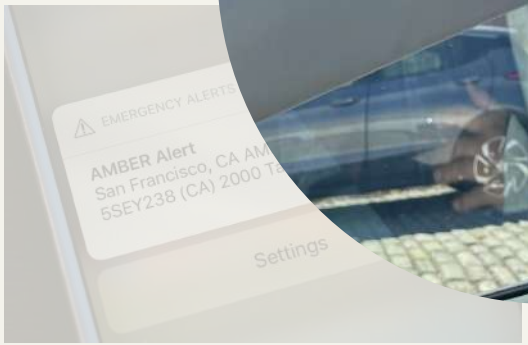
PlatePatrol

Crowdsourced Automatic License Plate Recognition (ALPR) Network

Team B2 : Christine Li, Vicky Liu, Andy Zhao

The Problem and Our Solution

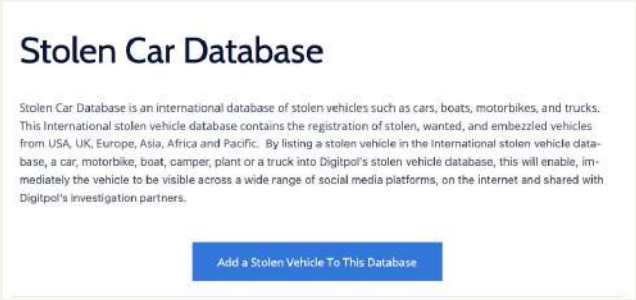
Hit-and-R



Everything You Need to Know About Mobile Amber Alerts

WOSU 89.7 NPR News

National Cyber Tip Line



Digitpol Stolen Car Database

Use Case and Design Requirements

Ease-Of-Use

- Hands-free operation
  - Initial installation < 10 minutes
  - No further driver interaction required

High Accuracy

- End-to-end accuracy [1] >= 80%
  - Detection >= 90% mAP50
  - OCR >= 90% accuracy

Low Latency

- Critical path latency (frame capture to tip line notification) < 1.1s
  - Detection <= 200ms
  - OCR <= 50ms
  - Watchlist query <= 500ms
  - Image upload <= 300ms

Privacy & Security

- Switch-based opt-in/out control
  - Setting update <= 1s
- Law-compliant data retention policy
  - Data at rest erased or encrypted (retain 21 days)
  - Data in transit encrypted
  - Access control w/ authentication

[1] End-to-end accuracy: (# of correctly identified vehicles) / (# of vehicles with driver-legible license plates).

Solution Approach

End-to-End Integration

- Recording & ALPR dual functionality
- Powered via car cigarette lighter

Near Real-Time Processing

- On-device ML
- Minimized server communication

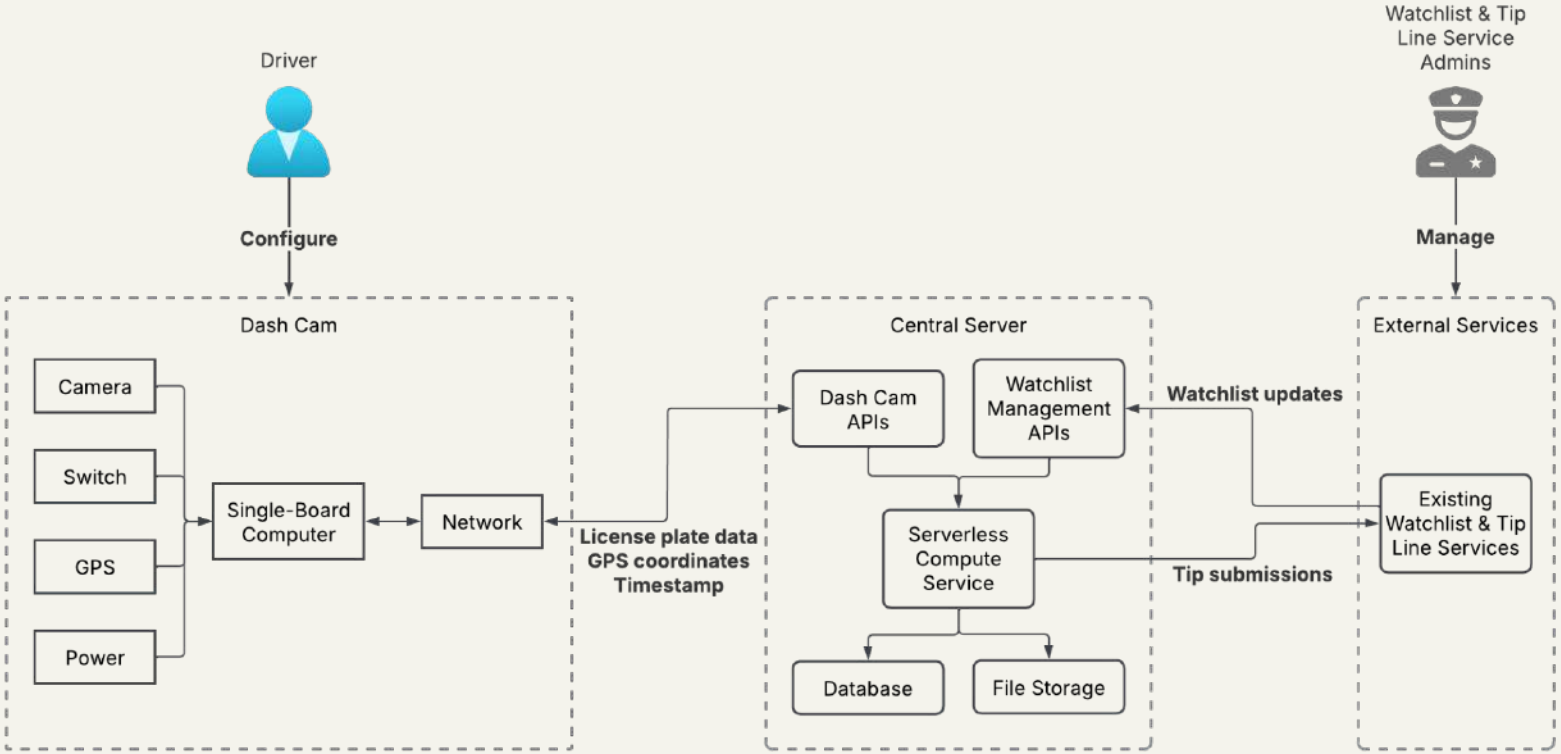
Distributed Cloud Server

- Serverless Lambda-based architecture
- RESTful APIs w/ caching

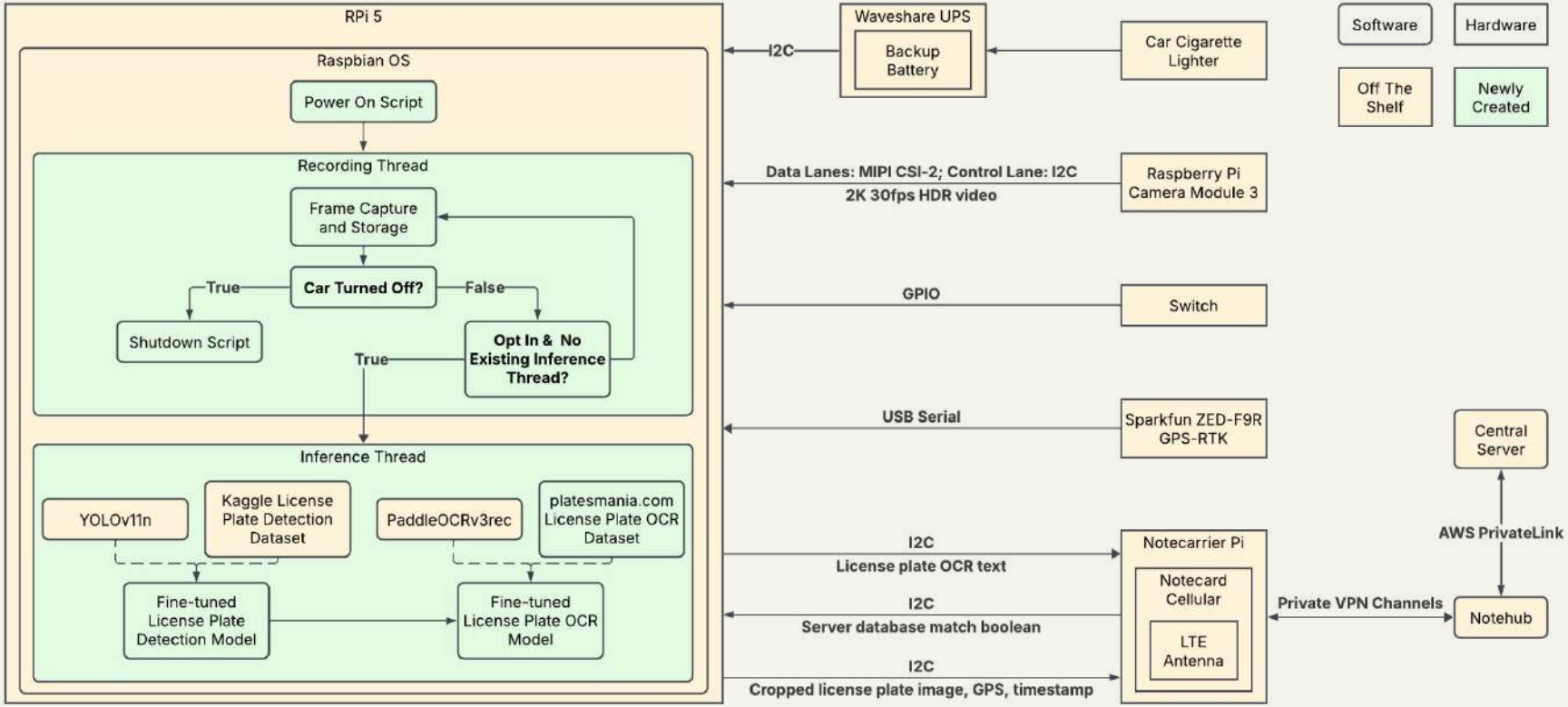
Privacy and Security Commitment

- Instant opt-in/out
- API key-based access control
- Data encryption w/ AWS KMS & PrivateLink

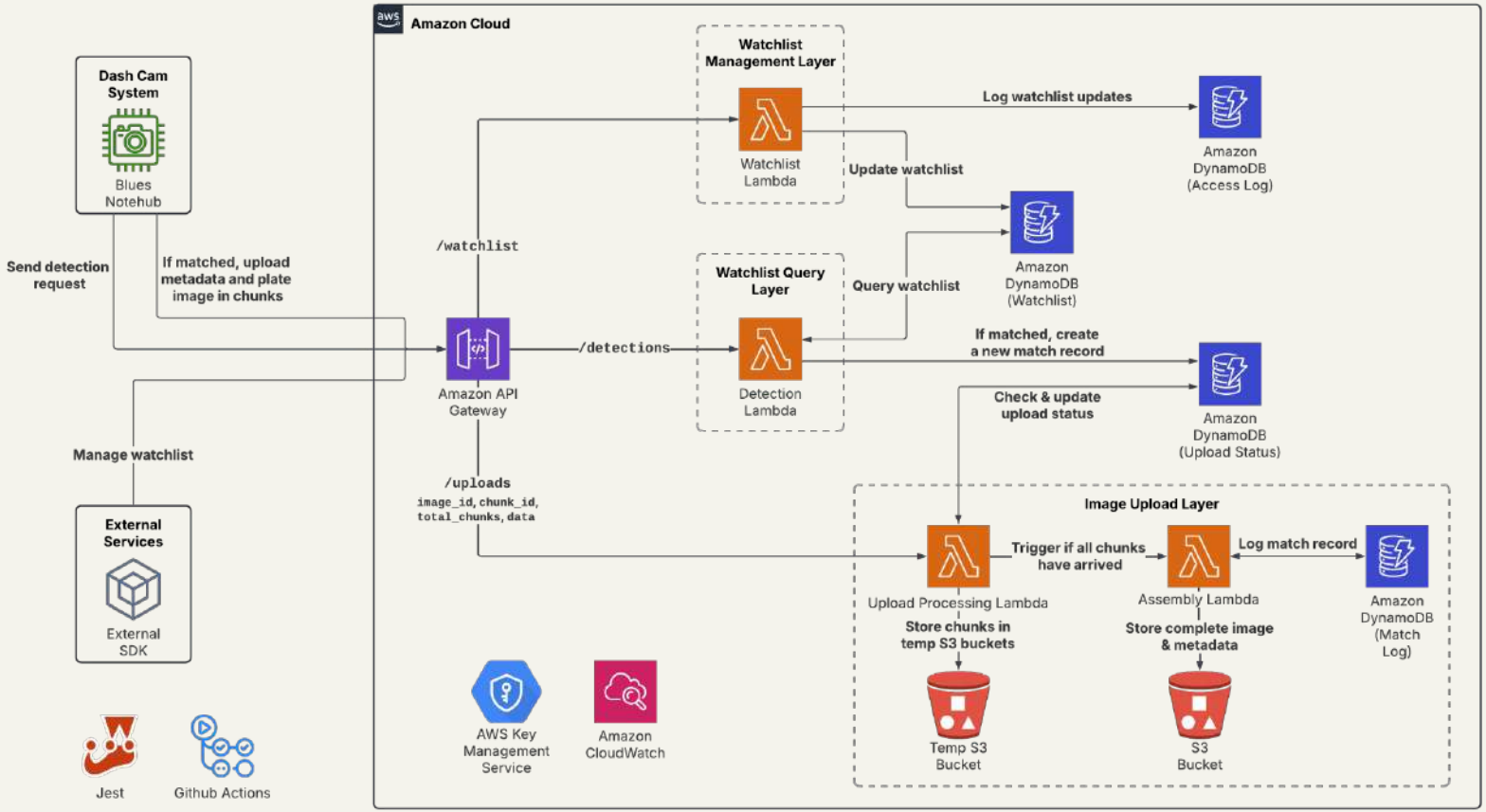
Complete Solution



Dash Cam Solution



Central Server Solution



Dash Cam Testing

	Test Plan	Requirement	Result
Basic Functionality	• Weigh the dash cam • Power via car cigarette lighter for a 30-minute road test	• < 1.5lbs weight • Powered via car cigarette lighter • 1-minute continuous clips	• 0.77lbs weight • Confirmed that power and storage function as expected
Ease-Of-Use	Measure install, startup, and shutdown time across 5 trials	• < 10 minutes installation • < 30s startup/shutdown script execution latency	• 5 minutes installation • 41s startup latency • 332ms shutdown latency
Privacy	Measure the time from toggling the switch to starting/pausing inference across 10 trials	<= 1s opt-in/out latency	< 1s opt-in/out latency (instantaneous)

ALPR Testing

	Test Plan	Requirement	Result
Detection Accuracy	Evaluate the detection model on 386 real-world images	>= 90% mAP50	90.4% mAP50
OCR Accuracy	Evaluate the OCR model on 4000 synthetic and 1000 real-world images	>= 90% accuracy	93.2% accuracy
Process Rate	Measure the time from capturing a frame to outputting an OCR result across 10 trials	>= 2fps	3.9fps • 123ms detection • 134ms OCR

End-To-End Testing

	Test Plan	Requirement	Result
End-To-End Accuracy	• Evaluate the ALPR pipeline on 5000 real-world images • Conduct a 30-minute road test	>= 80% accuracy	• 79% accuracy with test dataset • 100% accuracy with road test, additional 468% plates recognized [1]
Critical Path Latency	Measure the time from capturing a frame to submitting a tip across 10 trials	< 1.1s latency	8.06s total latency • 123ms detection • 134ms OCR • 469ms watchlist query [2] • 7332ms image upload [3]
Security	• Inspect data storage after a 30-minute road test • Attempt unauthorized server requests	• Data at rest erased or encrypted (retain 21 days) • Data in transit encrypted • Access control w/ authentication	• Confirmed secure erase and encryption • Unauthorized requests rejected

[1] The driver identified 25 license plates while driving. All 25 plates were correctly identified by the dash cam. In addition, the dash cam detected an extra 117 license plates that the driver was unable to observe while driving.
[2] From the server log, the average API response time is 33ms with a 500 entries watchlist. This means 436ms out of 469ms is attributed to Blues network overhead.
[3] From the server log, the average API response time is 132ms per 2KB chunk. For an average cropped image (5KB), it contains 3 chunks. This means 6936ms out of 7332ms is attributed to Blues network overhead.

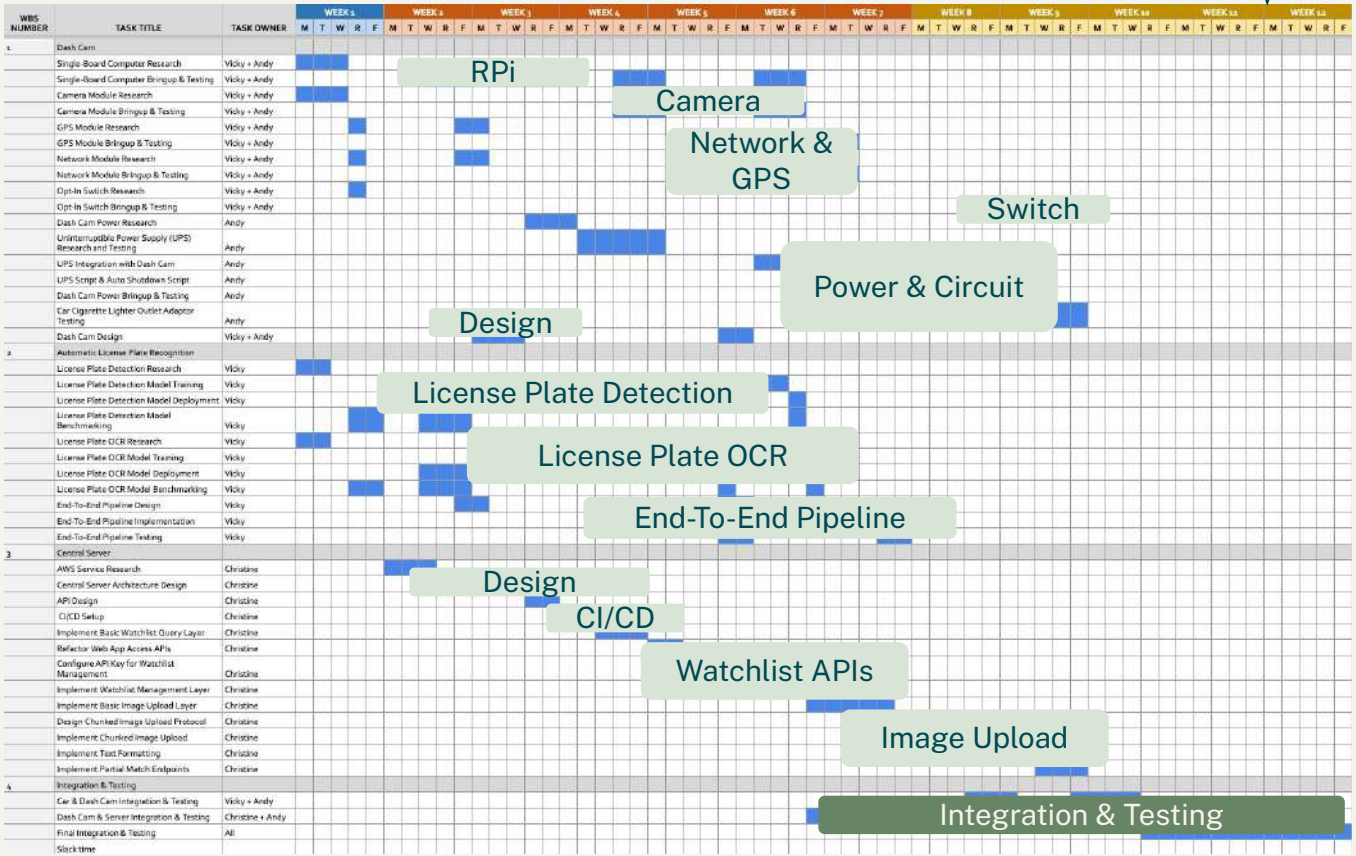
Design Trade-Off Highlight

Approach			ML Latency	Network Load	Concerns
Detection	OCR	Watchlist Query			
Cloud	Cloud	Cloud	20ms [1]	• **Frequent** full image (~162KB) upload (470s)	Network bandwidth
Edge	Cloud	Cloud	129ms [2]	• **Frequent** cropped image (~5KB) upload (7.3s)	Network bandwidth
Edge	Edge	Edge	257ms	• **Moderate** watchlist sync (2.16s [3]) • **Rare** cropped image (~5KB) upload (7.3s)	Security & watchlist synchronization
Edge	Edge	Cloud	257ms	• **Frequent** watchlist query (469ms) • **Rare** cropped image (~5KB) upload (7.3s)	/

[1] 14ms detection on Nvidia T4 GPU in TensorRT format, and 6ms OCR on Nvidia T4 GPU in Paddle format.
[2] 123ms detection on RPi 5, and 6ms OCR on Nvidia T4 GPU in Paddle format.
[3] Assuming 500 entries based on the size of Digitpol Stolen Car Database.

Schedule

Here we are



Dash Cam

ALPR

Central Server