluster communication and relaying data to the base station.
- **Routing:** AODV can be used for routing data between clusters and towards the base station. When a cluster head needs to communicate with another cluster or the base station, it can initiate route discovery using AODV.
- **Data Transmission:** Once routes are established, data can be transmitted through the network following the routes discovered by AODV.
- **Energy Efficiency:** The combination of cluster-based organization and AODV routing helps in reducing energy consumption by minimizing communication overhead and optimizing routing paths.

In integrating AODV with cluster-based algorithms, the routing functionality provided by AODV complements the hierarchical organization of clusters. AODV handles inter-cluster routing, facilitating communication between clusters and the base station, while the cluster-based algorithm manages intra-cluster communication and data aggregation. This synergy optimizes network performance, energy utilization, and scalability, making it well-suited for wireless sensor networks deployed in dynamic and resource-constrained environments.

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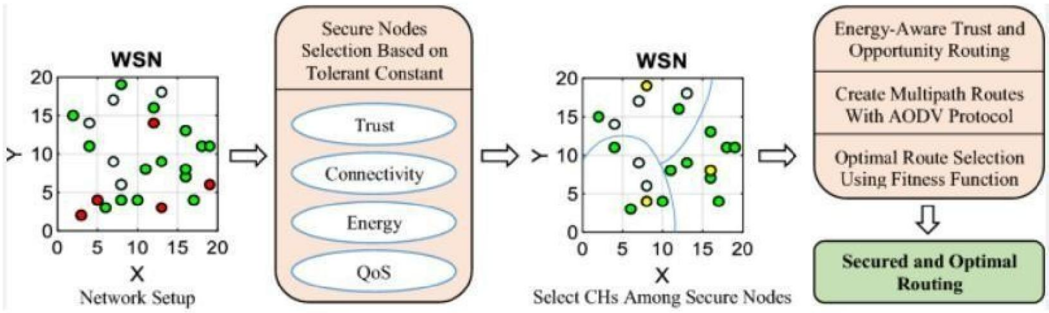
Architecture Diagram



Code:

```
/*
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THIS SOFTWARE IS PROVIDED BY THE AUTHOR ``AS IS'' AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIESOF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED.
IN NO EVENT SHALL THE AUTHOR BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL
SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
The AODV code developed by the CMU/MONARCH group was optimized and tuned by Samir Das and Mahesh Marina, University of Cincinnati. The work was partially done in Sun Microsystems.
*/
#include <aodv/aodv_rtable.h>
//#include <cmu/aodv/aodv.h>
/*
The Routing Table
*/
aodv_rt_entry::aodv_rt_entry()
{
int i;
rt_req_timeout = 0.0;
rt_req_cnt = 0;
rt_dst = 0;
rt_seqno = 0;
rt_hops = rt_last_hop_count = INFINITY2; rt_nexthop = 0;
LIST_INIT(&rt_pclist); rt_expire = 0.0;
```

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```
rt_flags = RTF_DOWN;
/*
rt_errors = 0;
rt_error_time = 0.0;
*/
for (i=0; i < MAX_HISTORY; i++) {
rt_disc_latency[i] = 0.0;
}
hist_indx = 0;
rt_req_last_ttl = 0; LIST_INIT(&rt_nblist);
}
aodv_rt_entry::~aodv_rt_entry()
{
AODV_Neighbor *nb;
while((nb = rt_nblist.lh_first)) { LIST_REMOVE(nb, nb_link); delete nb;
}
AODV_Precursor *pc;
while((pc = rt_pclist.lh_first)) { LIST_REMOVE(pc, pc_link); delete pc;
 }
}
void aodv_rt_entry::nb_insert(nsaddr_t id)
{
AODV_Neighbor *nb = new AODV_Neighbor(id);
assert(nb);
nb->nb_expire = 0; LIST_INSERT_HEAD(&rt_nblist, nb, nb_link);
}
AODV_Neighbor* aodv_rt_entry::nb_lookup(nsaddr_t id)
{
AODV_Neighbor *nb = rt_nblist.lh_first;
for(; nb; nb = nb->nb_link.le_next) { if(nb->nb_addr == id)
break;
}
return nb;
}
void aodv_rt_entry::pc_insert(nsaddr_t id)
{
if (pc_lookup(id) == NULL) {
AODV_Precursor *pc = new AODV_Precursor(id);
assert(pc);
LIST_INSERT_HEAD(&rt_pclist, pc, pc_link);
}
}
AODV_Precursor* aodv_rt_entry::pc_lookup(nsaddr_t id)
{
AODV_Precursor *pc = rt_pclist.lh_first;
for(; pc; pc = pc->pc_link.le_next) { if(pc->pc_addr == id)
return pc;
}
return NULL;
```

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```
}
void
aodv_rt_entry::pc_delete(nsaddr_t id) { AODV_Precursor *pc = rt_pclist.lh_first;
for(; pc; pc = pc->pc_link.le_next) { if(pc->pc_addr == id) { LIST_REMOVE(pc,pc_link); delete pc;
break;
 }
}
}
void aodv_rt_entry::pc_delete(void) { AODV_Precursor *pc;
while((pc = rt_pclist.lh_first)) { LIST_REMOVE(pc, pc_link); delete pc;
}
}
bool aodv_rt_entry::pc_empty(void) { AODV_Precursor *pc;
if ((pc = rt_pclist.lh_first)) return false; else return true;
}
/*
The Routing Table
*/
aodv_rt_entry* aodv_rtable::rt_lookup(nsaddr_t id)
{
aodv_rt_entry *rt = rthead.lh_first;
for(; rt; rt = rt->rt_link.le_next) { if(rt->rt_dst == id)
break;
}
return rt;
}
void aodv_rtable::rt_delete(nsaddr_t id)
{
aodv_rt_entry *rt = rt_lookup(id);

if(rt) {
LIST_REMOVE(rt, rt_link); delete rt;
}
}
aodv_rt_entry* aodv_rtable::rt_add(nsaddr_t id)
{
aodv_rt_entry *rt;
assert(rt_lookup(id) == 0); rt = new aodv_rt_entry; assert(rt);
rt->rt_dst = id; LIST_INSERT_HEAD(&rthead, rt, rt_link); return rt;
}
```

IV. RESULT AND CONCLUSION

Cloud-based spectrum sensing in CNRs holds promise for boosting spectrum utilization. By analyzing data from geographically spread CNRs, the cloud could identify underused spectrum, leading to better allocation and less interference. Additionally, a centralized database in the cloud could provide real-time information on spectrum occupancy, aiding CNRs in dynamic spectrum access decisions. Powerful cloud resources could also enable complex sensing algorithms for more accurate detection of usable spectrum. However, challenges like latency, data security, and algorithm development need to be addressed. Overall, this approach has the potential to significantly improve spectrum efficiency in CNRs, but further research is needed to explore its practical implementation.

Leveraging the cloud for spectrum sensing in Cognitive Radio Networks (CNRs) presents exciting possibilities for optimizing spectrum usage. Cloud-based processing of spectrum data collected from geographically distributed CNRs can enable real-time analysis, uncovering underutilized spectrum opportunities. This translates to more efficient allocation of spectrum resources and reduced interference between users. Furthermore, a centralized database in the cloud can store spectrum data, providing users with real-time information on spectrum occupancy. This information empowers CNRs to make dynamic decisions on accessing available spectrum.

However, implementing cloud-based spectrum sensing in CNRs comes with its own set of challenges. Latency, or the time it takes for data to travel between CNRs and the cloud, is a crucial factor. Delays can impact the effectiveness of real-time spectrum analysis. Security of spectrum data stored in the cloud is another concern that needs to be addressed. Finally, developing efficient algorithms that can exploit the cloud's capabilities while being mindful of factors like latency is essential.

In conclusion, cloud-based spectrum sensing in CNRs has the potential to revolutionize spectrum utilization. While challenges exist, further research can pave the way for practical implementation and reap the benefits of improved spectrum efficiency in CNRs

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