OPPORTUNITIES & CHALLENGES IN UTILIZING INTERNET OF THINGS IN PUBLIC TRANSPORT – A RESEARCH STUDY

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ABSTRACT

Research under the title "Opportunities & Challenges in utilizing Internet of Things in Public Transport" was undertaken with the objectives of studying the current advancements in Internet of Things (IoT) technologies for Public Transport System (PTS), studying the current scenario of IoT usage in Public Transport Management, taking inventory of prevailing technologies for Public Transport Management, studying the opportunities and challenges in the application of IoT in Public Transportation System (PTS), and suggesting a comprehensive model using the available IOTs for Public Transport Management in Smart Cities. Two sets of respondents were identified for the collection of primary data. A cross-validation method of study was used. First, responses were collected from the public transport service suppliers, Depot Managers, and Bus Drivers. Ten such staff members, 7 managers and 3 drivers, were interviewed.Their responses were collated and analyzed. They were then cross-validated from the public transport service users, that is, the daily commuters from the two smart cities of Pune and Ahmedabad. Before a full-fledged study was undertaken, a pilot study was carried on a sample size of 40 commuters each from Pune and Ahmedabad. This paper presents the results of the pilot study.

Keywords: *Internet of Things, Public Transport System, Smart Cities*

Introduction

This work discusses Opportunities & Challenges in utilizing the Internet of Things in Public Transport (Buses) in the Indian smart cities of Pune and Ahmedabad. Internet of Things (IoT) is a dynamic technology-based describing the network of multiple physical objects (things) that are embedded with sensors through software and other technologies to integrate and exchange data with the other devices and systems over the Internet. The state of Indian roads and public transport system is notoriously known for several problems, including pollution. The following image aptly tells the entire story. A big structure looks like in the background in the Indian capital thanks to dense toxic smog from October to December.

Figure 1: The dense toxic smog in Delhi during October-December
(Source: New York Times, 2017)

Indian cities are now shaping-up as smart cities, and one can expect that there will be a robust development in the public transport system. This study looks into the application of the internet of things in this area. What are the opportunities and challenges for applying the internet of things in the public transport system is the central research question of the study. Following objectives have been set for the study:

1. To study the current advancements in IoT technologies for Public Transport,
2. To study the current scenario of IoT usage in Public Transport Management,
3. To take inventory of prevailing technologies for Public Transport Management,
4. To study the opportunities and challenges in the application of IoT in PTS, and
5. To suggest a comprehensive model using the available IOTs for Public Transport Management in Smart Cities.

Before a full-fledged study was undertaken, a pilot study was carried on a sample size of 40 commuters each from Pune and Ahmedabad. This paper presents the results of the pilot study.
The pilot study aimed at achieving the following objectives:

1. To get practical experience of likely issues in data collection
2. To check the actual use of the questionnaire
3. To test the hypotheses as per the research methodology
4. To test validity and reliability of questionnaire prepared from the primary data collected

Literature Review

Public transport plays a vital role in decreasing private vehicles' utilization by the populace, which will ultimately decrease traffic overcrowding, pollution, and consumption of fossil fuel. The study offers a summary of these algorithms. It also classifies current problems which need to be resolved (Patel et al., 2019). The public transportation system (PTS) in a metropolitan city is an active, intricate, and nonlinear system. Handling and offering appropriate public transportation services is tough. The study offers an Internet of Things-based intelligent PTS (IoT-IPTS) in a metropolitan city. The software-defined network is used to empower the cloud computing and EI network to communicate the commuters' public transportation services (Chavhan et al., 2019). With the IoT development, applications have become cleverer, and linked devices give upsurge to their manipulation in all features of a contemporary city. Moreover, route optimization, parking, and accident detection tend to be the most prevalent ITS applications among scholars (Zantalis et al., 2019). The new Internet of Things/Everything (IoT/IoE) model and architecture permits one to reconsider the method Smart City set-ups are designed and managed, but on the other hand, various issues need to be solved. The review study comprises numerous constructing blocks of the IoT platform, which validate that a supple and dynamic arrangement is possible, supporting safety, security, local, cloud, and mixed solutions (Badii et al., 2019). Internet of Things (IoT) is swiftly rising and contributing severely to enhance the quality of life. The study offers a summary of the accepted reviews in the Special Issue on IoT OS management: chances, challenges, and solutions (Zikria et al., 2019). Transportation and logistics administration play an essential role in the growth of a nation. The study offers two real-life IoT and Blockchain-based reviews to highlight IoT and Blockchain's involvement in logistics and transportation (Humayun et al., 2020). Intelligent Transportation Systems (ITS) focus on incorporating detecting, regulate, analyzing, and communication technologies into travel infrastructure and transportation to enhance mobility, ease, security, and efficacy. The study highlights upcoming study paths to create ITS safer, protected, and privacy-preserving (Hahn et al., 2019). The chief challenges experiencing the 21st-century world demand disruptive technology-based resolutions. The study uses the best opinions of 100s of scholars from 3 administrations concentrating on quickening IoT TSS road mapping efforts (Islam et al., 2020).
A study considering views of both the suppliers of public transport and its users in the context of a smart city is not on record. It is felt that such a study will help provide useful insights to policy-makers for making most of the opportunities of the internet of things in the public transport system and understanding the challenges in doing so.

Methodology

A cross-validation method of study was used. First, responses were collected from the public transport service suppliers, Depot Managers, and Bus Drivers by way of following questions:

1. What are the problems with existing technologies for Public Transport Management including those related to repair time of buses, breakdown time?
2. What are the opportunities in the application of IOT in PTS and can they address issues like repairs and breakdowns?
3. What are the challenges in the application of IOT in PTS?
4. What are the suggestions for developing a comprehensive model using the available IOTs for Public Transport Management in Smart Cities?
5. What are your views about things like SMART BOARDS (L&T) that are used at places like Delhi?

Ten such managers (seven) and drivers (three) were interviewed. Their responses were collated and analyzed. They were then cross-validated from the public transport service users, that is, the daily commuters from the two smart cities of Pune and Ahmedabad.

Sample

For the pilot study, the sample size was fixed at 10% of the main study sample size, that is, of 40 respondents each from the smart cities of Pune and Ahmedabad. The sample size for the main study was taken as 400 commuters each from Pune and Ahmedabad, considering a large population and using a 95% confidence level and 5% confidence interval (Krejcie and Morgan, 1970).

Instrument for survey

In line with the hypothesis, the questionnaire was divided into the following parts:

- Profile
- Problems with existing technologies
- Opportunities for IoT in PTS
- Challenges for the use of IoT in PTS
- Proposed Model using IoT

The structure of the questionnaire was kept simple by framing questions /statements/ factors as questions.

Based on the responses from the ten Depot Managers (seven) and Drivers (three) and also with some inputs from Literature Review, the following factors were used under the four main sections:

I. Problems with existing technologies

1. Heavy traffic
2. High pollution
3. Roadway congestion
4. High commute and waiting hours
5. No concrete timings for buses
6. Traffic accidents
7. Lack of planning
8. Lack of coordination
9. Less use of technology
10. Technologies are outdated

II. Opportunities for IoT in PTS

1. Lower commute time and waiting time.
2. Real-time status information to commuters.
3. Commuters can know the exact Estimated Time of Arrival (ETA) for their buses.
4. Commuters can also know if buses and trains are filled or empty.
5. Commuters can know the number of people waiting at the bus stop.
6. Preventive maintenance leading to lower breakdown instances
7. Better planning of transport routes
8. Plan new transit routes and start new bus services
9. Minimizing traffic as more number of people prefer public transport
10. Minimizing pollution

III. Challenges for use of IoT in PTS

1. Higher operational or running costs
2. Lack of investments by the private sector
3. Lack of technical knowledge among the planners
4. Lack of access to technology
5. Privacy and security issues
6. System failure issues
7. Lack of integration of IT networks
8. Internet connectivity
9. Lack of IT infrastructure
10. Lack of standardization

IV. Proposed Model using IoT

1. Passenger information systems such as smart boards by L & T
2. Smart cards and integrated ticketing
3. Real time parking management

4. Automated speed enforcement
5. Electronic toll collection
6. Vehicle control technologies
7. Cybersecurity of traffic systems
8. Connected cars (A connected car has its connection to the internet)
9. Bus Stand Surveillance and Safety equipment
10. Use of RFID technology

Responses were sought by way of rating the various statements on 5-point Likert Scales of Agreement/Disagreement.

The questionnaire was tested for validity and reliability as under:

Test of validity –The hypotheses, hypotheses testing method, questionnaire, etc., were validated by the Guide and other experts in the field to ensure that the measurement was adequate and accurate in terms of the desired direction.

A check-list as prescribed by Collingridge et al. (2015) was applied for validation as under:

Table 1: Application of Collingridge check-list for validation

Step No.	Step	Action
1	Establish Face Validity	The questionnaire was validated for face validity by guide and group of experts.
2	Clean Collected Data	The mechanism of collecting data ensured that there was no invalid entry because there was no manual entry that was to be done. Responses were to be selected from the pop-up menu selection.
3	Use Principal Components Analysis (PCA)	As there were not many variables under consideration PCA was not used.
4	Check Internal Consistency	This was done through Cronbach's Alpha

Test of reliability – Cronbach's Alpha and other tests were applied on the questionnaire using "Siegle Reliability Calculator" an excel program and the results are summarized as in Table 2:

Table 2: Cronbach's Alpha Scores

Sr. No.	Questionnaire	**Cronbach's Alpha**
1	Pune Commuters	0.9207
2	Ahmedabad Commuters	0.8292

As the Cronbach's alpha score was more than 0.70, the questionnaire was considered as reliable.

Hypotheses formulation

The hypotheses formulation is presented below:

Table 3: Hypotheses formulation

Sr. No.	Area of study	Null Hypotheses (Ho)	Alternate Hypotheses (Ha)
1	Problems with existing technologies	There are no significant problems with existing technologies.	There are significant problems with existing technologies.
2	Opportunities for the use of IoT in PTS of SCs	There are no significant opportunities for the use of IoT in PTS of SCs.	There are significant opportunities for the use of IoT in PTS of SCs.
3	Challenges for the use of IoT in PTS of SCs	There are no significant challenges for the use of IoT in PTS of SCs.	There are significant challenges for the use of IoT in PTS of SCs.
4	Increase in number of passengers due to proposed model using IoT in PTS	There will be no significant increase in number of passengers due to proposed model using IoT in PTS.	There will be significant increase in number of passengers due to proposed model using IoT in PTS.

Scheme formed for testing of hypotheses

- A questionnaire was designed to collect primary data in order to test the hypothesis, as stated earlier.
- In line with the hypothesis, the questionnaire was divided into the following parts:
  - Problems with existing technologies
  - Opportunities for IoT in PTS
  - Challenges for the use of IoT in PTS
  - Proposed Model using IoT
- The questionnaire structure was kept simple by framing ten questions /statements/ factors as questions under each of the four sections.
- Responses were sought by way of rating the various statements on a 5-point Likert Scale of Agreement/Disagreement: Can't say, Somewhat Agree, Strongly Agree, Somewhat Disagree, Strongly Disagree.
- For each of the extreme elements of the responses, Strongly Agree and Strongly Disagree, a weight of 2 was used to separate the responses from the other two moderate responses.
- Scores for each of the questions were aggregated and bifurcated into opposite groups of agree/disagree.
- Agree/Disagree percentages to questions under one particular section of the questionnaire were averaged to get a single agreement/disagreement percentage for that section.
- The average agreement/disagreement percentage was compared with a hypothesized mean of the population of 50% agreement/disagreement connoting an agreement/disagreement by chance and not due to statistical significance,
- P-values were calculated, and the null hypotheses were checked for rejection or non-rejection.
- These calculations were done at a 95% confidence level using a t-test since the population's standard deviation (SD) is not known.

Data analysis and interpretation

a. Profile analysis (Table set 4)

	Pune	Ahmedabad	Total
Smart City	40	40	80

The distribution of respondents was 40 each for the two smart cities selected for the study, Pune and Ahmedabad.

Other features of the pilot study samples are given below:

	Male	Female	Total
Gender	34	46	80

	<20 years	20-30 years	30-40 years	>40 years	Total
Age	26	17	13	24	80

	Public Transport	Own Vehicle	Total
Commute using	39	41	80

	<3 years	3-5 years	>5 years	Total
Commutes since	31	19	30	80

	Yes	No	Total
Regular user of technology like GPRS or other Apps	40	40	80

b. Inferential analysis (Testing of hypotheses)

Responses of the 80 respondents were averaged. Results are summarized below:

Summary of responses to the 4 sections of the questionnaire (Table set 5)

Qstn.	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	Average
Agree %	77%	78%	82%	70%	66%	81%	77%	81%	80%	68%	76%

Qstn.	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	Average
Agree %	81%	81%	80%	79%	77%	78%	80%	87%	80%	81%	80%

Qstn.	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	Average
Agree %	77%	86%	88%	94%	92%	84%	80%	81%	85%	79%	85%

Qstn.	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.10	Average
Agree %	74%	77%	77%	83%	79%	70%	76%	81%	87%	79%	78%

Hypotheses testing @ 95% confidence level

The average responses for each section were compared with a hypothesized population mean of 50% agreement taking it as an event by chance. Results are given in Table 5.

Table 6: Hypotheses testing @ 95% confidence level

Sr. No.	Parameter	H1	H2	H3	H4
1	Average	76%	80%	85%	78%
2	SD (Standard Deviation)	0.9823	0.97294	0.92166	1.00457
3	H1 (Hypothesized mean of population)	50%	50%	50%	50%
4	Ho (Sample mean)	0.76	0.80	0.85	0.78
5	n (Sample Size)	80	80	80	80
6	t-value	2.36	2.78	3.36	2.51
7	p-value	0.010478	0.003365	0.000605	0.007082
8	Decision	Reject Null	Reject Null	Reject Null	Reject Null

Going by the p-values of <0.05, all the null hypotheses stand rejected in favor of the alternate hypotheses.

Summary of inferential analysis

Summary of the testing of all the four hypotheses along with their interpretation is given below:

Table 7: Summary of inferential analysis

Sr. No.	Null Hypotheses	p-value	Decision	Interpretation
1	Ho1: There are no significant problems with existing technologies	0.010	Reject Null	There are significant problems with existing technologies.
2	Ho2: There are no significant opportunities for the use of IoT in PTS of SCs	0.003	Reject Null	There are significant opportunities for the use of IoT in PTS of SCs.
3	Ho3: There are no significant challenges for the use of IoT in PTS of SCs	0.001	Reject Null	There are significant challenges for the use of IoT in PTS of SCs.
4	Ho4: There will be no significant increase in number of passengers due to proposed model using IoT in PTS	0.007	Reject Null	There will be a significant increase in number of passengers due to proposed model using IoT in PTS.

Conclusions

There are significant problems with the existing technologies in the Public Transport System. Simultaneously, there are significant opportunities for using the Internet of Things in the Public Transport System of smart cities. Also, there are significant challenges for using the Internet of Things in the Public Transport System of smart cities. Finally, there will be a significant increase in passengers' number due to the proposed model using IoT in PTS.

It is possible to collect the required data. Moreover, further processing of the data into variables required for inferential analysis of data can be done using spreadsheet software. As per the methodology, the hypotheses can be duly tested. The questionnaire used for the survey tests reasonably well for validity and reliability. However, and importantly, confidentiality is demanded by respondents.

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