Wireless Networks for Agriculture *

Using WhatsApp to learn Farm operations and Provision Network Resources †

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ABSTRACT

Farming forms the backbone of agricultural production and are essential to meet the hunger needs in the face of a changing climate and fast depletion of our natural resources. It also provides the employment to the smallholder farmers to improve their social welfare. The motivation behind this project is to integrate technology in agriculture for better productivity and help smallholder farmers integrate precision agriculture and management of operations in their daily tasks. We have approached this method by analyzing the WhatsApp chats of the farmers for the past one year and preprocess their conversations by creating a parser which generates graphs based on three metrics alpha, beta and gamma, introduced later in the sections. We have inferred from these graphs about their activities over space, time and team members and the amount of network and Access Points(APs) required to collect the data for future purposes and help them understand the best suitable agriculture methods for particular areas.

CCS CONCEPTS

Networks → Network reliability, Prediction, farm operation analysis, farm operations reconstruction, WhatsApp Chat Analysis

KEYWORDS

SmallHolder farms, Precision Agriculture, data analytics, metrics

ACM Reference format:

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1 INTRODUCTION

In the last decade, there has been an intense change in the climatic conditions, increase in poverty and hunger. Due to the increasing population the resources have been fast depleting. There is an ever-increasing need of agriculture for the efficient use of resources to eradicate hunger and also save the environment. The small holder farms are the backbone of agriculture, but they have limited resources especially in the sector of Networks. According to the sources from UN, there are 500 million family farms around the world, representing up to 80 percent of all farms in many countries. Farms in the United States tend to be much larger and are operated differently than smallholder family farms in developing countries. Such an increased demand requires better facility and resources in terms of wireless networks to collect their data in order to perform task management and precision agriculture. Precision agriculture is the cyclic activity of performing data collection, data analysis, data evaluation and decision making.

Our work can be used as the data analytics for the previously proposed novel approach [1], where after collecting the data from WhatsApp chats the parser can generate graphs based on the locations and the keywords used by the farmers related to their daily farming operations. The parser will also help in calculating the metrics (i) α is occupancy over time given by frequency at time t / all-time frequency (ii) β is the occupancy over team members given by number of participants/total frequency of keywords and (iii) γ is the occupancy over space given by number of places where the keyword is mentioned. From these metrics we have inferred the amount of APs required at a particular location for a given time and load of the participants. The previous work [1] proposed the data analytics methods. As mentioned in the paper [1], to enable robust knowledge discovery from noisy and sparse sensor measurements and to employ them for analytic tasks such as anomaly detection, root cause analysis, historical trend detection and prediction based on statistical data-driven models and simulation which have been implemented in this paper. Using trend-based detections and analysis Our work is for two of the farming operations Dairy and tillage, but the parser can be extended for other farming operations and related keywords.

2 RELATED WORK

There has been related work for wireless sensor networks and precision agriculture. Ojha et al. [2] have proposed the analysis of current state of the art wireless sensor networks their technologies, standards and hardware. They have also discussed problems and prospects of the current frameworks, identifying the factors for improvement. Marino et al [3] have also proposed the need for biological models based on data acquisition and radios used for collecting the data for better viticulture applications. Their approach is limited to the biological aspect of the agriculture. Sahitya et al [4] have also proposed a novel approach Zigbee for making precise decision about smart agriculture as mentioned in

[4], This design uses arduino as the core component. Here we are designing a sensor network; each node has a group of sensors connected to the arduino and Zigbee (Xbee). The values which are measured by the sensors are transmitted to a centralized device which is Zigbee (Co-ordinator). Bencini et al [5] have proposed a novel approach for precision agriculture based on the data collected by the Global Positioning System.

Our approach is more focused on their informal daily conversations on WhatsApp which highlight the trivial issues and every day operations throughout the year. The chat is really noisy and random, but it does help in inferring their needs and conversations about certain farming operations. We have also calculated the metrices which will help in infer the number of APs required to setup at a particular location or time.

3 DESIGN AND IMPLEMENTATION

3.1 Data Collection

The data we have used for our data-driven project is the WhatsApp chat of the farmers for the past one year. We have mainly focused on the two farming operations Dairy and Tillage. The WhatsApp chats are mainly group chats among the farmers/team members about their day to day activities given to us by Professor Mariya Zheleva. There are separate groups for Dairy and Tillage. The group chat about dairy goes by the name Dairy team and the group chat about tillage goes by the name Essex Fam loop mark. An instance of each group chat can be seen in Fig 1 and Fig 2

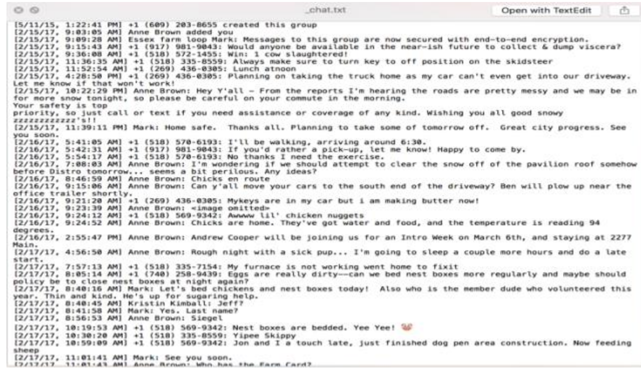
```
_chat.txt                                              Open with TextEdit
[4/21/17, 7:25:54 AM] Anne Brown: Going for no limits for Dairy on the NYC Order form this week. Let me know if you
think that is a problem!
[4/21/17, 7:53:57 AM] +1 (518) 570-6193: No problem as far as I can tell.
[4/21/17, 7:55:14 AM] Meghan Brooks: It looks like we will have 3, potentially 4 intro shares this week. Not sure if
that will make a big difference in quantities
[4/21/17, 7:56:25 AM] Anne Brown: Wowza, ok, thanks Barbara & Meghan!
[4/21/17, 9:12:55 AM] +1 (917) 981-9043: For Kristin: I just checked w/ Phil and it turns out it makes more sense for
Thurs night jarred milk to go in the front of trailer 4, rather than the back
[4/21/17, 9:13:59 AM] +1 (917) 981-9043: Re) glass inventory: not sure who's on this, but FYI that I used 5 new cases
of half gallons today, leaving 22 total unopened cases half gallons
[4/21/17, 9:14:11 AM] +1 (917) 981-9043: 69 hg jarred this morning
[4/21/17, 9:16:58 AM] Kristin Kimball: Got it thanks Anya and Phil
[4/21/17, 2:14:26 PM] +1 (760) 877-2402: Currently in distro:
Milk: 128
BM: 38
Yogurt: 50Qt 32Pt
Skim: 16
SC: 11pt 72hp
Butter: 41pt 99hp
[4/21/17, 4:58:59 PM] +1 (770) 876-2201: Kimber got her head stuck in a hay feeder for the second time in a month give
or take.
[4/21/17, 5:48:54 PM] Mark: Let's see where she got it stuck if there's anything we can do to change that opening and
let's make sure to lift up the hay feeders once a week so that they don't get too low.
[4/22/17, 5:29:55 PM] +1 (518) 572-1455: Didn't see a left over bedding core in dairy this aft...
[4/22/17, 6:01:45 PM] Mark: On it.
[4/23/17, 8:39:15 AM] +1 (518) 570-6193: Sunday's yogurt went in @8:30, forgot to take the temp of the last jar but am
confident it was above 100 degrees. Incubator at 100.8. Mark/Kristin, can you unplug etc around 7pm? Tks.
The batch was 41 quarts and five pints. I'm planning to make 84+ quarts tomorrow and that should last us until I get
back.
[4/23/17, 9:40:17 AM] Mark: I will unplug it tonight at 7 PM thank you Barbara
[4/23/17, 5:38:13 PM] Mark: Why are dairy cows licking wooden posts? Any ideas Ben?
[4/23/17, 7:53:27 PM] +1 (518) 335-7154: No not right off top of my head
[4/23/17, 7:57:29 PM] Mark: Yogurts are opened and look good
[4/24/17, 5:45:44 AM] +1 (770) 876-2201: Do I need to save milk for lambs?
[4/24/17, 6:30:00 AM] Kristin Kimball: If you did that's great if not this evening is fine
[4/24/17, 6:51:36 AM] Anne Brown: I imagine you guys are on top of this, but the Farm Store is out of milk so it'd be
great if more could be jarred this morning.
[4/24/17, 6:55:54 AM] +1 (518) 570-6193: On top. Coming soon to a store near you.
[4/24/17, 6:56:54 AM] Anne Brown: Sweet, thanks Barbara!!
[4/24/17, 9:05:21 AM] +1 (518) 570-6193: Yogurt in @9:03. Last jar 98.0
[4/24/17, 9:07:04 AM] +1 (518) 570-6193: Should be unplugged around 7pm. Mark or Kristin, are you up for it?!  I can't
do it, I'll be in Denver.
[4/24/17, 9:14:03 AM] Mark: On it
[4/24/17, 4:13:32 PM] Meghan Brooks: NYC:
6 skim quarts
10 skim hg
10 cream hp
```

Figure 1 WhatsApp group chat for Dairy

Each group chat shows the farmers/team members involved and the content about the related farm operations. Through our parser, we have also calculated the volume of team members for each operation.

3.2 Data Characteristics

As mentioned previously, the main location in concern is the small farm which can further be divided into different sub locations such as barn, milk house, hub, willow etc. In this paper we have focused on two farm operations Dairy and Tillage. The sub locations we inferred from the WhatsApp group chats for Dairy are barn,



```
_chat.txt                                              Open with TextEdit
[5/11/15, 1:22:41 PM] +1 (609) 203-8655 created this group
[2/15/17, 9:03:05 AM] Anne Brown added you
[2/15/17, 9:09:28 AM] Essex farm loop Mark: Messages to this group are now secured with end-to-end encryption.
[2/15/17, 9:15:43 AM] +1 (917) 981-9043: Would anyone be available in the near-ish future to collect & dump viscera?
[2/15/17, 9:36:08 AM] +1 (518) 572-1455: Win: 1 cow slaughtered!
[2/15/17, 11:36:35 AM] +1 (518) 335-8559: Always make sure to turn key to off position on the skidsteer
[2/15/17, 11:52:54 AM] +1 (269) 436-0305: Lunch atnoon
[2/15/17, 4:28:50 PM] +1 (269) 436-0305: Planning on taking the truck home as my car can't even get into our driveway.
Let me know if that won't work!
[2/15/17, 10:22:29 PM] Anne Brown: Hey Y'all - From the reports I'm hearing the roads are pretty messy and we may be in
for more snow tonight, so please be careful on your commute in the morning.
Your safety is top
priority, so just call or text if you need assistance or coverage of any kind. Wishing you all good snowy
zzzzzzzzzzzz's!!
[2/15/17, 11:39:11 PM] Mark: Home safe.  Thanks all. Planning to take some of tomorrow off.  Great city progress. See
you soon.
[2/16/17, 5:41:05 AM] +1 (518) 570-6193: I'll be walking, arriving around 6:30.
[2/16/17, 5:42:31 AM] +1 (917) 981-9043: If you'd rather a pick-up, let me know! Happy to come by.
[2/16/17, 5:54:17 AM] +1 (518) 570-6193: No thanks I need the exercise.
[2/16/17, 7:08:03 AM] Anne Brown: I'm wondering if we should attempt to clear the snow off of the pavilion roof somehow
before Distro tomorrow... seems a bit perilous. Any ideas?
[2/16/17, 8:46:59 AM] Anne Brown: Chicks en route
[2/16/17, 9:15:06 AM] Anne Brown: Can y'all move your cars to the south end of the driveway? Ben will plow up near the
office trailer shortly.
[2/16/17, 9:21:20 AM] +1 (269) 436-0305: Mykeys are in my car but i am making butter now!
[2/16/17, 9:23:39 AM] Anne Brown: <image omitted>
[2/16/17, 9:24:12 AM] +1 (518) 569-9342: Awwww lil' chicken nuggets
[2/16/17, 9:24:52 AM] Anne Brown: Chicks are home. They've got water and food, and the temperature is reading 94
degrees.
[2/16/17, 2:55:47 PM] Anne Brown: Andrew Cooper will be joining us for an Intro Week on March 6th, and staying at 2277
Main.
[2/17/17, 4:56:50 AM] Anne Brown: Rough night with a sick pup... I'm going to sleep a couple more hours and do a late
start.
[2/17/17, 7:57:13 AM] +1 (518) 335-7154: My furnace is not working went home to fixit
[2/17/17, 8:05:14 AM] +1 (740) 258-9439: Eggs are really dirty--can we bed nest boxes more regularly and maybe should
policy be to close nest boxes at night again?
[2/17/17, 8:40:16 AM] Mark: Let's bed chickens and nest boxes today!  Also who is the member dude who volunteered this
year. Thin and kind. He's up for sugaring help.
[2/17/17, 8:40:45 AM] Kristin Kimball: Jeff?
[2/17/17, 8:41:58 AM] Mark: Yes. Last name?
[2/17/17, 8:56:53 AM] Anne Brown: Siegel
[2/17/17, 10:19:53 AM] +1 (518) 569-9342: Nest boxes are bedded. Yee Yee!
[2/17/17, 10:30:20 AM] +1 (518) 335-8559: Yipee Skippy
[2/17/17, 10:59:09 AM] +1 (518) 569-9342: Jon and I a touch late, just finished dog pen area construction. Now feeding
sheep
[2/17/17, 11:01:41 AM] Mark: See you soon.
[2/17/17, 11:01:43 AM] Anne Brown: Who has the Farm Card?
```

Figure 2 WhatsApp group chat for Tillage

basement, bay, hub, pedestal, solar, playground incubator and farm. Similarly, the sub locations for Tillage are Black Kettle, Purple Palace, Windy Willow, hub, office, pavilion, barn ADK and drainage. These locations are related to the farm operations in considerations and the most talked about by farmers. In order to achieve our goal, we inferred the workload (over space, time and team members) for these locations and describe the metrices for provisioning network resources, thus relating to the cruciality of the data and locations.

The data given to us was in the form of .txt files having each message of the farmer comprising date and time followed by the sender and the text message. The duration of the Group chat for Dairy is from October 22, 2015 till March 8, 2018 with users being the farmers on the farm. Similarly, the duration of the WhatsApp Group chat Tillage is from May 11, 2015 till March 3 2018 for over an year.

The characteristics we have captured from the data are the text of the messages sent by farmers which helped in creating the Dairy and tillage wise threads. Lastly, we inferred the frequency of operations over space, time and team members which helped in generating the metrics described in Section 3.3.

A tradeoff of our analysis is that initially, we designed the graphs as frequency of the operations and keywords (such as dairy, milk, skim, harvest, weed etc) over time but it did not give any significant results for the analysis. So, we designed the metrics detailed in Section 3.3 which are collectively based on frequency over time, space and team members which better helped in understanding the analysis and provision network resources.

Although, an additional data such as Trello boards which the farmers use for task management might have helped in fetching the locations and operations in a proper manner. Nevertheless, we were able to retrieve the farm locations and operations by reading the WhatsApp group chats of the farmers.

3.3 Implementation and Methodology

Our methodology for analyzing the data and operations was based on trend detection and frequency. To begin with, we developed a parser for analyzing and breaking down the WhatsApp group chats to fetch the volume of users/farmers, the locations and the most frequent keywords related to the farming operations. We have used the python library regex to fetch the date, sender and text. After fetching the information, we have created threads for the specific operations calculating the frequencies or occurrences of the operations over space, time and team members.

Supporting our methodology of trend detection, we have defined the novel analysis of our data using the time series graphs on a Monthly, weekly and daily basis. We have also designed the metrics based on these graphs for provisioning the network resources. The graphs are based on the frequency or occurrences of the operations over the time period of monthly, weekly or daily. The X-axis of the graphs represent the time as month, week and days and the Y-axis of the graphs represent the frequency. Based on these graphs we have designed the metrics as follows:

(i) α is occupancy over time given by frequency at time t / all-time frequency. Since α is normalized frequency over time, the higher the value, the more we need the network resources. (ii) β is the occupancy over team members given by number of participants/total frequency of keywords. Since the number of team members for a task is fixed, the lower the β goes, the more we need network resources and (iii) γ is the occupancy over space given by number of places where the keyword is mentioned. The higher value of the γ suggests that we need more network resources for that location. We have developed a python code for parsing the chats and generate graphs and metrices which can be used as a framework for future purposes and analyze other farm operations for network resources.

4 EVALUATION RESULTS

As this is a data driven project, we have generated graphs on a Monthly, weekly, daily and hourly basis and also the metrics (as discussed in Section 3.3) using our parser. The graphs are frequency over time. We have used the graphs generated on the monthly basis for our analysis. We have also plotted the graphs for α, β, γ. As mentioned above, the α is the frequency at a time t over the all-time frequency and normalized over time. The β is occupancy of the team members given by participants over total frequency of keywords. The γ is the given number of locations. The

Monthly graphs for Dairy can be seen as follows (Fig 3 and Fig 4).

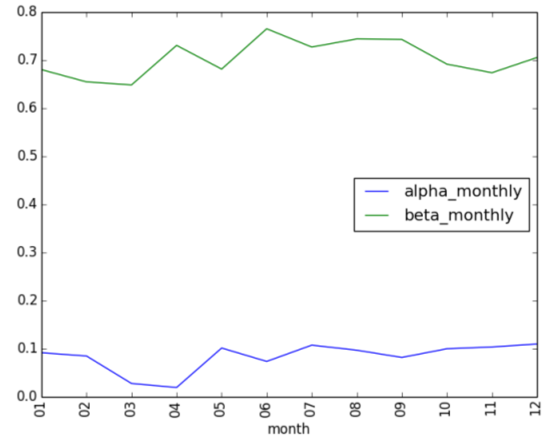


Figure 3 Monthly Graph and metrics α, β for Dairy

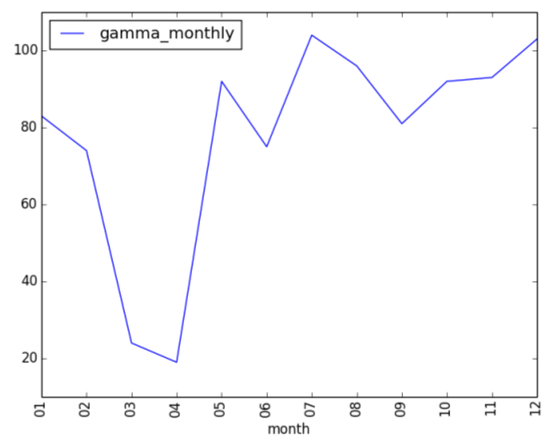


Figure 4 Monthly Graph and metrics for γ Dairy

From these graphs, we can infer that for the Month 5 i.e. May α is increasing and β is decreasing. And the steep increase in the value of γ validates that there is an increased need of network resources for the month of May. Similarly, we can see the graphs for Tillage as follows (Fig 5 and Fig 6). From these graphs, we can infer that there is an increase in the value for the month of May, but it is not as high as dairy, so we do need network resources, but they can be sparse. Looking at the, values of these metrics and graphs. Both the farm operations have hikes in the metrics, but the Dairy operation has a higher increase as compared to the Tillage. We can finally infer that we need more concentrated network resources for the operation Dairy and less for the operation Tillage.

Due to the volume of the graphs for weekly and daily basis, we have not included them in the paper

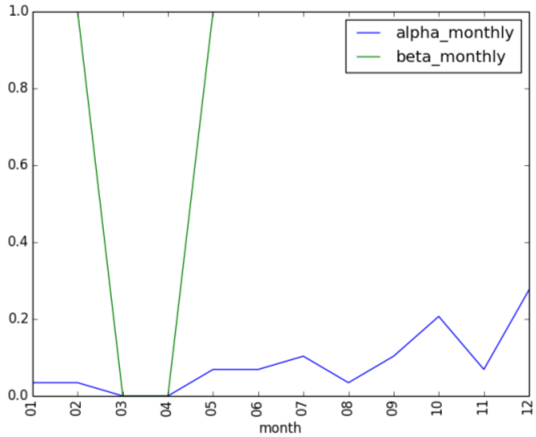


Figure 5 Monthly graph for Tillage and metrics α, β

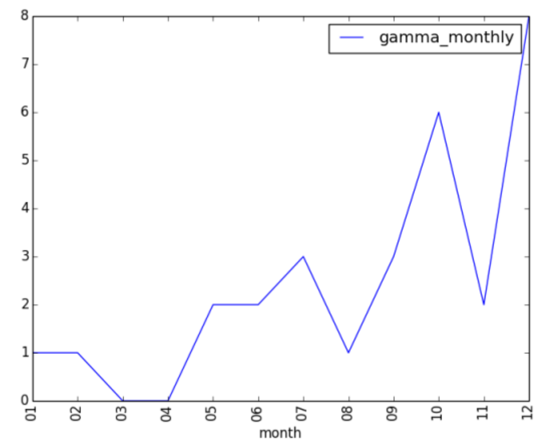


Figure 6 Monthly graph for Tillage and metrics γ

The analysis can further be extended as per need and network resources can be calculated (Fig 7)

```
if __name__ == '__main__':
    dairy_words = ['dairy', 'milk', 'butter','skim','grazing','grass','pigs','pig','cows','cow']
    dairy_places = ['barn','basement','bay','hub','pedestal','solar','playground','incubator','farm store','fence',
                    'milk house','milkhouse']
    tillage_places = ['Black Kettle','Purple Palace','Windy Willow','hub','office','pavilion','barn','ADK','drainage']
    tillage_words = ['harvest','weed','transplant']
    create_graph(dairy_words,dairy_places)
    create_graph(tillage_words,tillage_places)
```

Figure 7 Framework for generating graphs and metrics

The Lessons we have learnt are that even though we see clear patterns of farming operations. All operations have different loads throughout the year and hence some of the farm locations can be prioritized over the other for network resources.

5 CONCLUSION

In this paper, we have analyzed the WhatsApp chats amongst the farmers of a small holder farm and analyzed their farming operations to provision network resources. We implemented a framework for parsing the chats, generating graphs of frequency over time, space and team members and the related metrics. Our work can be extended in future to answer the questions about precision agriculture and provision network resources for other farming operations.

6 CONTRIBUTIONS

Both the team members have participated equally in implementation, research, design and writing the report by following the agile methodology of software prototyping.

A HEADINGS IN APPENDICES

The rules about hierarchical headings discussed above for the body of the article are di.erent in the appendices. In the appendix environment, the command section is used to indicate the start of each Appendix, with alphabetic order designation (i.e., the first is A, the second B, etc.) and a title (if you include one). So, if you need hierarchical structure within an Appendix, start with subsection as the highest level. Here is an outline of the body of this document in Appendix-appropriate form:

A.1 Introduction

A.2 Related Work

A.3 Design and Implementation

A.3.1 Data Collection

A.3.2 Data Characteristics

A.3.3 Implementation and methodology

A.4 Evaluation Results

A.5 Conclusion

A.6 Contributions

A.7 References

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