AIR SELANGOR DATA & DIGITAL HACKATHON 2024

TOPIC: INTELLIGENT METER - INVENTORY MANAGEMENT SYSTEM

SUBTOPIC: DEVELOPING A SMART METER INVENTORY MANAGEMENT SYSTEM FOR THE AIR SELANGOR DISTRIBUTION NETWORK

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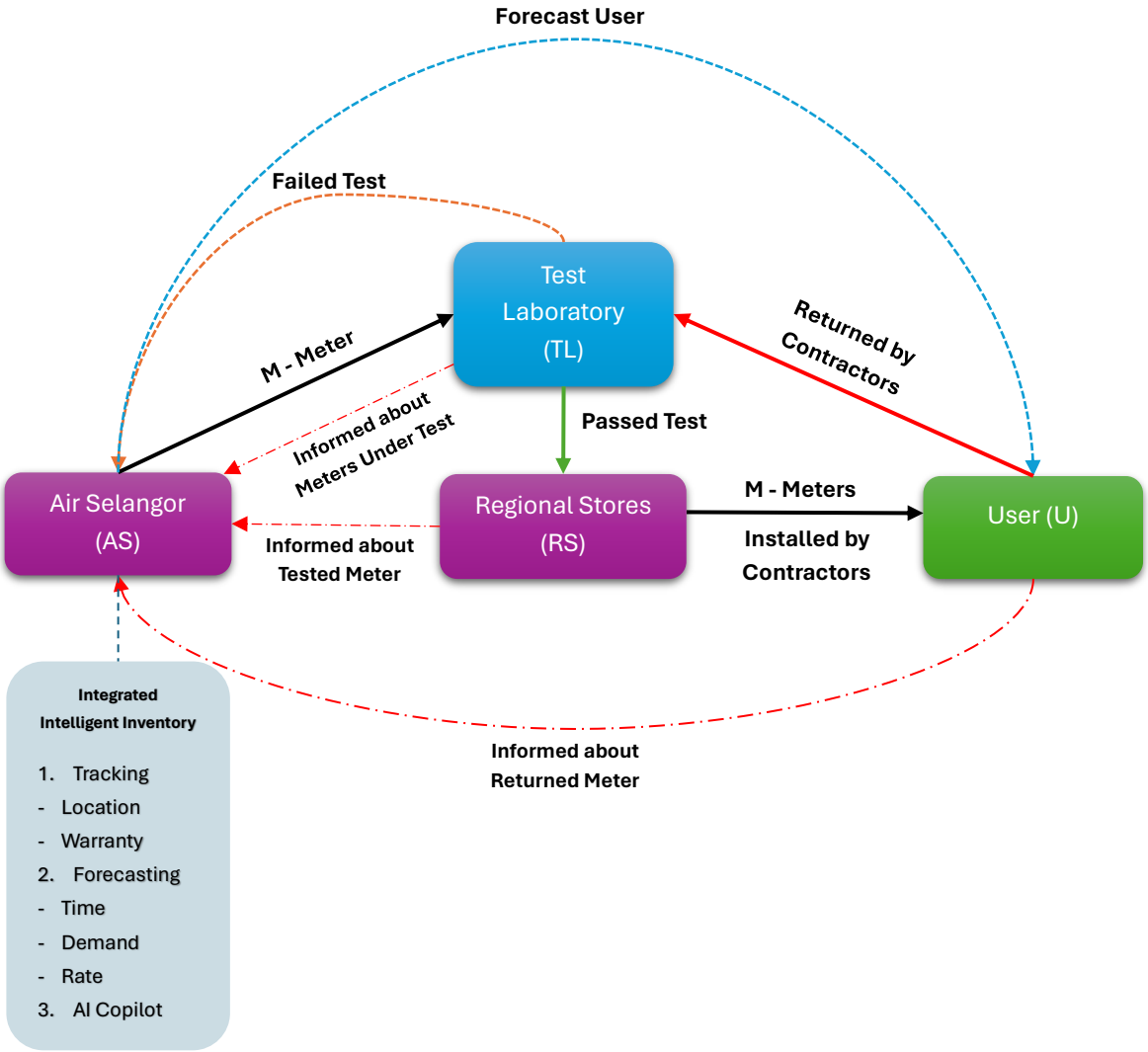
OBJECTIVE

The present water meter management faces challenges such as imprecise forecasting of new meter demand, manual tracking causing unrecorded or missing meters, and lack of integration with meter testing lab results, resulting in suboptimal inventory levels.

There's a need for an advanced system employing intelligent algorithms to achieve higher efficiency and accuracy.

GRAPHICAL ABSTRACT



ABSTRACT

Air Selangor distributes water to over 9.3 million consumers. These distributions are monitored by meters which are also vulnerable to defects like leakage, meter stuck, faulty program and other manufacturing abnormalities. The present meter management system is not smart for forecasting new meter demand. Tracking is also manual, resulting in unrecorded or missing meters, and the paucity of an integrated system with the test lab makes the inventory levels suboptimal. This design adopts a blend of Machine learning and AI algorithms to develop an Intelligent Meter Inventory Management System (IMIMS) capable of tracking the location and warranty of Installed and returned meters. IMIMS will also forecast the best sale periods, meters required for subsequent months or years, and seamless distribution of meters from regional stores. In addition, lab testing rate, purchasing rate of meters and integration of an AI copilot for interaction and decision-making will be introduced to the system.

EXPECTATIONS OF UNITS

Air Selangor – Purchased Meters from Vendors (PM_V), Dispatched meters to Lab (DM_L), Damaged Meters (D_M), *Received meters from Air Selangor (RM_{AS}), Meters Under Test (MUT), Meters Failed Test (MFT), Meters Passed Test (MPT), Dispatched meters to regional offices (DM_{RO}), Received meters from Lab (RM_L), Dispatched Meters to Users (DM_U)*

Laboratory – Received meters from Air Selangor (RM_{AS}), Meters Under Test (MUT), Meters Failed Test (MFT), Meters Passed Test (MPT), Dispatched meters to regional offices (DM_{RO}),

Regional Offices – Received meters from Lab (RM_L), Dispatched Meters to Users (DM_U)

THINGS TO TRACK (TTT)

1. Track location and warranty of Installed and returned meters.

THINGS TO PREDICT (TTP)

1. Forecast the best sale periods in the month.
2. Meters required for subsequent months or years.
3. Seamless distribution and transfer of meters from regional stores
4. Optimized warrantees check of meters for replacement and tracking.
5. Possible future sales and user demand
6. Laboratory testing rate
7. Purchasing rate of meters per month and year

AI COMPONENT

1. Integrate an AI copilot for interaction and decision-making.

ASSUMPTIONS

1. All returned Meters were replaced/reworked.
2. The monetary value of meters over time remains the same.
3. The cost of meters is the same.
4. All meters have different serial numbers

Table 1: Inventory Sample Track 1

Date	Purchased Meter (PM)			Test Laboratory			Available Meter (AM)	Dispatched Meter (DM)	Returned Meter (RM)
	PM_T	PM_R	PM_{Cum}	Under Test (UT)		Tested (Ts)			
				UT_T	UT_Y				
1/01/2024	10	0	10	5	0	5	3	2	0
2/01/2024	6	0	16	3	5	8	5	6	1
3/01/2024	9	1	26	3	3	10	5	10	0
Total produced				25		**Total sold**		18	1
						Total Available		5	
						Total Under test		3	

PM_T = Meters purchased today

PM_R = Meters returned from the previous day

PM_{Cum} = Cumulative purchased meters

UT_T = Meters Under Test Today

UT_Y = Meters Under Test from Yesterday

EQUATIONS

Input = **PM_T, Ts, DM, RM**

PM_{Cum} = **PM_T** + **PM_R** + **PM_T** of the previous day

UT_T = **PM_T** + **PM_R** + **UT_Y** – **Ts**
UT_Y of Today = **UT_T** of the previous day

AM = **AM** of the previous day + **Ts** – **DM**

METER IDENTIFICATION

1. Serial Number only

There will be a database for all meter information linked to serial no.

Table 2: Database for Meter Information

Serial No.	Meter Size	Meter Type	Meter Manufacturer	Meter Model	Manufactured Year
X	X	X	X	X	X
X	X	X	X	X	X

Table 3: Warranty Tracking

Serial No.	Warranty Boundary		Return Date	Decision (AI Copilot)
	Start	End		
AIS17BAXXX	2/12/2021	2/12/2024	5/8/2023	Covered by warranty, kindly replace for user
AWT27BAXXX	5/10/2021	5/10/2024	2/9/2025	Not covered by warranty, request payment

We can extrapolate these figures for the next 2000 days to have enough data, or we use the company data which will be given, then run an ML algorithm for the prediction of **TTP 1 - 7**

METER DISTRIBUTION

Table 4: Meter distribution suggestions using AI

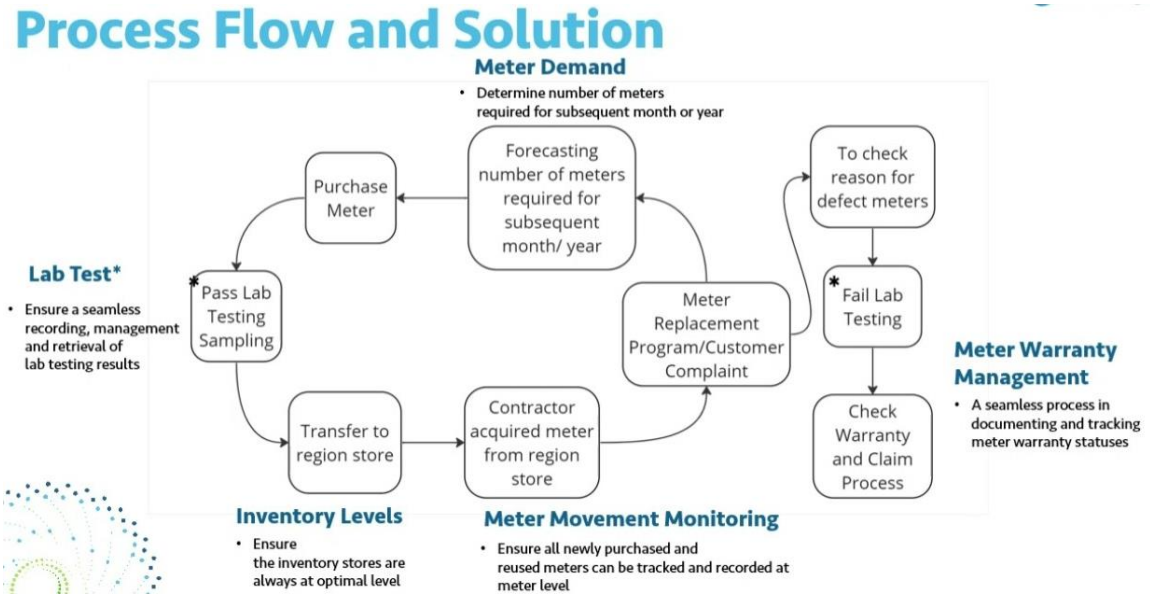
Available Meter	AI Copilot Suggestions		
	Kuala Lumpur	Selangor	Putrajaya
AIS17BAXXX	X		
AWT27BAXXX		X	
AWT27BAXXX		X	
AWT27BAXXX	X		
AWT27BAXXX			X

RECOMMENDATIONS

- Use of QR codes for meters and integrating with existing serial number tracking system.
- Checked date is removed on the datasheet due to over information, since the warranty is initiated from date of return.

APPENDICES

Process Flow and Solution



Meter Data

Serial Number	Meter Size	Meter Type	Meter Manufacturer	Meter Model
AIS17BA00XXXXX	15	Mechanical Meter - Brass Body & Piston Volumetric Type	George Kent Malaysia	PSM Volumetric 15mm
AIS21CA00XXXXX	20	Mechanical Meter - Brass Body & Piston Volumetric Type	George Kent Malaysia	PSM Volumetric 20mm
AIS23PD00XXXXX	15	Mechanical Meter - Plastic Body & Piston Volumetric Type	Aqua Flo Sdn. Bhd.	Glass Fibre Grivory Meter 15mm
RSYA0501XXXXX	15	Mechanical Meter - Brass Body & Piston Volumetric Type	Ningbo Water Meter	LXH 15B 15mm
AIS22PD02XXXXX	15	Mechanical Meter - Plastic Body & Piston Volumetric Type	Aqua Flo Sdn. Bhd.	Glass Fibre Grivory Meter 15mm
AIS17DA00XXXXX	25	Mechanical Meter - Brass Body & Piston Volumetric Type	George Kent Malaysia	PSM Volumetric 25mm
AIS21CA00XXXXX	20	Mechanical Meter - Brass Body & Piston Volumetric Type	George Kent Malaysia	PSM Volumetric 20mm
PUAS041015XXXXX	150	Mechanical Meter - Ductile Iron Body & Woltmann Type	George Kent Malaysia	HELIX METER 6" METER
AIS17PA03XXXXX	15	Mechanical Meter - Plastic Body & Piston Volumetric Type	George Kent Malaysia	KSM Volumetric 15mm

Data Dictionary

Serial Number:	Unique meter serial number
Meter Size:	Size of the meter in mm
Meter Type:	Type of the meter
Meter Manufacturer:	Manufacturer of the meter
Meter Model:	Model of the meter

Lab Test Result Data

Serial Number	Region	Tested Date	Result
AIS17BA0013XXX	SABAK BERNAM	15/11/2022	PASS
AIS17BA0025XXX	SABAK BERNAM	15/11/2022	FAIL
AIS17PA0052XXX	SEPANG	17/11/2022	FAIL
AIS17PB0037XXX	SEPANG	17/11/2022	PASS
AIS17BA0049XXX	HULU LANGAT	29/12/2022	FAIL
AIS17PA0035XXX	HULU LANGAT	02/12/2022	PASS
AIS18PA0407XXX	KUALA LUMPUR	11/01/2023	FAIL
AIS18PA0415XXX	KUALA LUMPUR	11/01/2023	PASS
AIS20PA0372XXX	HULU SELANGOR	17/01/2023	FAIL
AIS20PA0372XXX	HULU SELANGOR	17/01/2023	PASS

Data Dictionary

Serial Number: Unique meter serial number
Region: Region where the meter was installed
Tested Date: The date of meter being tested in the lab
Result: Lab result after meter being tested

Inventory Level Data

Air Selangor SOP for purchase of meters:

The Meter Management Section must purchase meters if the existing meter stock has reached the minimum stock level. Minimum stock level means that the quantity of meters in the store only lasts for use within (1) month.

Meter Size	15mm (P)	15mm (B)	20mm	25mm	40mm	50mm	80mm	100mm	150mm	Total
Minimum Buffer Stock	36,608	1,458	72	75	36	50	27	52	35	**38,413**

Meter Movement Monitoring Data

Transaction From	Transaction To	Item Description	Quantity	Calendar Month
SABAK BERNAM - STORE	SEPANG - STORE	WATER METER 15MM PLASTIC - KSM	1,000	2022 / 03
SEPANG - STORE	GOMBAK - STORE	WATER METER 15MM PLASTIC - KSM	100	2022 / 03
GOMBAK - STORE	PETALING - STORE	WATER METER 25MM BRASS - NINGBO	18	2022 / 05
SABAK BERNAM - STORE	KLANG - STORE	WATER METER 40MM BRASS - PSM	5	2022 / 05
PETALING - STORE	KUALA LANGAT - STORE	WATER METER 15MM PLASTIC	2,000	2022 / 06
PETALING - STORE	HULU LANGAT - STORE	WATER METER 15MM PLASTIC	1,000	2022 / 08
GOMBAK - STORE	HULU SELANGOR - STORE	WATER METER 15MM PLASTIC	200	2023 / 05
GOMBAK - STORE	KUALA LUMPUR - STORE	WATER METER 15MM PLASTIC	300	2023 / 05
KUALA SELANGOR - STORE	KLANG - STORE	WATER METER 15MM PLASTIC	500	2023 / 05
KUALA LANGAT - STORE	HULU SELANGOR - STORE	WATER METER MECHANICAL IRON 150MM	2	2023 / 07

Data Dictionary

Transaction From: Original location of the meter being transferred from
Transaction To: Destination of meter being transferred to
Item Description: Model of meter being transferred
Quantity: Total number if meter being transferred
Calendar Month: Year and month of the meter being transferred

Meter Warranty Data

Serial Number	Meter Size	Manufactured Year	Received Date	Physical Checked Date	Defect	Status
AIS19PA03XXXXX	15	2019	03/09/2021	03/09/2021	4. LEAKING AT ANY PART OF METER BODY	CAN CLAIM
AIS19PA03XXXXX	15	2019	03/09/2021	03/09/2021	3. LEAKING THROUGH INDICATING DEVICE & PULSE OUTPUT	CAN CLAIM
AIS19PA00XXXXX	15	2019	03/09/2021	03/09/2021	9. METER NOT IN METER WARRANTY CATEGORY	CANNOT CLAIM
AIS19PA04XXXXX	15	2019	15/09/2021	29/09/2021	8. METER STUCK	CAN CLAIM
AIS19PA01XXXXX	15	2019	15/09/2021	29/09/2021	9. METER NOT IN METER WARRANTY CATEGORY	CANNOT CLAIM
AIS20PA03XXXXX	15	2020	15/09/2021	29/09/2021	9. METER NOT IN METER WARRANTY CATEGORY	CANNOT CLAIM
AIS20PA02XXXXX	15	2020	15/09/2021	29/09/2021	8. METER STUCK	CAN CLAIM
AIS21PA01XXXXX	15	2021	15/09/2021	29/09/2021	9. METER NOT IN METER WARRANTY CATEGORY	CANNOT CLAIM
AIS21PA01XXXXX	15	2021	15/09/2021	29/09/2021	8. METER STUCK	CAN CLAIM
AIS21PA01XXXXX	15	2021	15/09/2021	29/09/2021	9. METER NOT IN METER WARRANTY CATEGORY	CANNOT CLAIM

Data Dictionary

Serial Number:	Unique meter serial number
Meter Size:	Size of the meter in mm
Manufactured Year:	Manufactured year of the meter
Received Date:	The date the meter was received by the laboratory
Physical Checked Date:	The date of the physical check of the meter by the laboratory
Defect:	Defect found on the meter
Status:	Warranty status whether can claim or not

Meter Demand Data

Current practice to determine number of meters required for subsequent month or year is based on average newborn of meter faulty program, meter complaint and meter leak in previous year. Example as below:

Complaint/ Program	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-24 Forecast
Faulty Program	8,000	12,000	11,000	7,800	16,000	5,000	11,000	16,000	9,200	7,500	6,000	6,000	9,625
Meter Complaint	1,800	1,900	1,650	1,500	2,000	2,000	2,000	1,500	2,000	1,600	1,600	1,400	1,746
Meter Leak Complaint	18,000	16,000	17,000	17,000	18,000	18,000	17,000	15,000	19,000	17,000	16,000	18,000	1,716
Total	**27,800**	**29,900**	**29,650**	**26,300**	**36,000**	**25,000**	**30,000**	**32,500**	**30,200**	**26,100**	**23,600**	**25,400**	**28,538**

Complaint/Program Description

Faulty Program:	Stuck counter, inaccurate readings, rust, damage, or lack of movement. Mainly reported by Air Selangor staffs
Meter Complaint:	Customer reported inaccurate readings, leaks, or damage
Meter Leak Complaint:	Visible water seepage, dampness, or pooling around the meter. Can be reported by customer or Air Selangor staffs