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Centralized Control over Greening Residential Wi-Fi Networks

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Abstract**—** *With the rapid growth in information and communication technology, reducing energy consumption of residential Wi-Fi networks has attracted increasing attention in recent years. Today's household equipment are not only limited to traditional devices but also devices for VoIP, health monitoring, security surveillance etc. Wireless access points are always on so as to give continuous online presence to such devices. Also with the continuously growing popularity of Wi-Fi networks, there is a considerable growth in user premises equipment. A typical home gateway comprises a modem; router and wireless access point and such devices consume high per bit energy even in the case of light traffic. A solution for reducing energy consumption in residential Wi-Fi networks is to aggregate all client traffic on some suitable access points and put remaining APs to sleep. In this scheme, a centralized approach is used for reducing energy consumption with the benefits of fairness, no client modification, explicit control of migrations and allowing for heterogeneity amongst households. A central operator takes all the responsibility of minimizing energy consumption and reduces the burden on users.*

Keywords**—** *Energy consumption, centralized approach, internet service provider(isp), the green operator, bandwidth aggregation, set and forget, information communication technology, Client monitoring radio management.*

I. INTRODUCTION

Wi-Fi is a technology that is used to provide internet access to devices that are within the range of a network that is connected to the Internet. It is wireless networking technology that uses radio waves to provide wireless high-speed internet and network connections that is no physical wired connection between sender and receiver.

a) Wi-Fi: Wi-Fi works with a frequency within the electromagnetic spectrum associated with radio wave propagation. When a RF current is supplied to an antenna, electromagnetic fields are created that then are able to propagate through space. An access point (AP) is a central device that broadband a Wi-Fi signal for Wi-Fi clients to connect to. The primary job of an access point is to broadband a wireless signal that computers can detect and tune into. In order to connect to a APs and join a wireless network connection, computers and devices must be equipped with wireless network adapters.

b) Energy consumption: Wi-Fi provides service in business, organization, hotels, cafes etc. In recent years Wi-Fi connectivity is not limited to only such places but has been extended for residential buildings. The number of wireless devices has increased tremendously in the recent year. Due to rapid evolution of information as communication technology (ICT) energy consumption is also increasing at a high rate. Information communication technology equipment's also major amount of energy is consumed in the access network due to user equipment like VoIP, health monitoring, smart metering, security surveillance etc and their high per bit energy consumption. As such devices are not energy proportional that is they consume maximum amount of energy even if light traffic is there, need to provide continuous online presence. Also, straight forward techniques for sleeping during idle periods are not appropriate in this environment because of the continuous lightweight traffic.

The pressure on reduction of the energy consumption of ICT has become more and more prominent, because of the reason: Economic the total cost of ownership of network is increasing because of higher capacity network equipment are used and they are more power hungry and requires more cooling, as well as due to increasing energy prices.

II. LITERATURE SURVEY

Paper: Insomnia in the access or how to curb access network related energy consumption
Author: E. Goma, M. Canini, A. L. Toledo, N. Laoutaris, D. Kostic, P.Rodriguez, R.Stanojevic, and P. Y. Valentiend.
Description: Authors have proposed a method for greening residential Wi-Fi networks which takes a distributed approach and embeds intelligence in clients. They have also taken a look at the problem of greening access networks, identify root problem and propose practical solutions for users and ISP. To address this, Broadband Hitch-Hiking (BH2) is introduced, that takes use of the overlap of wireless networks to aggregate user traffic in as few gateways as possible. Which is the suggested approach dynamically aggregates user traffic on some access points hence put remaining to sleep.

Paper: Green WLANs: On-demand WLAN infrastructures.
Author: A. P. Jardosh, K. Papagiannaki, E. M. Belding, K. C. Almeroth, G. Iannaccone, and B.Vinnakota.
Description: Authors have suggested the method for greening enterprise Wi-Fi networks. This method is based on the adoption of resource on-demand wireless LAN strategies that can efficiently reduce energy consumption of a wireless LAN without adversely impacting the performance of clients in the network. RoD strategies power on or off wireless LAN access points dynamically, based on the volume and location of user

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demand. As a specific solution, a practical RoD strategy, called SEAR, is proposed. SEAR is a demand-driven RoD strategy for WLANs that efficiently manages wireless access points in high rate density wireless Local Area Networks and adheres to the design requirements. This proposed system includes description of resource management strategies for power conservation in WLANs and the impact of design choices, the design of a new policy-driven resources on demand strategy called SEAR. SEAR uses measurements to dynamically power on or off WLAN access points based on the location and volume of user demand, and manages user associations to ensure the complete coverage and sufficient bandwidth to the users.

Paper: CUBS: Coordinated upload bandwidth sharing in residential networks
Author: E. Tan, L. Guo, S. Chen, and X. Zhang.
Description: Author concluded that CUBS: Coordinated upload bandwidth sharing in residential networks as the energy savings schemes primarily rely on bandwidth from neighboring wireless gateways being pooled and shared across many users, authors has proposed CUBS to enable residential user to share available bandwidth of its neighbors in a coordinated manner.

Paper: Energy in ICT-trends and research directions.
Author: M. Pickavet.
Description: Author has suggested trends and research directions of energy savings in information and communication technology. These trends include improving energy efficiency of hardware components, better power management of devices and technologies, switching to new network paradigms and adapting policy supporting actions. This research concentrates on energy consumption of ICT during its use phase and does not focus on life cycle assessment which includes energy consumption during excavation, production, transport and end-of-life.

Paper: NAPman: Network-assisted power management for Wi-Fi devices.
Author: Rozner, V. Navda, R Ramjee, and S. Rayanchu.
Description: In this paper, authors have proposed NAP man, a system to minimize Wi- Fi energy consumption in mobile devices. Although Power Save Mode (PSM) is part of the Wi-Fi standard, the authors note that competing background traffic can adversely impact energy consumption. An energy aware fair scheduling algorithm is developed.

III. Approches to Reduce the Energy Consumption

These issues can be better addressed by using centralized approach rather than distributed approach. The system gives following specific contribution:

a) Architecture for reducing energy consumption in residential Wi-Fi networks is based on a centralized approach.
b) It addresses the fairness in energy savings, allowing heterogeneity amongst household's equipment and no client modification is required.
c) Algorithm is developed that maximize reduction of energy consumption and demonstrated on the performance of real traffic.

A. Centralized Approach

An ISP or a third party referred to as operator works as the central controller. This operator takes on the responsibility of reduction of energy consumption in residential Wi-Fi networks. The central controller runs the energy savings algorithm periodically to determine the set of access points that need to be on. As operator works as a controller for whole system.

- For reducing energy consumptions, migrations of clients are used, so as to aggregate user traffic on fewer APs and to minimize number of APs required to fulfill user requirements. The migration is also controlled by central controller.
- An Optimization algorithm determines the set of APs that need to be on so that other APs can be set to sleep mode. The operator runs this algorithm periodically and find out set of APs which should be on.
- The proposed system reduces the burden on clients. Clients only need to choose the greening service by ticking a box during signing up, hand over control of their AP to the operator, configure one new SSID on their client devices, and then use their devices as normal.

B. The Green Operator

A central controller takes on the responsibility of reduction in energy consumption of residential Wi-Fi networks which is called as green operator or sometimes operator. An ISP or a third party can work as an operator. This operator has control residential gateways or APs and takes decisions of states of APs. That is whether the APs are in awake state or in asleep state. This operator periodically runs the proposed algorithm and find out which APs should be on and its client association in order to perform all these functions operator need to install following capabilities at this APs:
1. Dual-SSIDs
2. Client monitoring
3. Radio management.

C. Set-and-Forget Approach

The proposed system reduces the burden on clients. Clients only need to choose the greening service by ticking a box during signing up, hand over control of their AP to the operator, configure one new SSID on their client devices, and then use their devices as normal.

IV. Existing System

The existing approaches for reducing energy consumption are based on are based on distributed approach which is not that much appropriate for residential Wi-Fi networks. But in such systems clients have the whole responsibility of reducing energy consumption in Wi-Fi networks hence all clients need to work together to aggregate user traffic on fewer access points thus remaining to sleep. If malicious clients are there in

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network, the whole system falls apart. It also requires complex client side machinery.

Other greening approaches are proposed for enterprise energy savings rather than residential areas. But any such system faces several barriers such as heterogeneity amongst households in Wi-Fi security settings, ISP connectivity, IP ranges etc. The solution is not specific to client platform or operating system and has to protect user experience. It is not directly converted into residential setting as it does not properly address fairness related issues.

While it is conceivable that future new enhancements of home gateways will implement sleep-on-idle (SoI) capability, this will show that it is ineffective when the household has devices that generate continuous light traffic. A typical household devices today is estimated to have between 3 and 8 wireless devices, and this number is estimated to grow 15 within a few years

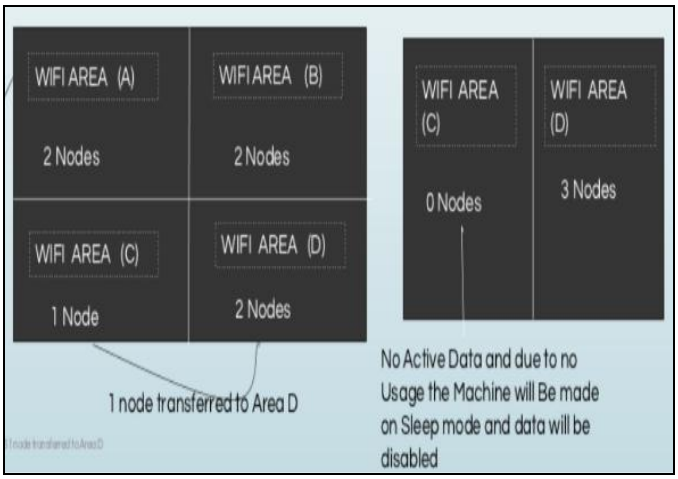

Fig. 1. Existing system

V. PROPOSED SYSTEM

The proposed system includes an algorithm and a methodology for reducing energy consumption of residential Wi-Fi networks using a centralized approach which will address fairness related issues and minimize the burden on users. The work includes investigate the feasibility of reducing the combined Energy footprint of home gateways by pooling their wireless resources and dynamically aggregate the user traffic on to a subset of gateways. The centralized entity could be an Internet Service Provider or any over the top third party. Centralization comes with the benefit of realizing optimal or near optimal solution more easily.

A. *Description of the Architecture*

The system is a Three-tier architecture having User, web-services, local and main server respectively.

User: User can be any android user who will be using the Wi-Fi network at residential areas.

Local server: The duty of the local server is to maintain the details of user (basic details, verification, authentication and communication between the user and main server)

Main server: The main server is used to store the user details, the required data by the user,

Web services: Web services is the mediator between the internet and user software without the presence LAN.

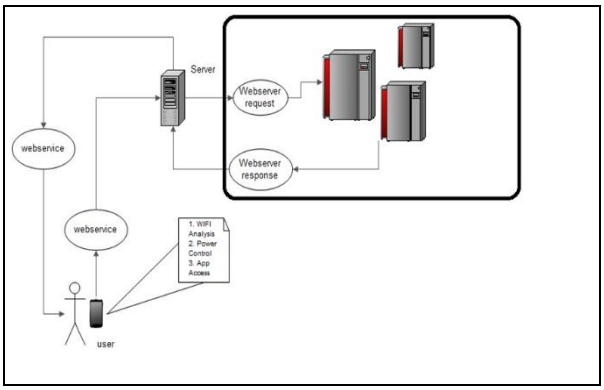

Fig. 2. System architecture

VI. ALGORITHM

A. *To Find Active Node (Heuristic Algorithm)*

The algorithm takes as input these to f clients U and their data rates for each AP_j. It also has set of visible clients S_j to each AP and weight *Wj*. A temporary variable X is taken to keep track of these to f clients that are not yet covered and it is initialized to all set of clients in the beginning.

1. To store the selected APs, a variable I is taken which is initially null.
2. The algorithm operates in a loop till all clients are covered, i.e. X=ϕ in step 2.
3. In each iteration, the A_j which has the maximum ratio of unconnected clients is selected in step 3.
4. This AP is added to the set I of selected APs and the clients S_j it covers are removed from X in step 4.
5. The set of active APs I is output in step 5.

The best set of APs to be turned on, so as to reduce energy consumption.

B. *RC5 Algorithm*

The RC5 algorithm consists of three components a key expansion algorithm, an encryption algorithm and a decryption algorithm. The plaintext input to RC5consists of two w bit words in which we denote A and B. Recall also that RC5 uses an expanded key table $[S...t-1]$ consisting of $t=2(r+1)w$ bit words. The key expansion algorithm initializes S from the user's given secret key parameter K. (We note that the Stable in RC5 encryption is not an S-box such assisted by DES RC5 uses the entries in S sequentially one at a time.)

a. Encryption Algorithm: We assume that the input block is given in two w bit registers A and B. We also assume that key -expansion has already been performed, so that the array $[S...t-1]$ has been computed. Here is the encryption algorithm in pseudo code:

A=A+S[0];
B=B+S[1];
for i=1 to r do
*A=((A⊕B)⋘B)+S[2*i];*
*B=((B⊕A)⋘A)+S[2*i+ 1];*

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The output is in the registers A and B .We note the exceptional simplicity of this 5 line algorithm. We also note that eachRC5 round up dates both registers A and B whereas a round in DES updates only half of its registers. An RC5half-round one of the assignment statements up dating A or B in the body of the loop above is thus perhaps more analogous to a DES.

b. *Decryption Algorithm*: The decryption routine is easily derived from the encryption.

for i=r downto 1 do
*B=((B-S[2*i+1])⋙A)⊕A;*
*A=((A-S[2*i]⋙B)⊕B;*
B=B-S[1];
A=A-S[0];

Key-expansion routine expands the user's secret key K to all the expanded key array S, so that S resembles an array of $t = 2(r+1)w$ random binary words determined by K. The key expansion algorithm uses two "magic constants" and consists of three simple algorithmic parts:

1. Converting the Secret Key from Bytes to Words.
2. Initializing the Array S.
3. Mixing the Secret key.

VII. RESULTS

The proposed system is basically depend on data transmission from neighboring remote portals being pooled and shared over the clients, we Centralized control and AP coordination. Unified control has been efficiently utilized in big business WLANs for Bandwidth Distribution or utilization. We build up a system for moderating covered up or uncovered terminal obstruction in big business WLANs. It is appeared to enhance the execution of the system significantly because of enhanced use of the remote medium. Much like our plan, the centralization usefulness is executed in a solitary focal server. In our framework we have characterized this limit is set to Bandwidth Utilization and is 50 kb/s, the calculation is mitigates all the fundamental viewpoints, since no movements are allowed, this permits APs to rest just on the off chance that they have no customers associated, i.e., compares to consider unmoving ability. As for our test situation,the vitality reserve funds with SoI (Sleep on Idle) are around 60 to 66 percent in a week.

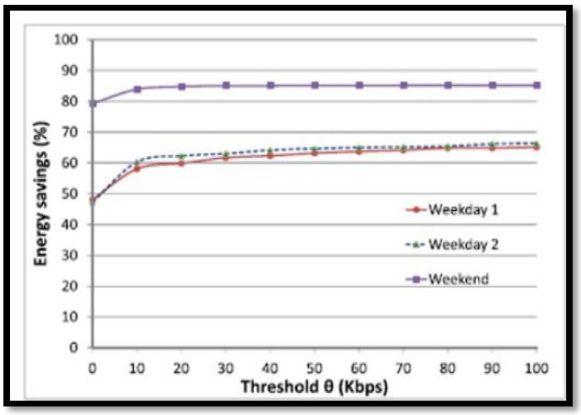

Fig. 3. Shows the energy saving comparison

It emerges on account of the customers to APs in this exhibition show use in look time just; the SoI investment funds are prone to be much lower in the private setting wherein most homes will have dependably on gadgets, for example, sensors, human services screens, and so forth. As the limit builds, customers can be relocated all the more openly to total them at a littler number of APs to permit more prominent vitality investment funds. The force reserve funds turn out to be more critical while considering regular use designs.

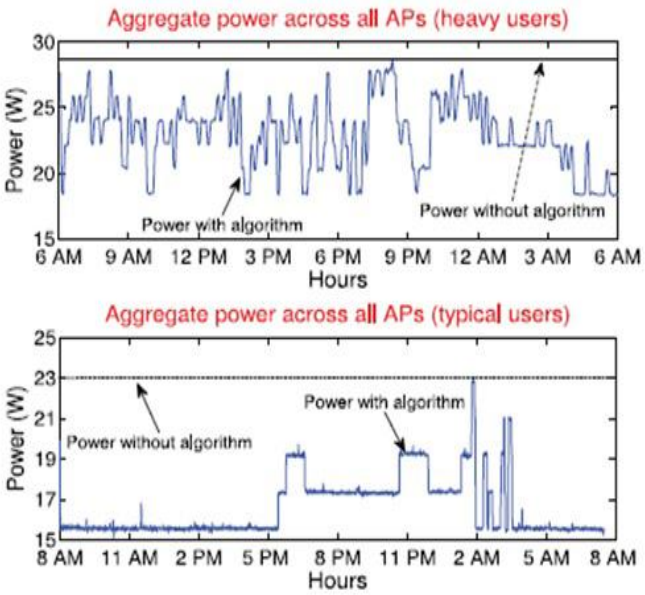

Fig. 4. Average aggregate power consumption of the Aps

VIII. ADVANATAGES

1. Reduces the burden on users: As centralized approach is used in proposed system, it reduces the burden on users to participate in reduction of energy consumption.
2. Address fairness related issues: As data costs of guest client downloads are shared equally amongst all APs, user fairness is maintained.
3. Allows heterogeneity amongst clients.
4. No client modification required.
5. Suitable for large scale deployment as it reduces energy consumption with minimal impact on user performance.

IX. DISADVANTGES

Do not directly address the problem of coverage black holes: The home or residential gateways have the capability of remote management. The operator turns the radio on or off remotely for reducing energy consumption. During the process of turning off a set of APs, radio creates a coverage black holes. If a new client reaches to this particular AP, the client sees no network to connect to.

X. CONCLUSION

The proposed system gives solution architecture for reducing energy consumption in residential Wi-Fi networks. This architecture is also applicable for large scale system as it provides centralized approach for energy savings. A central

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operator works as a controller hence reducing the burden on users. The system aggregates users onto some Wi-Fi access points and put remaining to sleep to reduce energy savings. It works across heterogeneous ISPs and clients, and allows for fairness in energy savings. An algorithm is developed to find best set of APs that should be on at any given time interval. It also gives association of clients with selected APs. The algorithm shows tradeoff between energy savings and session disruption using campus Wi-Fi traces.

XI. Future Scope

In the future, the capability of gateways can be enhanced so that gateways will have sleep-on idle and remote wake-up capability. Due to this enhancement the entire gateway can be put to sleep and wake up and greater energy savings can be achieved. Also the revised algorithm can be developed to overcome the problem of coverage black holes.

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