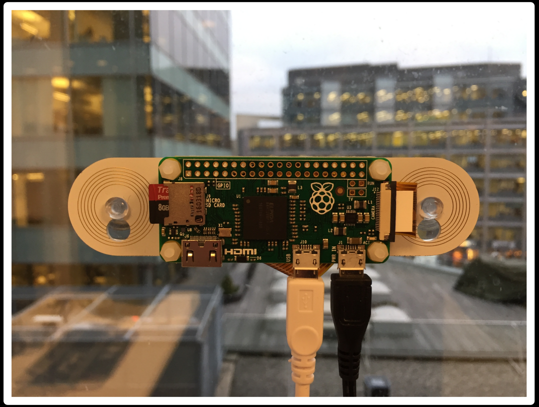
BUILDING A SMART SECURITY CAMERA WITH PIZERO, JAVA AND AWS

@markawest



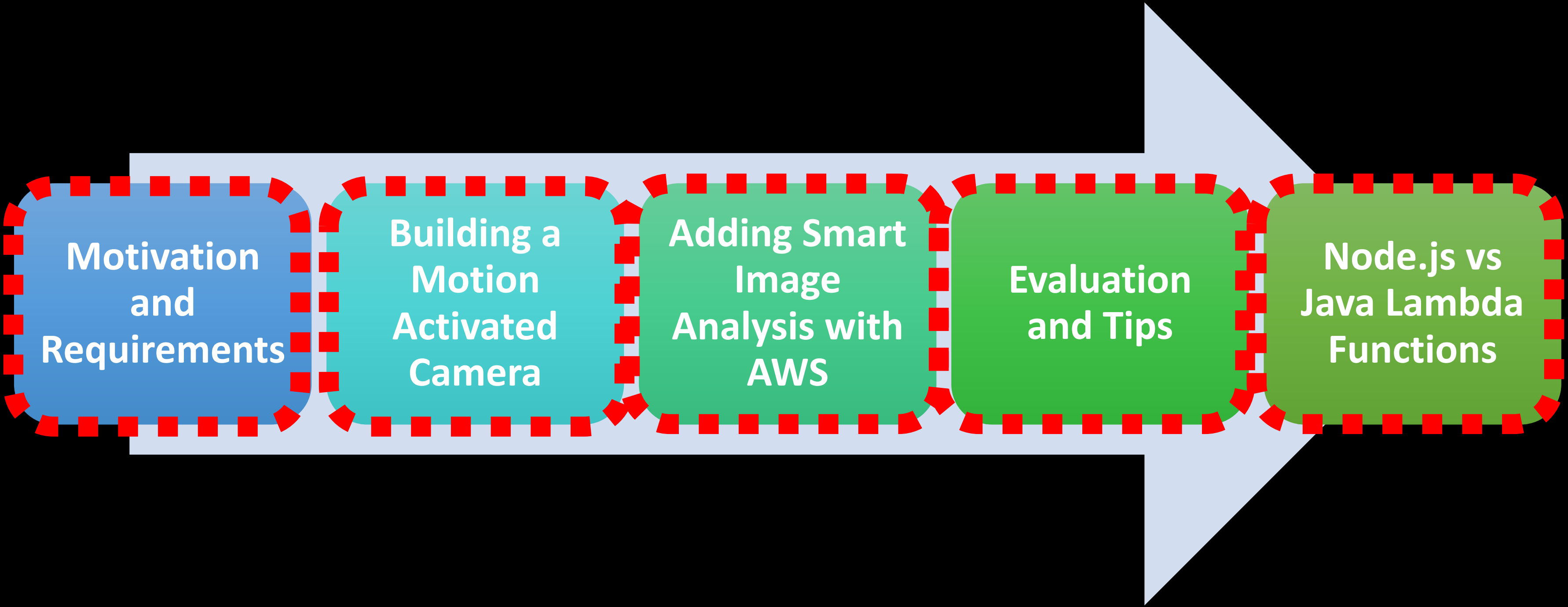
Who Am I?

- IT Consultant at Bouvet.
- Hacker and Maker.
- Java, JavaScript, AI, Cloud & IoT.
- Active member of javaBin - the Norwegian JUG.

Joker<?>

@markawest

Talk Outline



Motivation and Requirements

Building a Motion Activated Camera

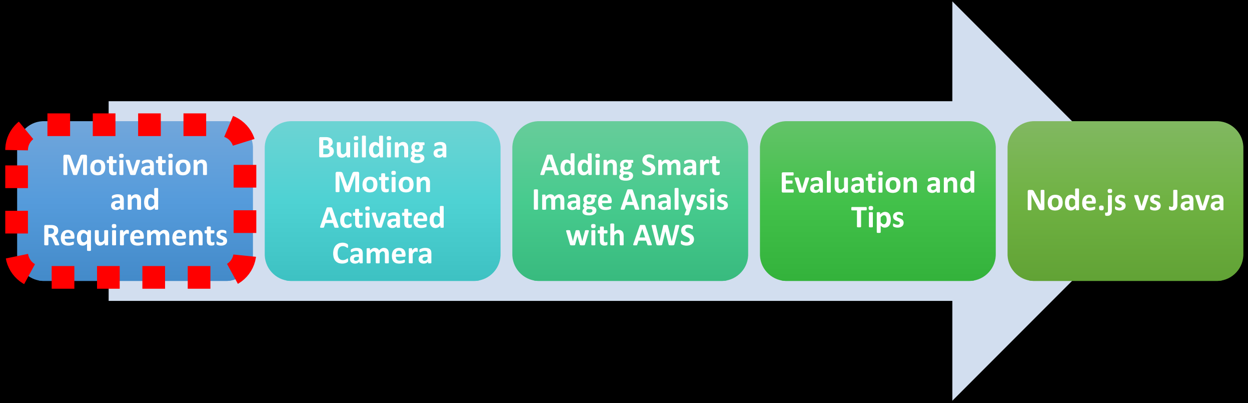
Adding Smart Image Analysis with AWS

Evaluation and Tips

Node.js vs Java Lambda Functions

Motivation and Requirements

Input from Stakeholder



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Initial Motivation

Project Requirements

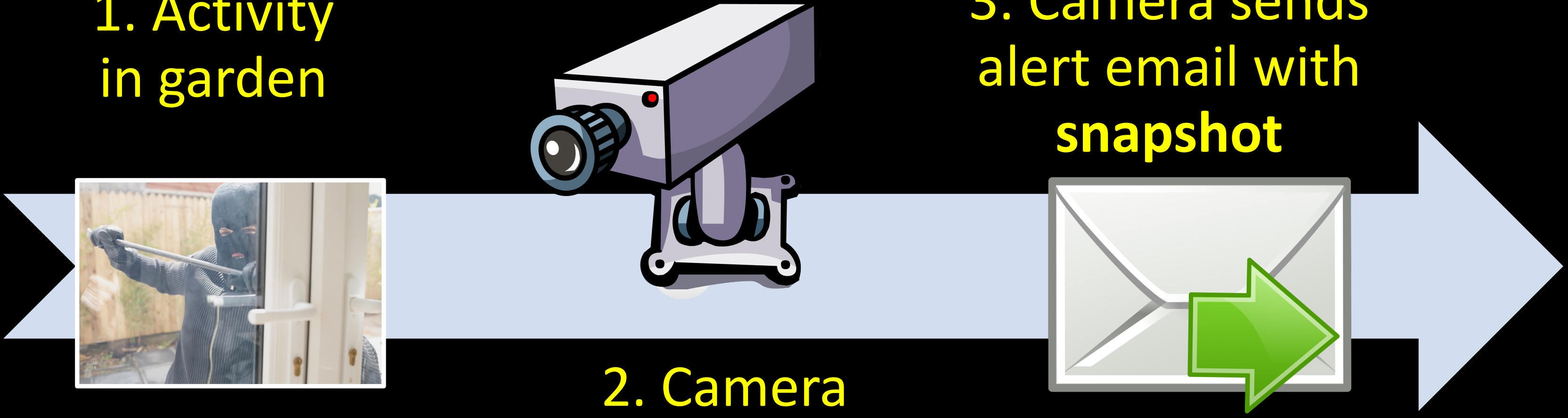
Functional

- Monitor activity in the garden.
- Send warning when activity detected.
- Live video stream.

Non-functional

- In place as soon as possible.
- Low cost.
- Portable.

Functional Design

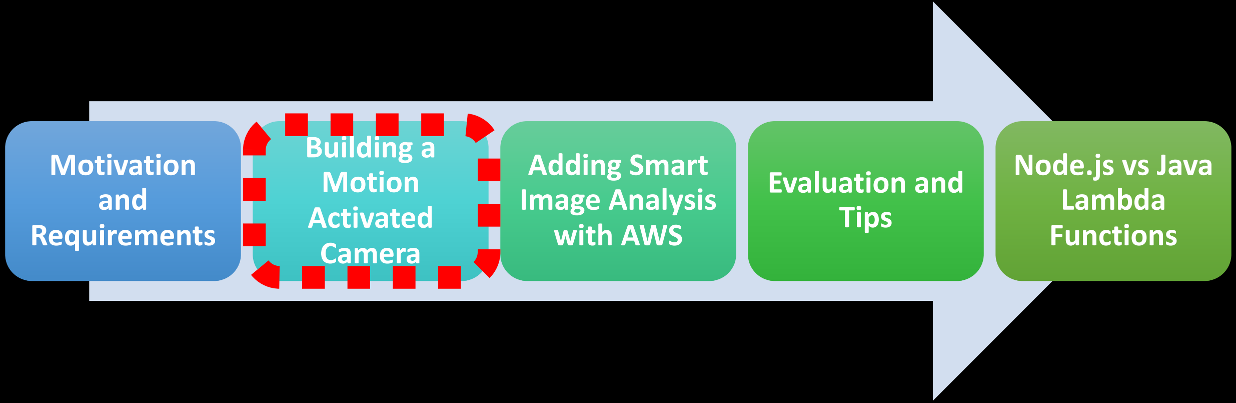


1. Activity in garden

2. Camera detects movement

3. Camera sends alert email with **snapshot**

Building a Motion Activated Camera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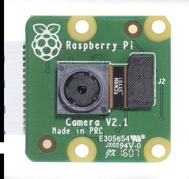
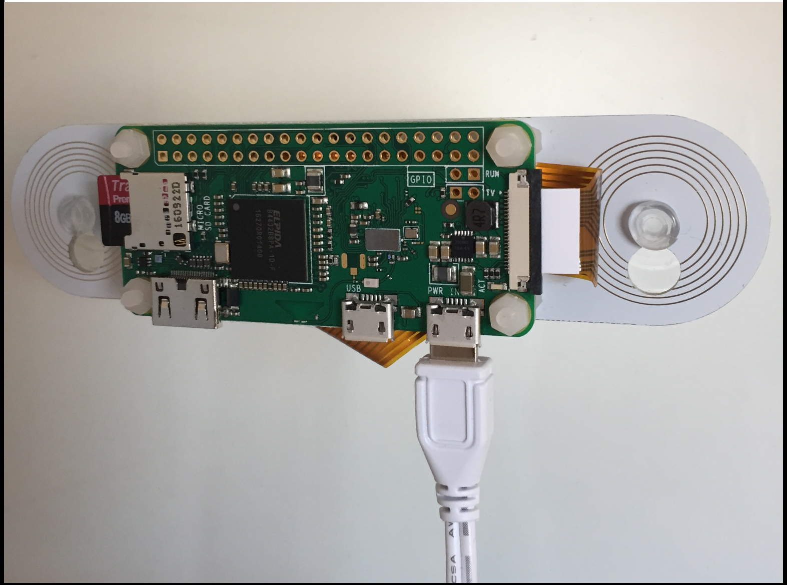
Hardware Shopping List



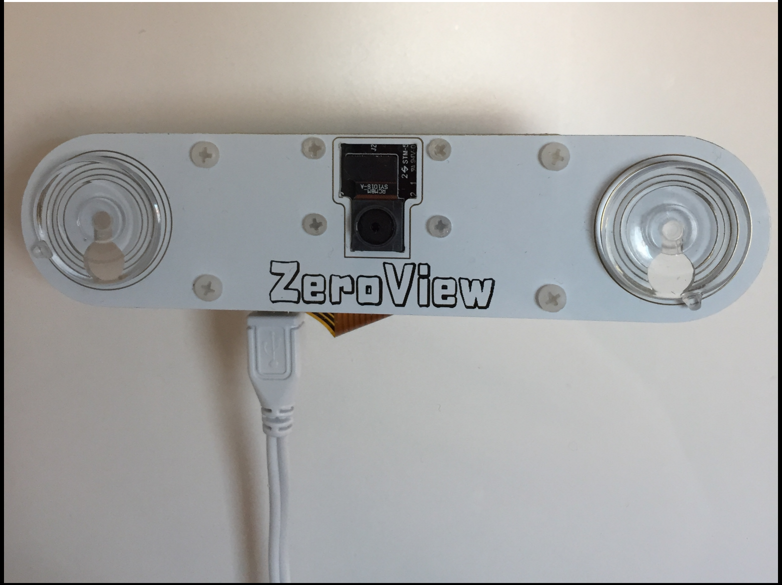
Pi Zero W Essentials Kit:	$35
Camera Module:	$33
Camera Adapter:	$7
ZeroView:	$10
Total Cost:	**$85**

Assembled Camera

Rear View

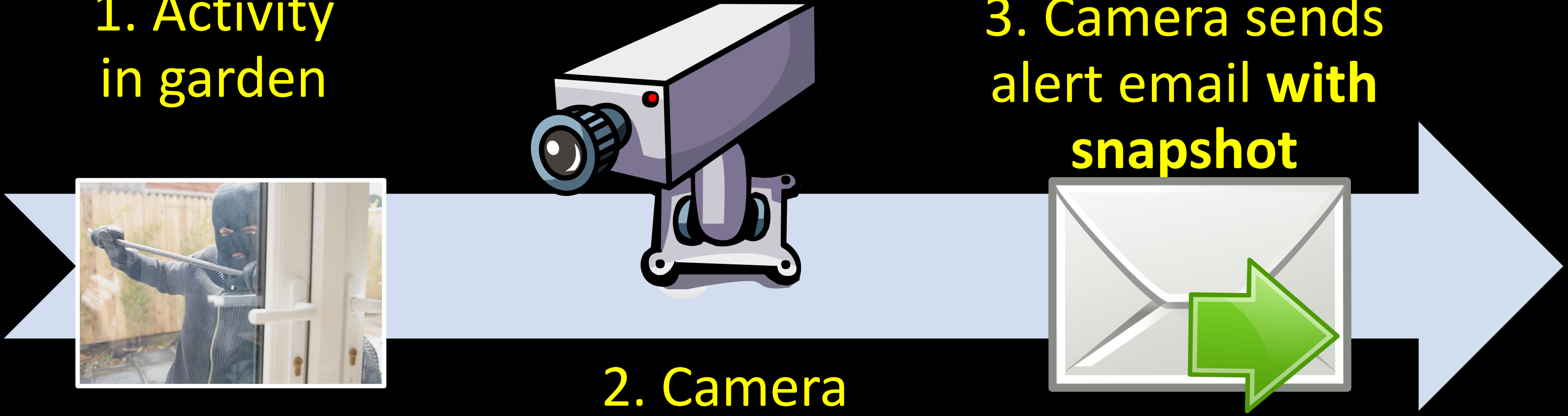


Front View



Implementing the Functional Design

1. Activity in garden



2. Camera detects movement

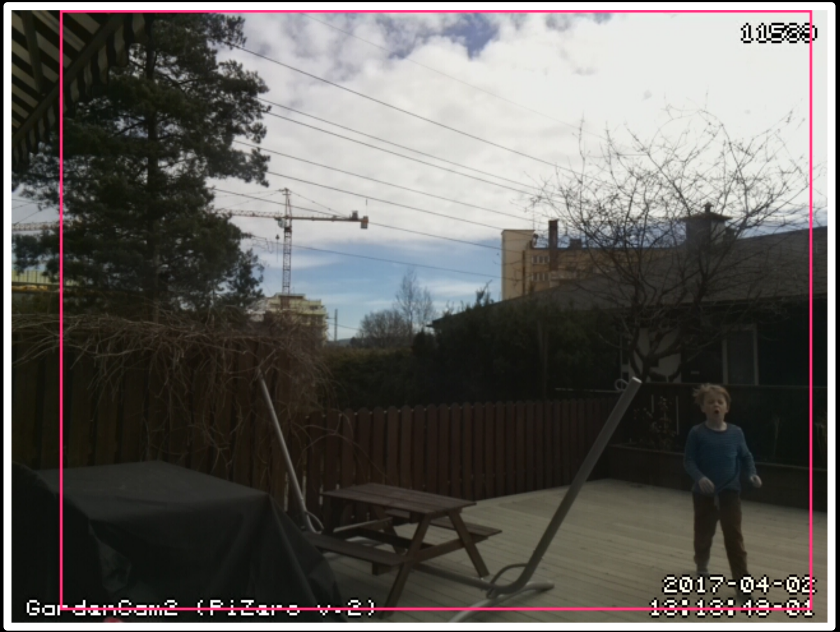
3. Camera sends alert email **with snapshot**

Motion

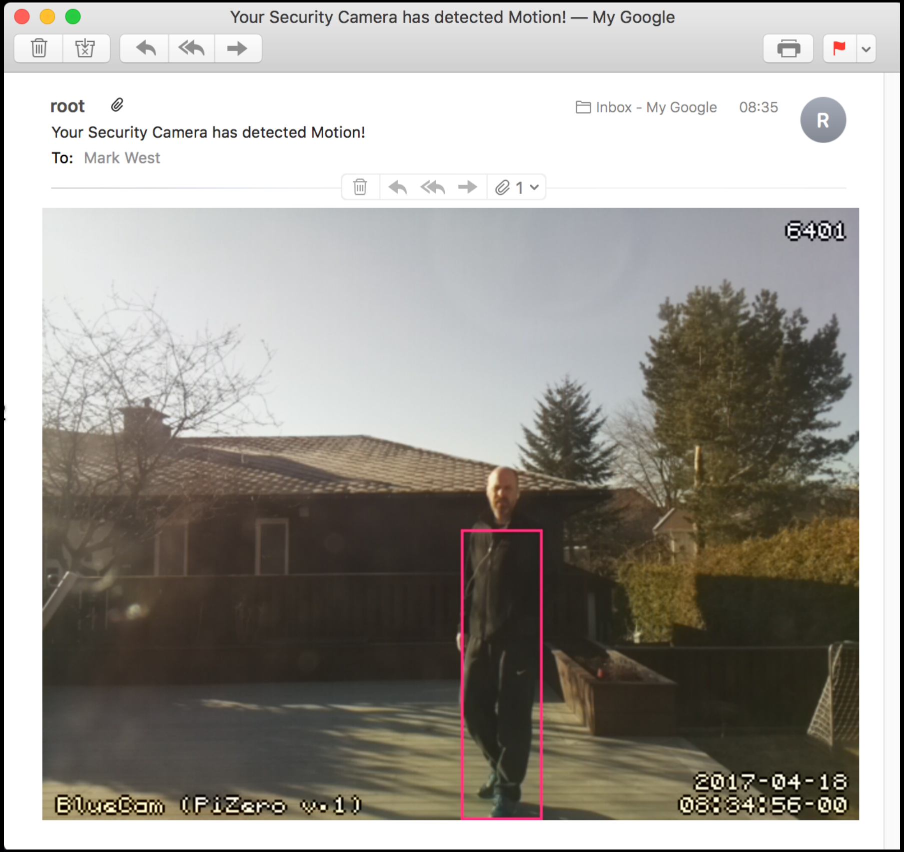
(https://motion-project.github.io)

- Open source **motion detection** software.
- **Excellent performance** on the Raspberry Pi Zero.
- Built-in Web Server for **streaming video**.
- Detected activity or ‘motion’ **triggers events**.
- **Works out of the box**. No need for additional programming.

Motion Streaming Demo



Example
Alert Email



Your Security Camera has detected Motion! — My Google

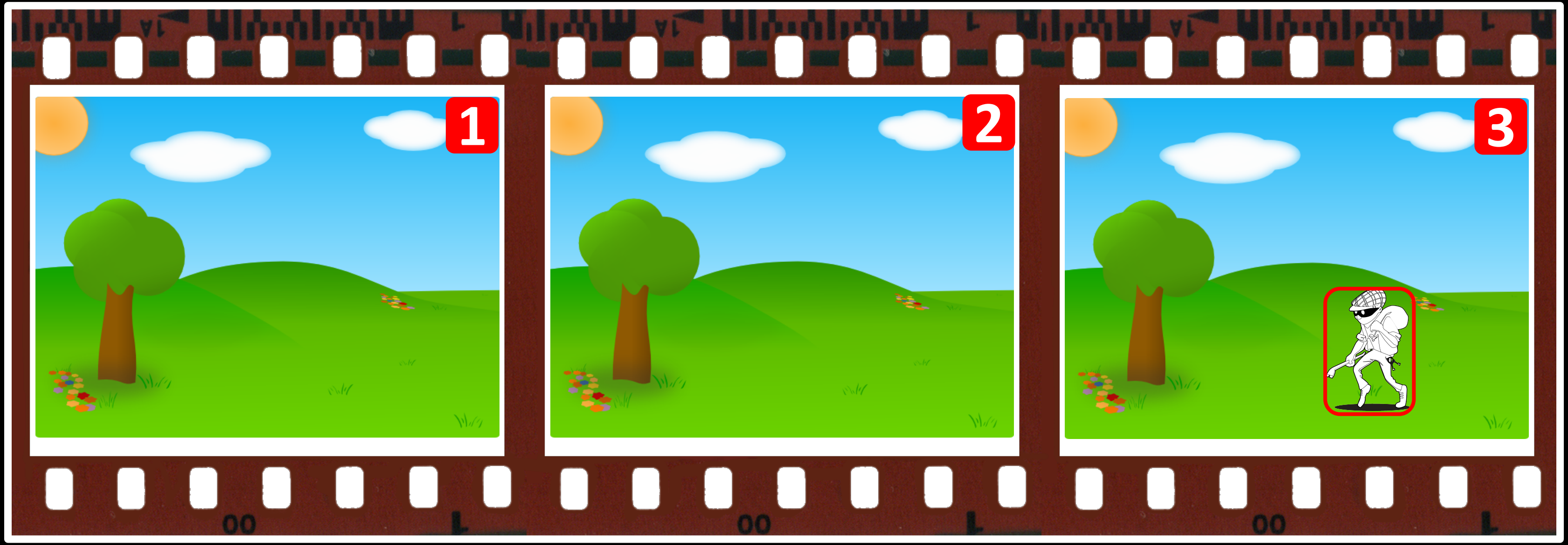
root

Inbox - My Google 08:35

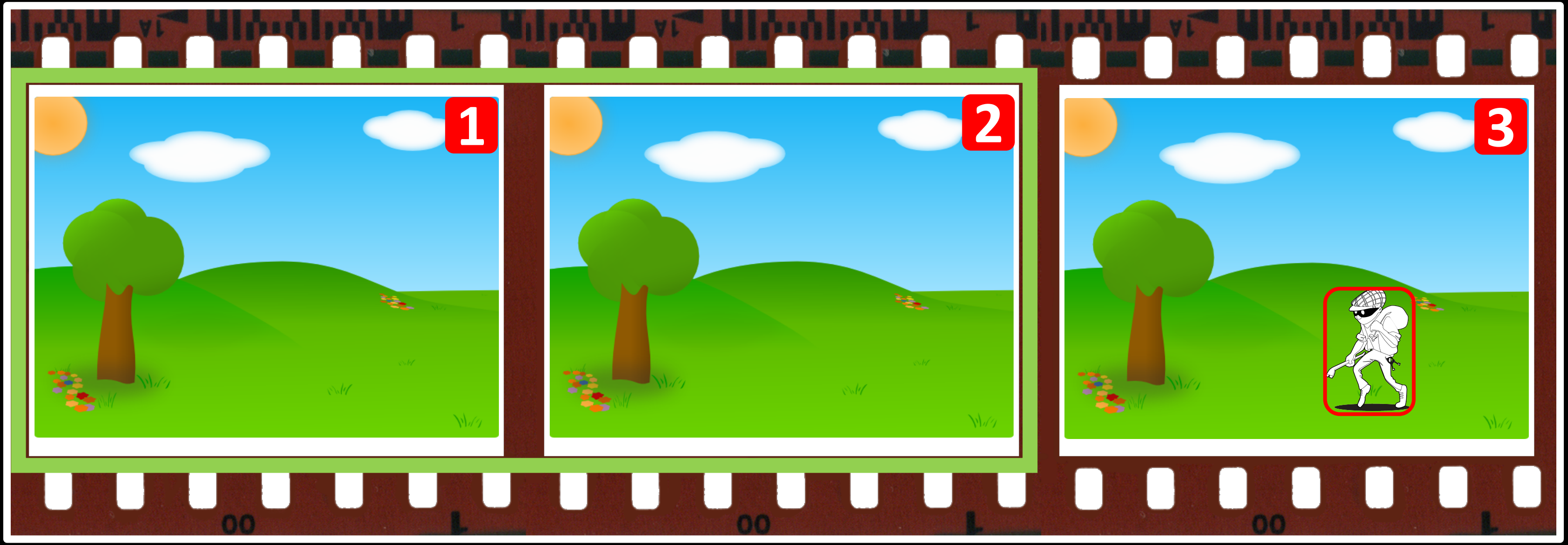
Your Security Camera has detected Motion!

To: Mark West

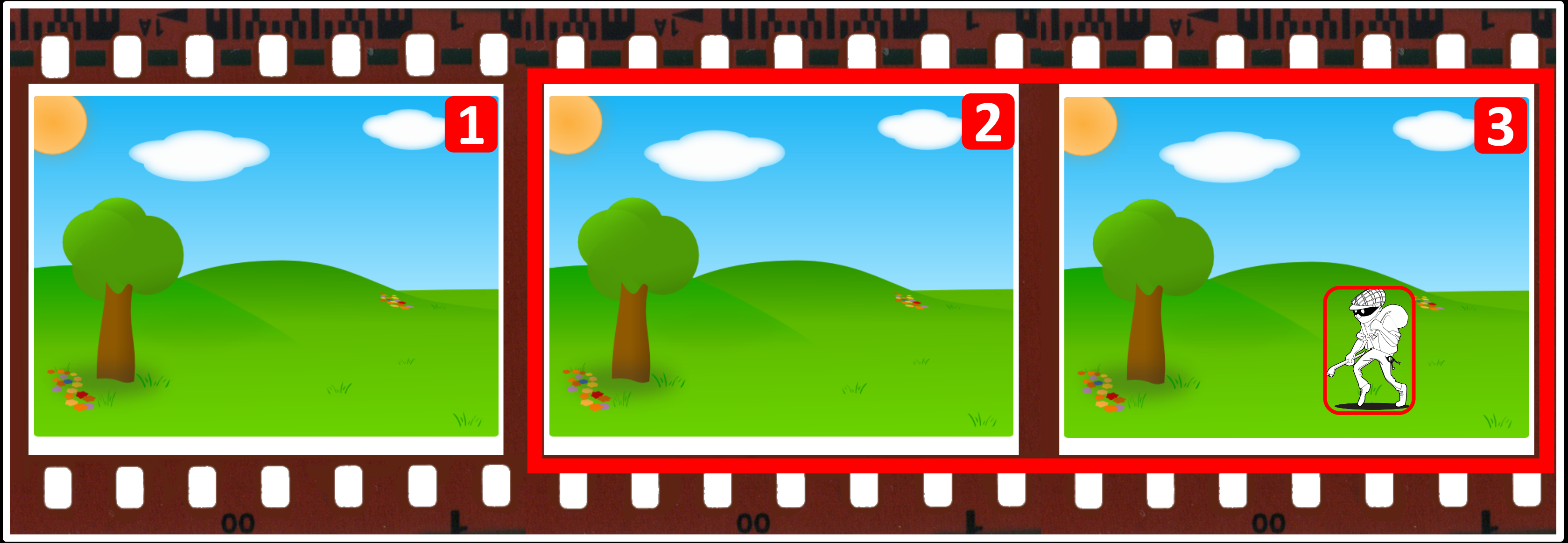
How the Motion Software works



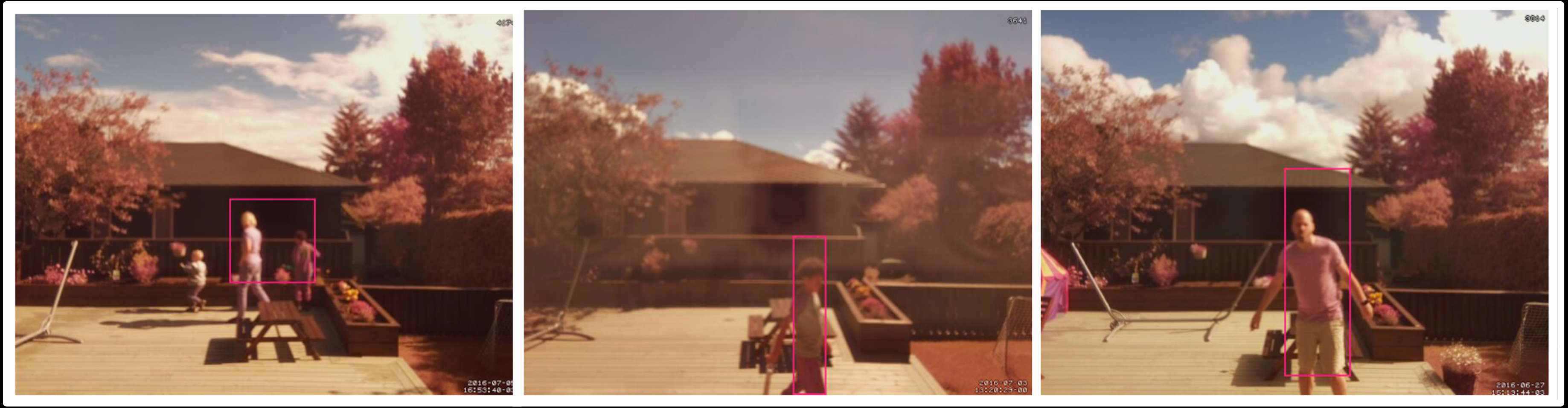
How the Motion Software works



How the Motion Software works



Alarm Snapshots from Web Camera



Project Requirements : Evaluation

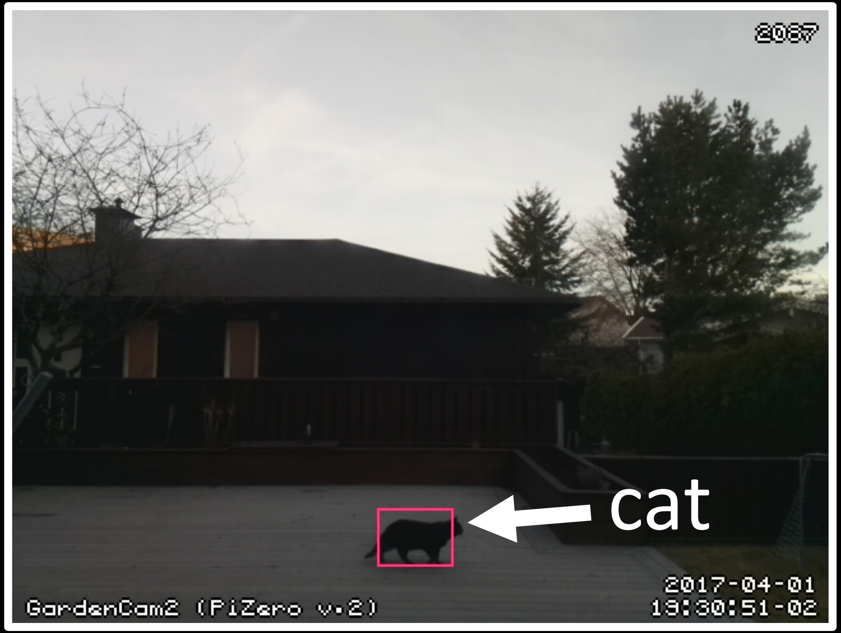
Functional

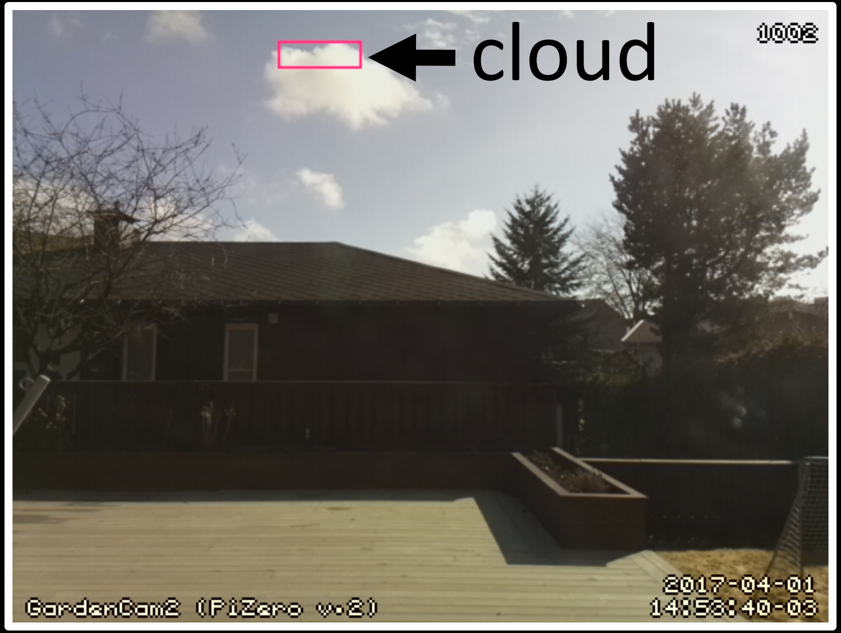
- Monitor activity in the garden. ✓
- Send warning when activity detected. ✓
- Live video stream. ✓

Non-functional

- In place as soon as possible. ✓
- Low cost. ✓
- Portable. ✓

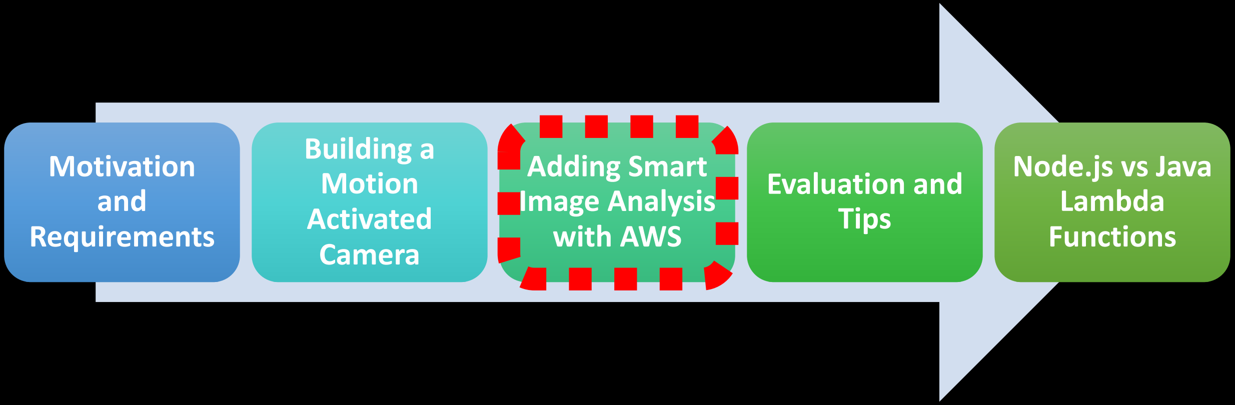
False Alarms from Web Camera





The Motion Software focuses on the **amount** of changed pixels, and not the **cause** of the changed pixels!

Adding Smart Image Analysis with AWS



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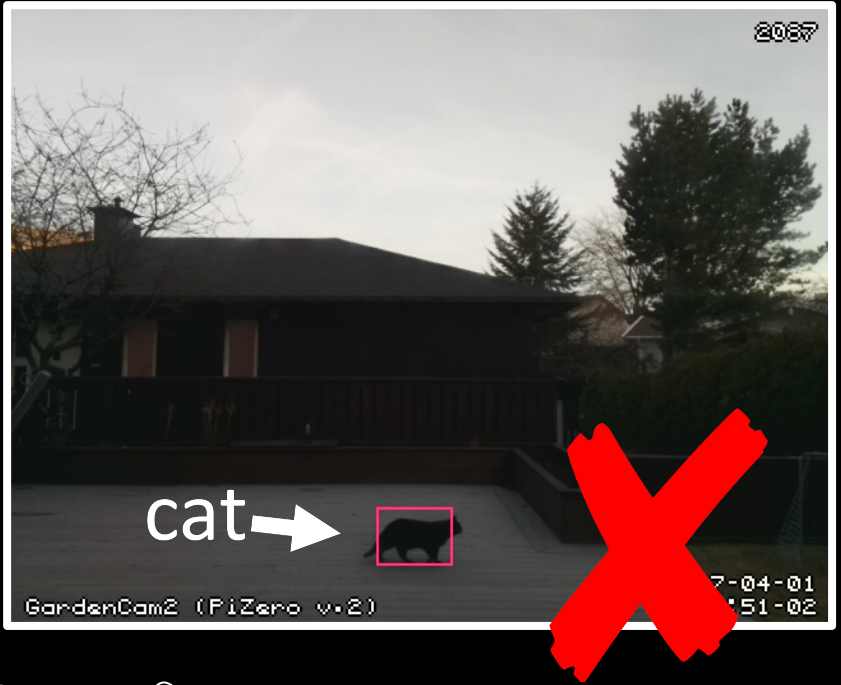
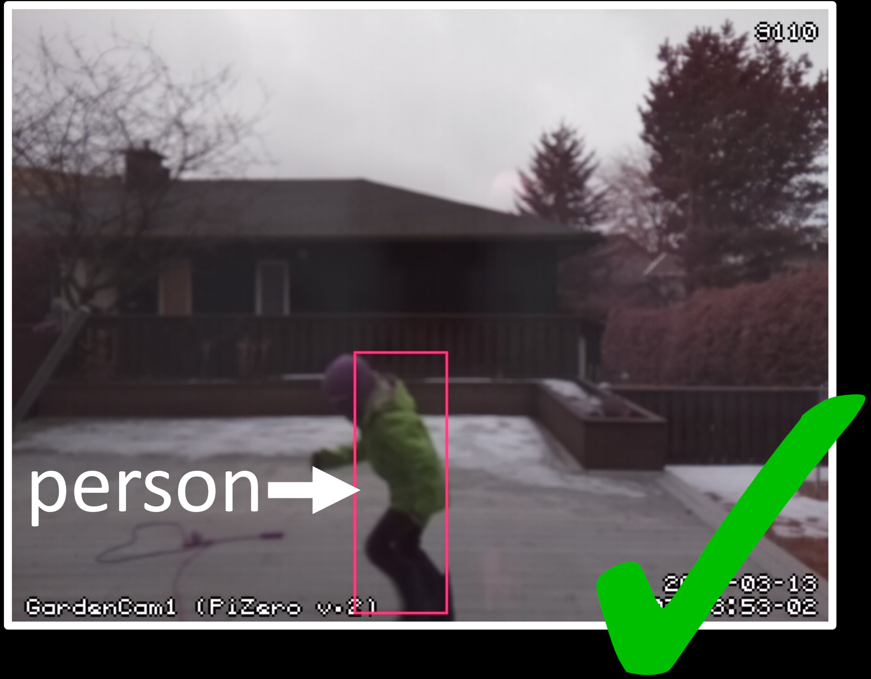
Improving Alarm Accuracy with Smart Image Analysis





Joker<?>

@markawest

Project Requirements Reloaded

Functional	Non-functional
• Monitor activity in our garden. • Send warning when activity detected. • Live video stream.	• In place as soon as possible. • Low cost. • Portable.

Project Requirements Reloaded

Functional

- Monitor activity in our garden.
- Send warning when **human** activity detected.
- Live video stream.

Non-functional

- In place as soon as possible.
- Low cost.
- Portable.

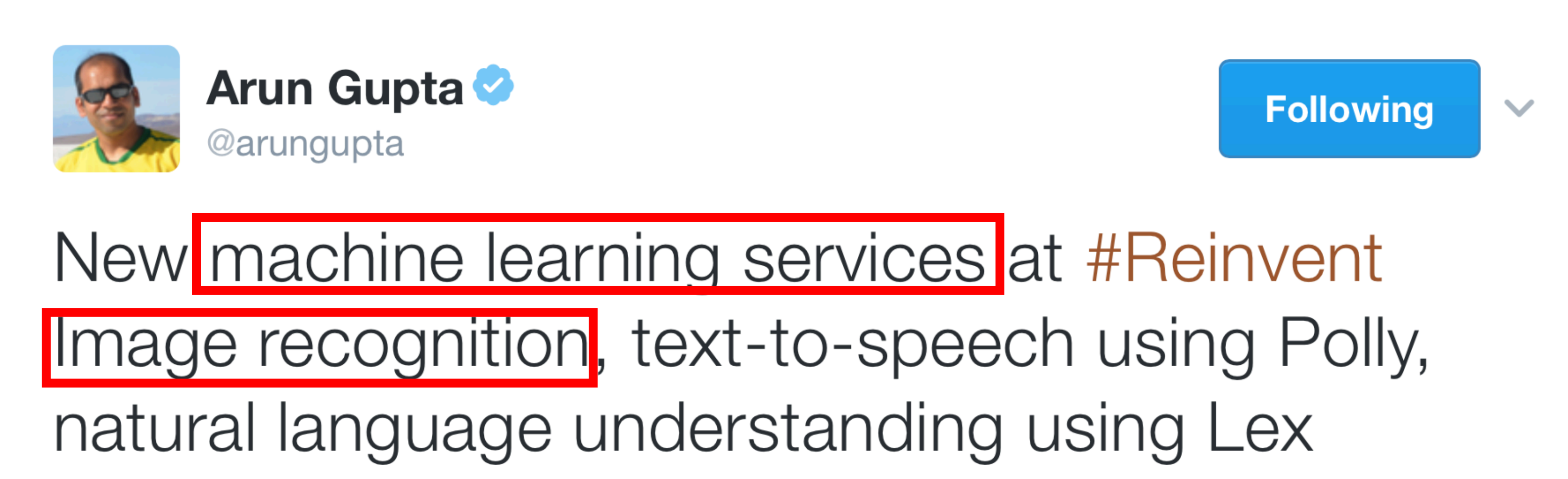
Finding an Image Analysis Solution

OpenCV

- Use **Face Detection** to find out if a human was in the snapshot.
- **Problem**: What if the subject was facing away from the camera, or wearing a mask?

TensorFlow

- Train and use a **Neural Network** to find humans in the snapshot.
- **Problem:** Potentially a fun project, but would take more time than I had available.



Arun Gupta
@arungupta

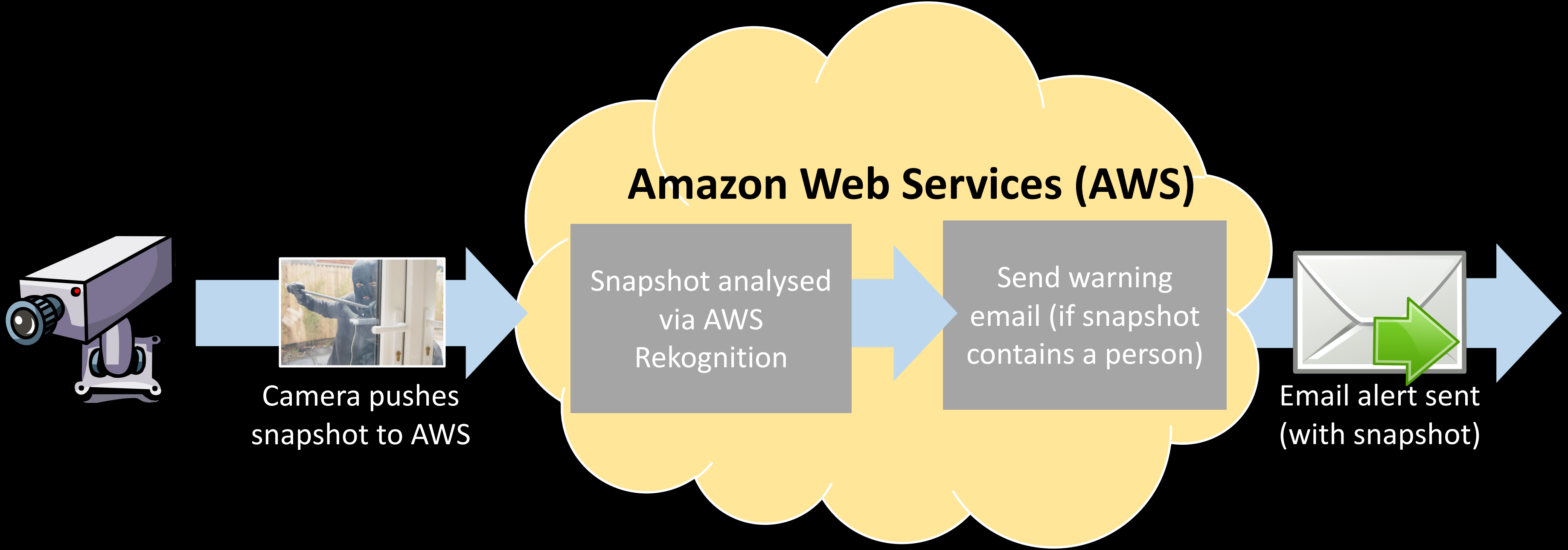
New machine learning services at #Reinvent
Image recognition, text-to-speech using Polly, natural language understanding using Lex

AWS Rekognition

- Part of **Amazon Web Services** suite of Cloud based services.
- **Image Analysis as a Service**, offering a range of API's.
- Built upon **Deep Neural Networks**.
- Officially launched in **November 2016**.
- Alternatives: Google Vision, MicroSoft Computer Vision, Clarafai.

AWS Rekognition Demo

Adding AWS to the Web Camera



Amazon Web Services (AWS)

Camera pushes snapshot to AWS

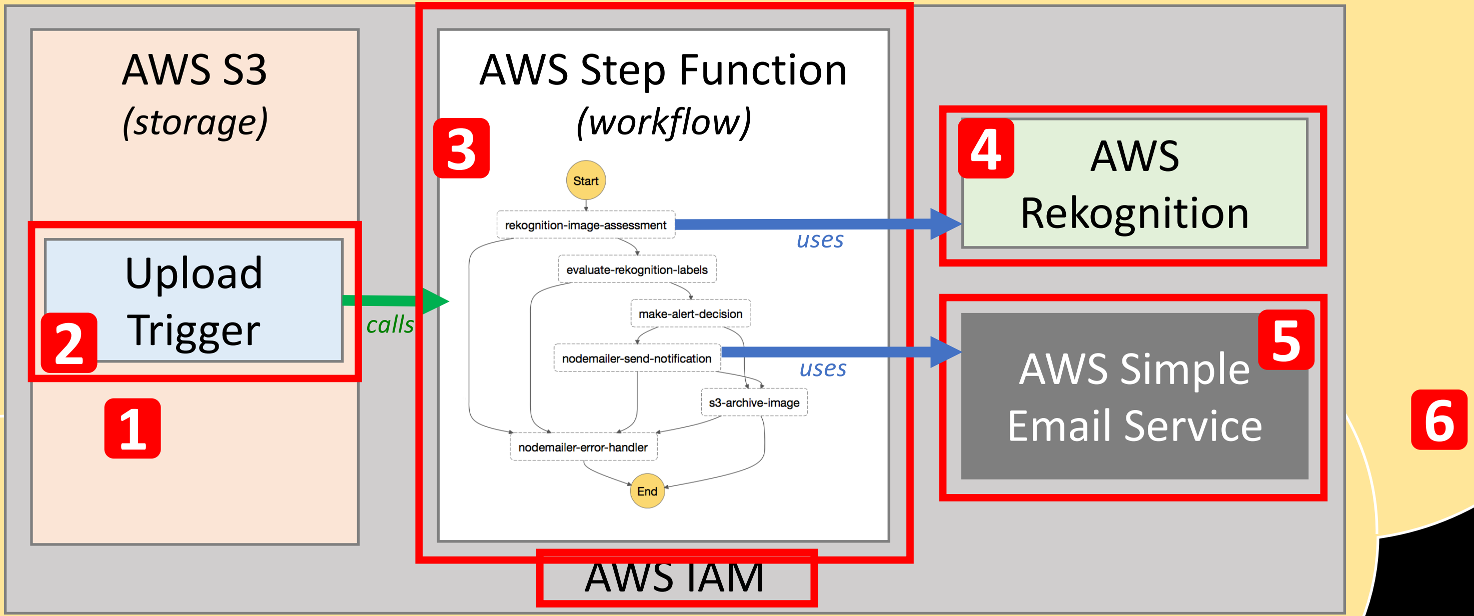
Snapshot analysed via AWS Rekognition

Send warning email (if snapshot contains a person)

Email alert sent (with snapshot)

Amazon Web Service Flow

Overview



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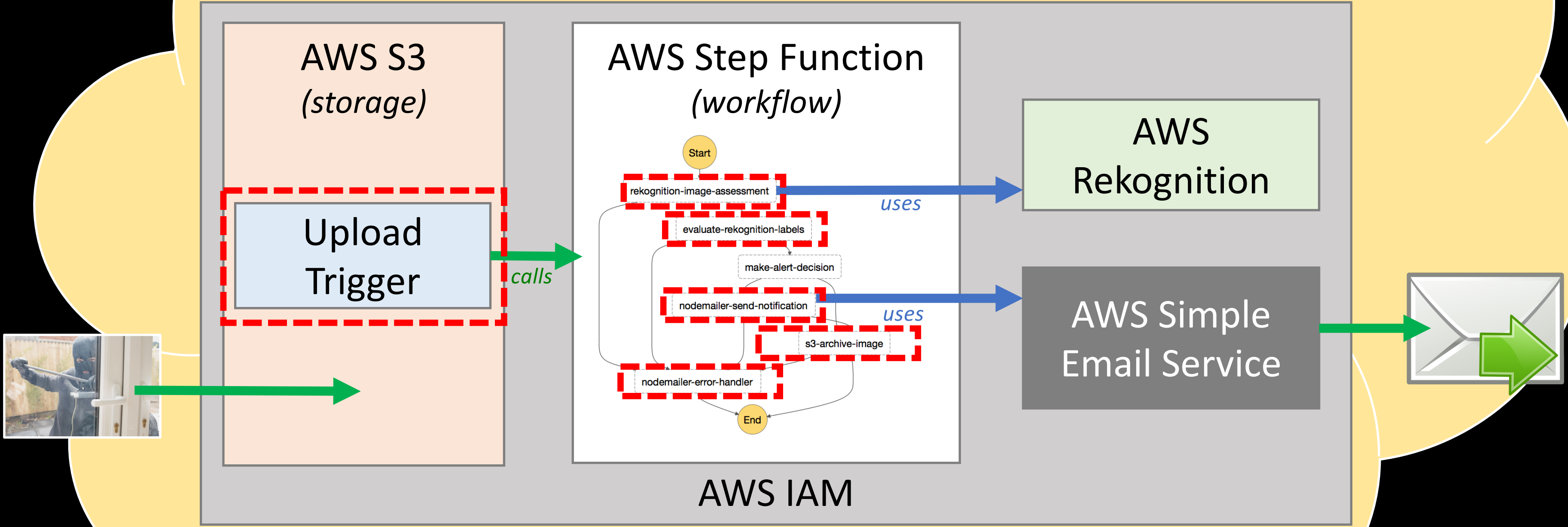
AWS Lambda Functions

Code Building Blocks (aka Microservices)



AWS S3

(storage)

Upload Trigger

calls

AWS Step Function

(workflow)

Start

rekognition-image-assessment

evaluate-rekognition-labels

make-alert-decision

nodemailer-send-notification

s3-archive-image

nodemailer-error-handler

End

uses

uses

AWS Rekognition

AWS Simple Email Service

AWS IAM

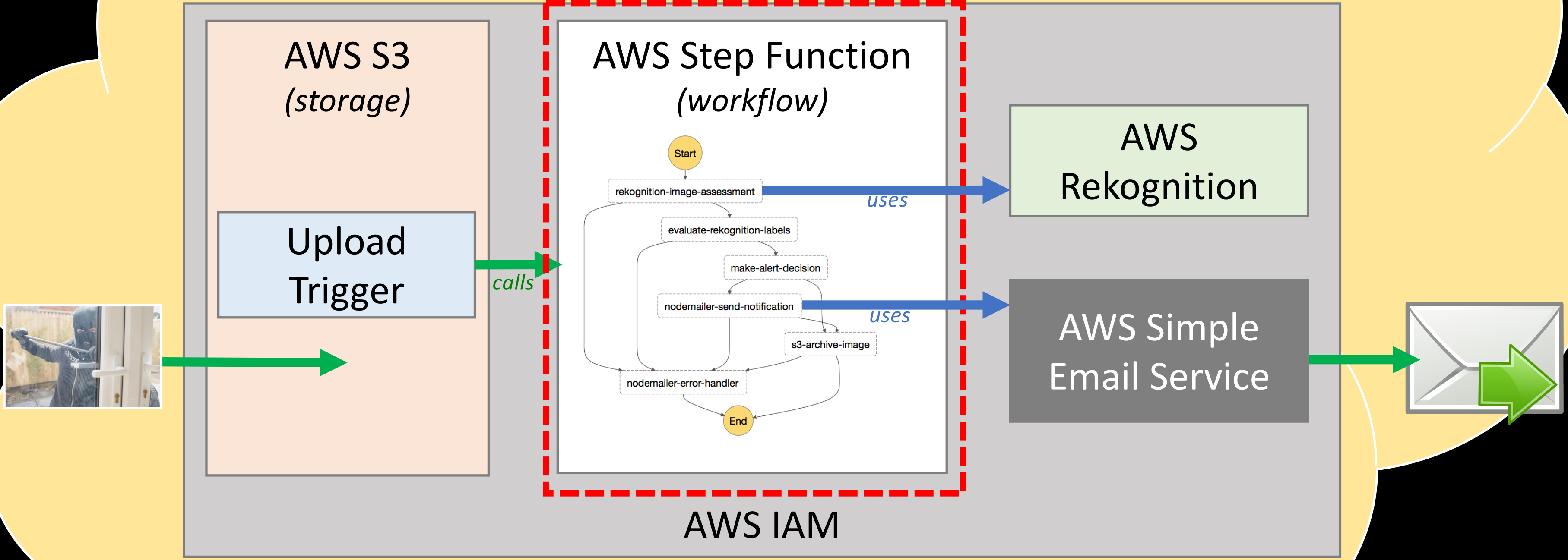
AWS Lambda Functions

- **Code units** based on Java, C#, Python or Node.js
- **Serverless**, no infrastructure to manage.
- **High availability** out of the box.
- **Pay as you go** model based on total **invocations** and **duration** - with a generous free tier.
- **Native AWS SDK** gives easy access to other AWS services.

AWS Lambda Demo

AWS Step Functions

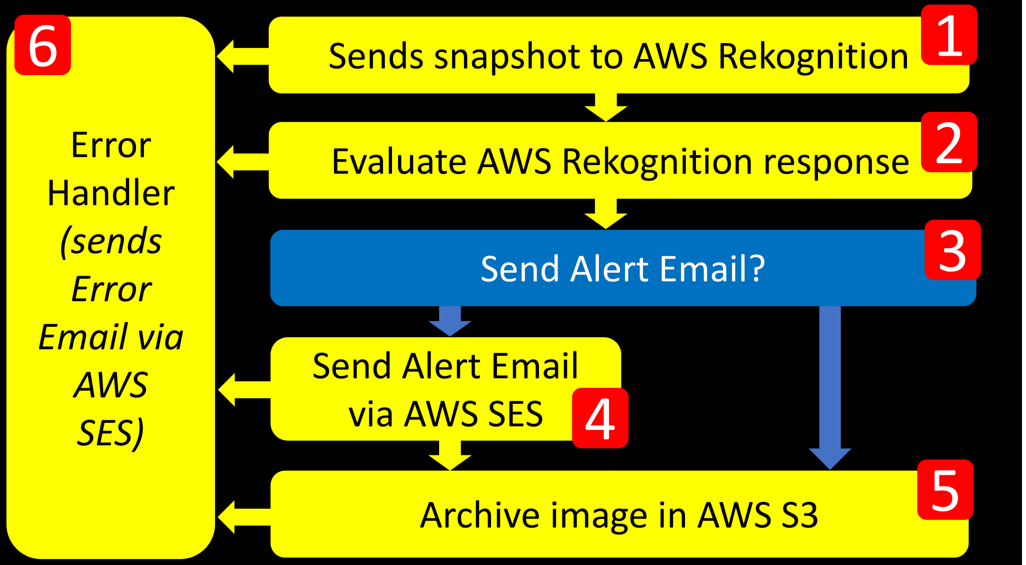
Orchestration of Lambda Functions



AWS Step Functions

- Coordinate and orchestrate Lambda Functions into **Workflows** or **State Machines**.
- Launched in **December 2016**.
- Defined via **JSON files**, displayed as visual workflows.
- Provide the **same benefits as AWS Lambda** (High Availability, Serverless, Scalable, “Pay as you go” pricing model).

Step Function for Image Processing



6 Error Handler *(sends Error Email via AWS SES)*

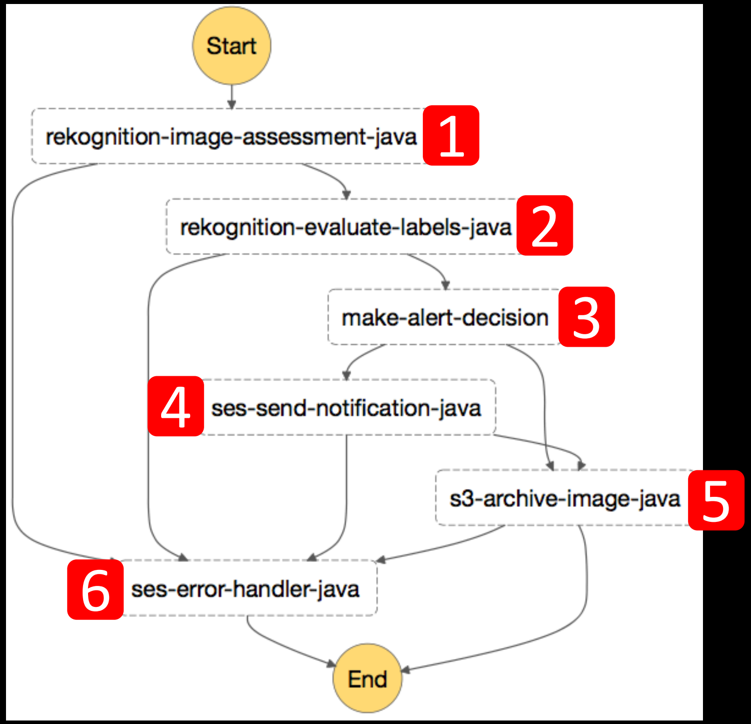
1 Sends snapshot to AWS Rekognition

2 Evaluate AWS Rekognition response

3 Send Alert Email?

4 Send Alert Email via AWS SES

5 Archive image in AWS S3


Start
rekognition-image-assessment-java 1
rekognition-evaluate-labels-java 2
make-alert-decision 3
4 ses-send-notification-java
s3-archive-image-java 5
6 ses-error-handler-java
End

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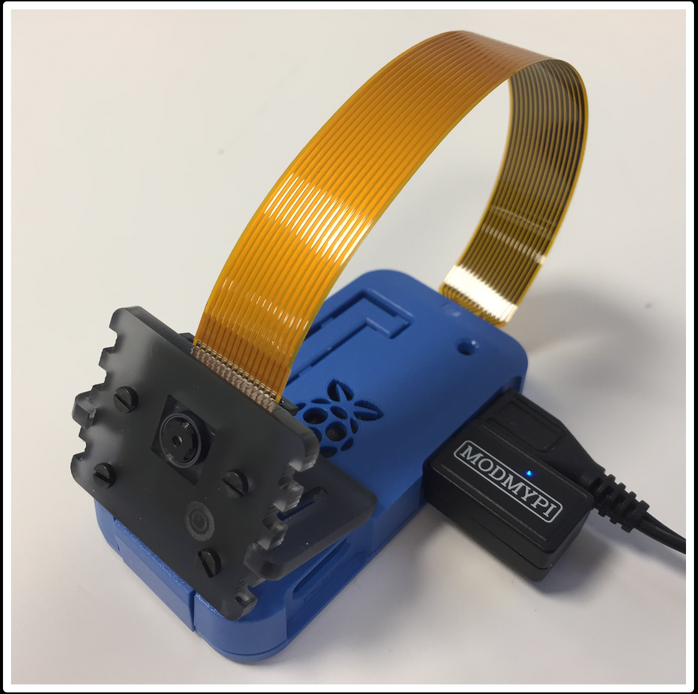
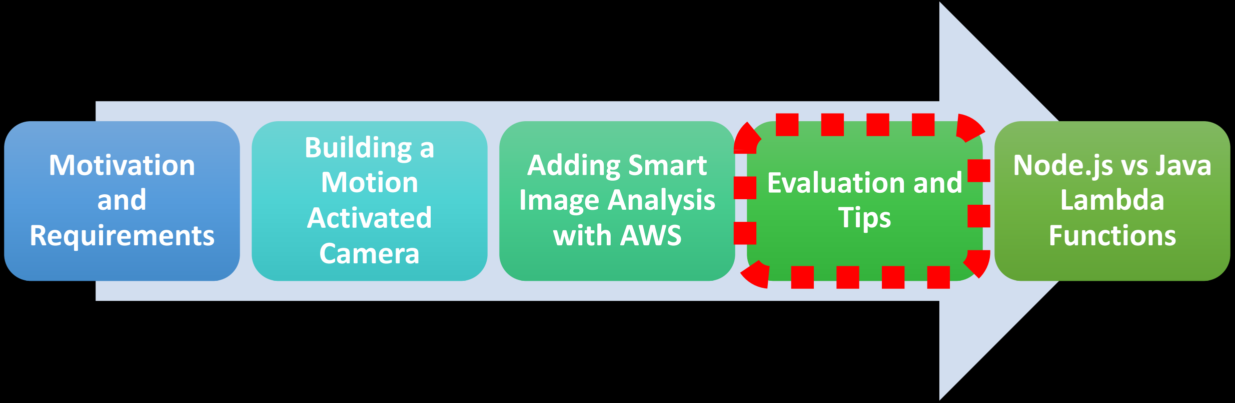
Smart Camera

(plus AWS Step Function)

Demo



Evaluation and Lessons Learned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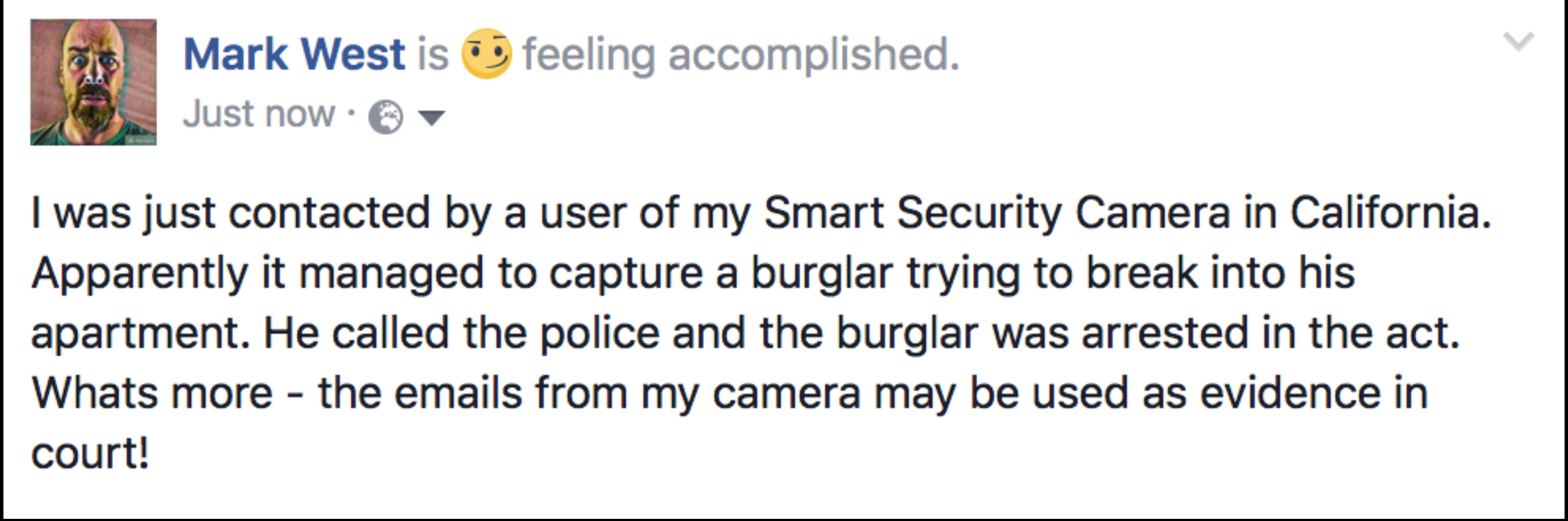
Project Requirements : Evaluation

Functional	Non-functional
• Monitor activity in the garden. ✓	• In place as soon as possible. ✓
• Send warning when **human** activity detected. ✓	• Low cost. ✓
• Live video stream. ✓	• Portable. ✓

“Fun project, but has it caught any **real** criminals?”



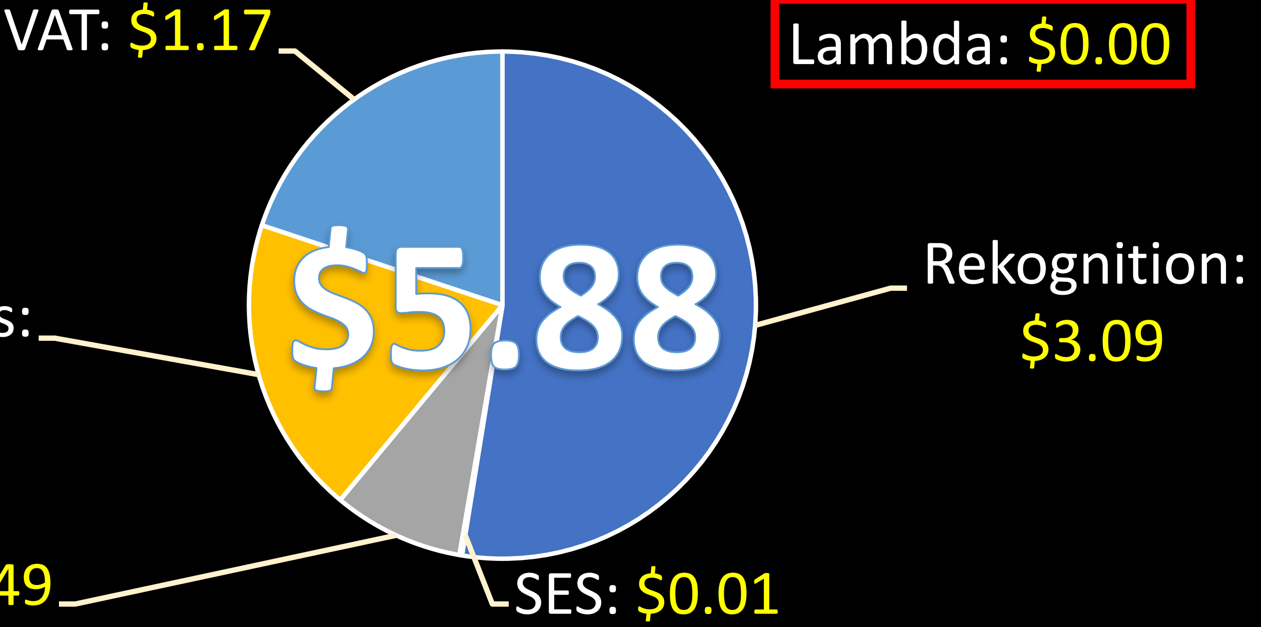
Mark West is 😏 feeling accomplished.

Just now · 🌐 ▾

I was just contacted by a user of my Smart Security Camera in California. Apparently it managed to capture a burglar trying to break into his apartment. He called the police and the burglar was arrested in the act. Whats more - the emails from my camera may be used as evidence in court!

AWS Monthly Cost : August 2017

(Based on 8093 images processed)



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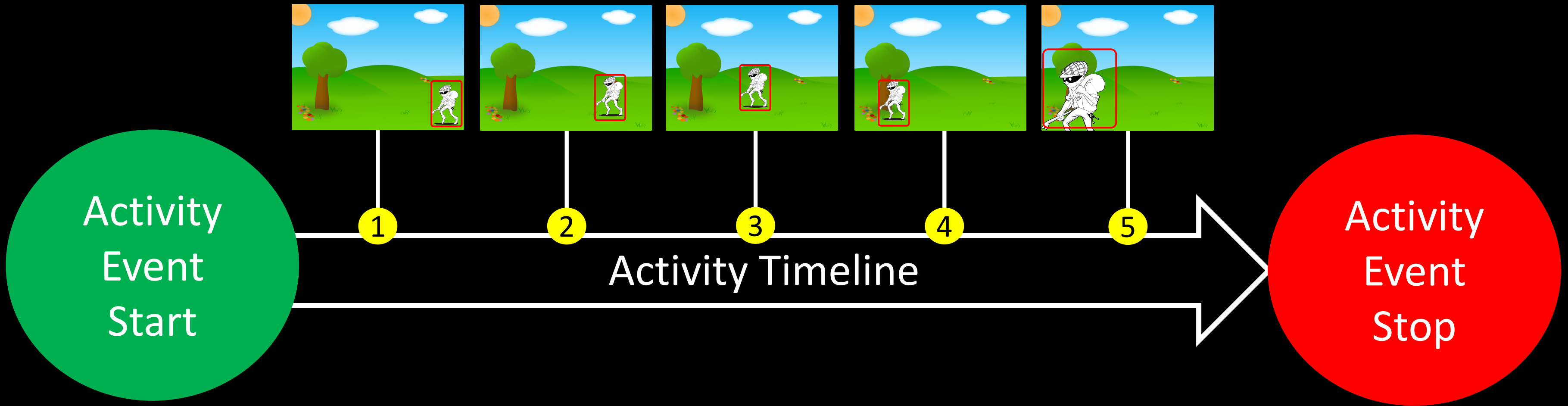
Which Image Should Motion Upload?



Activity Event Start

1

2

3

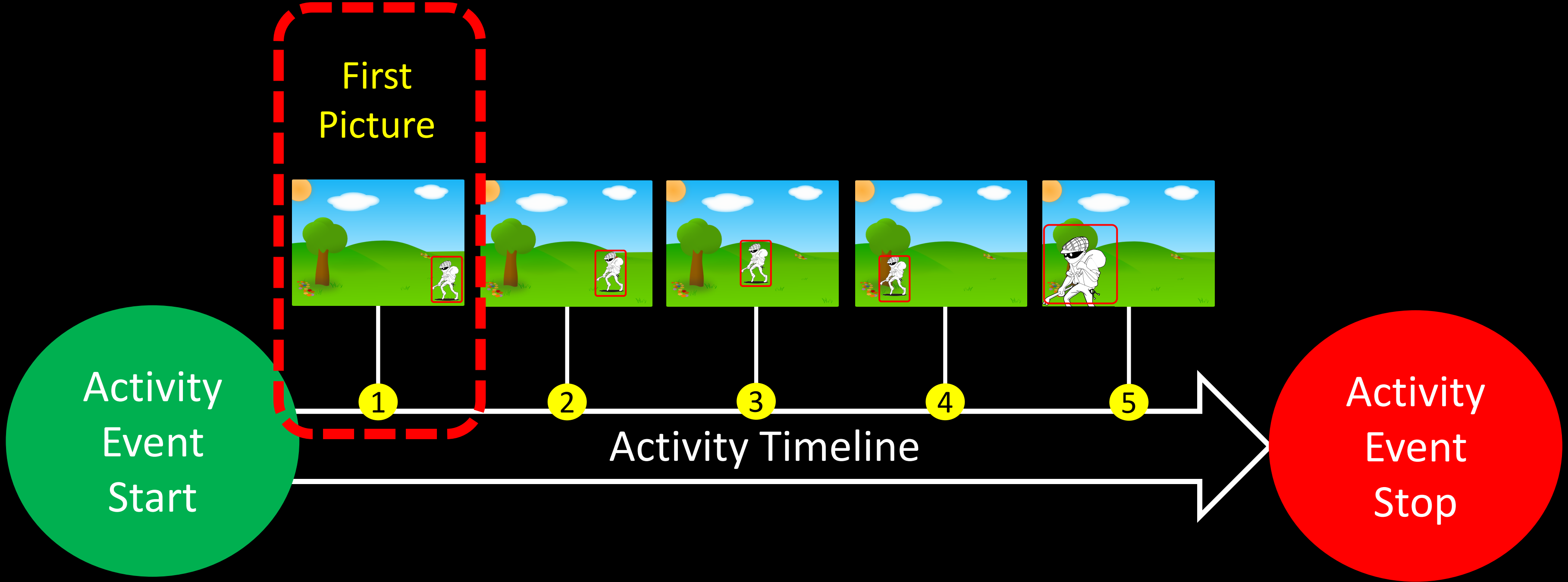
4

5

Activity Timeline

Activity Event Stop

Which Image Should Motion Upload?



First Picture

Activity Event Start

1

2

3

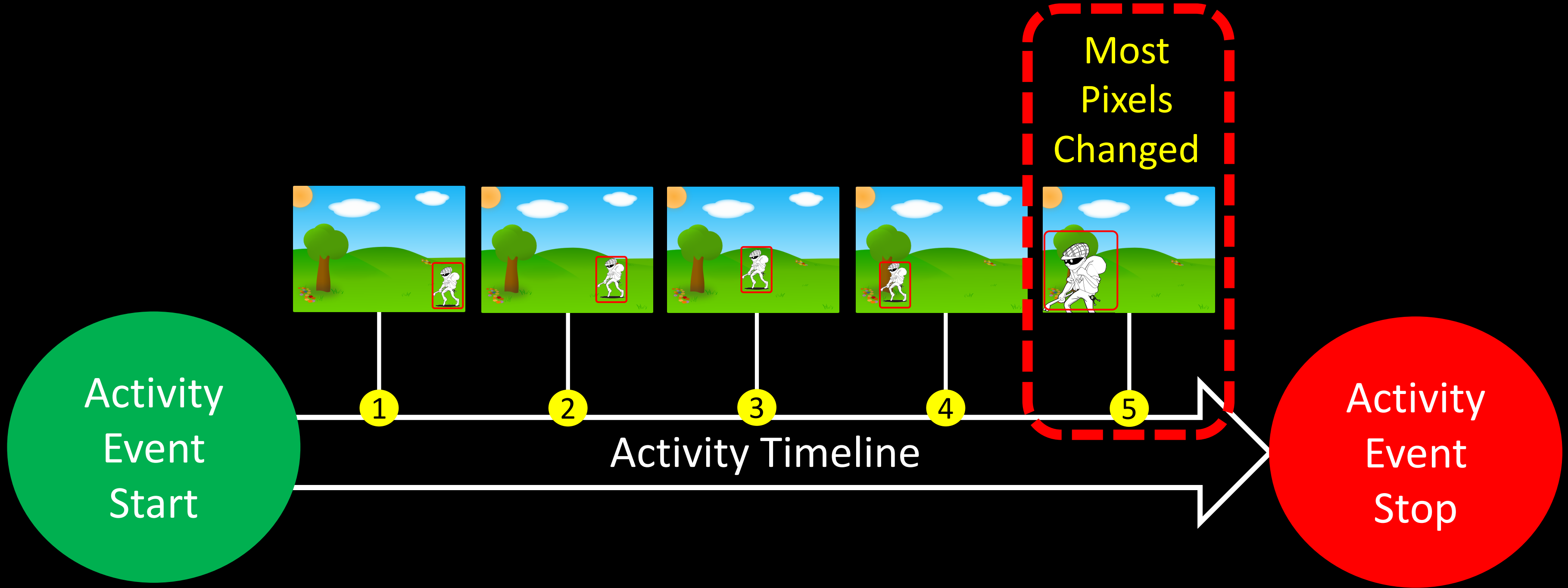
4

5

Activity Timeline

Activity Event Stop

Which Image Should Motion Upload?



Activity Event Start

1

2

3

4

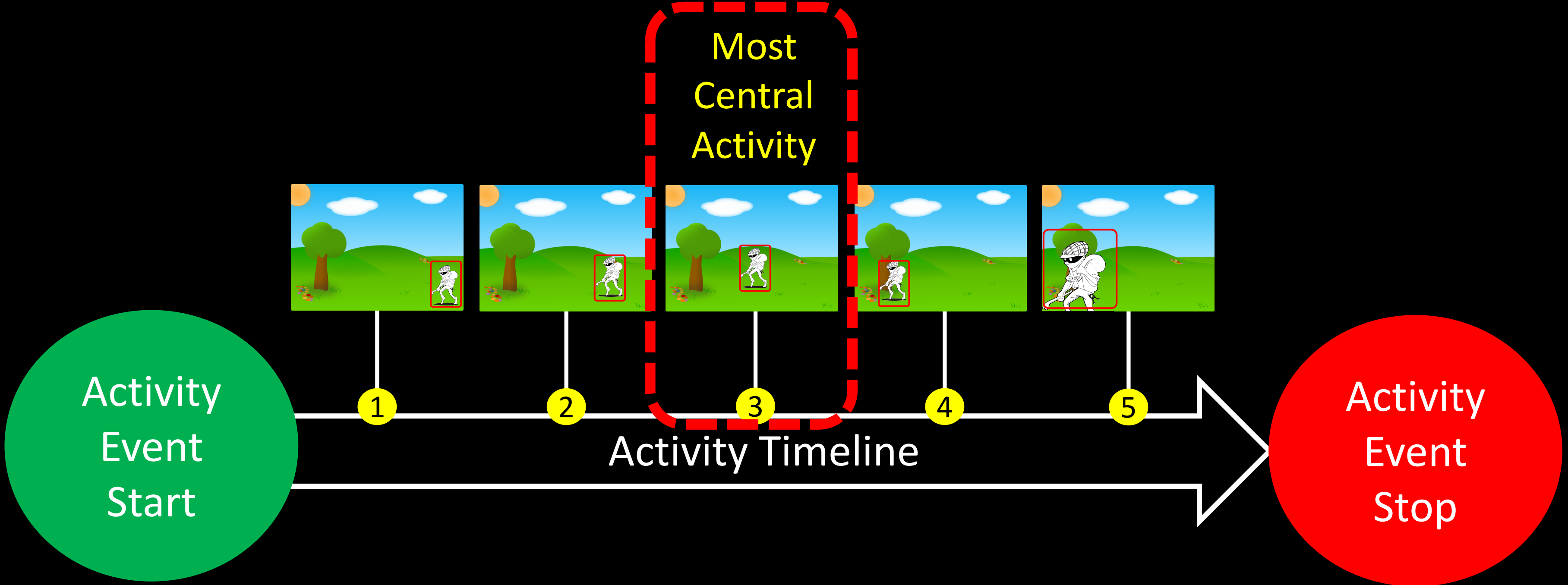
5

Most Pixels Changed

Activity Timeline

Activity Event Stop

Which Image Should Motion Upload?



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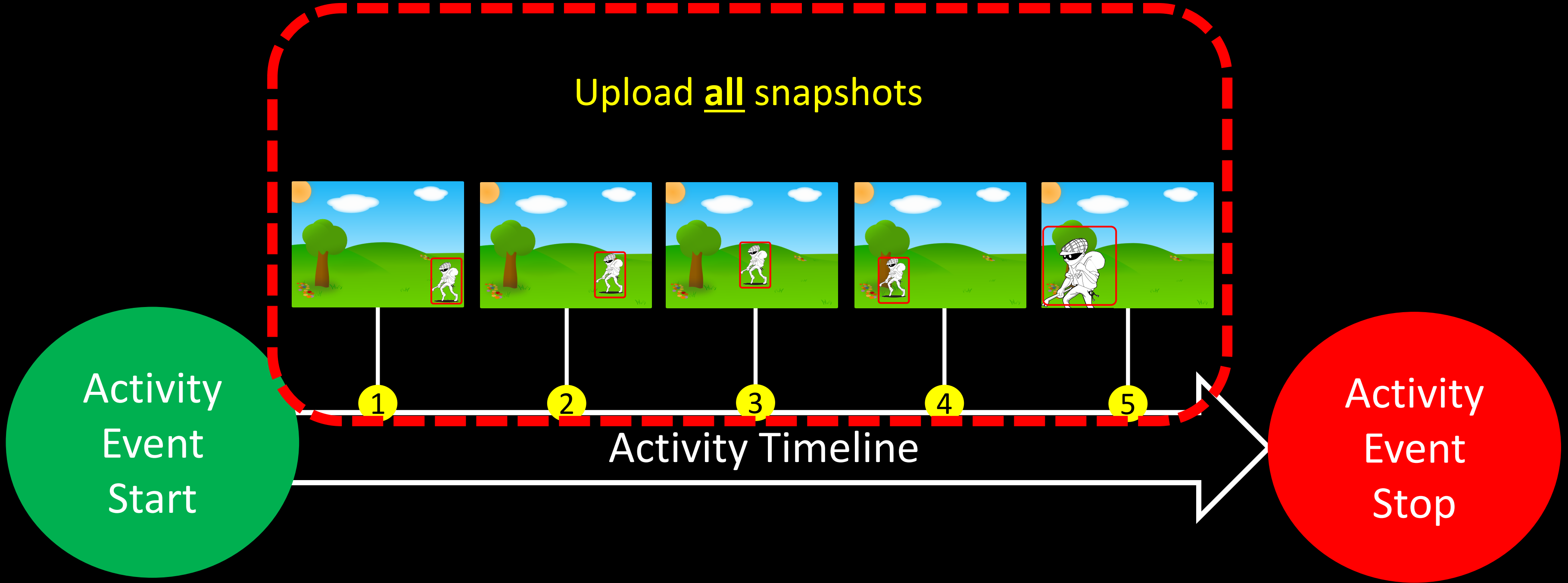
Which Image Should Motion Upload?



Upload **<u>all</u>** snapshots

Activity Event Start

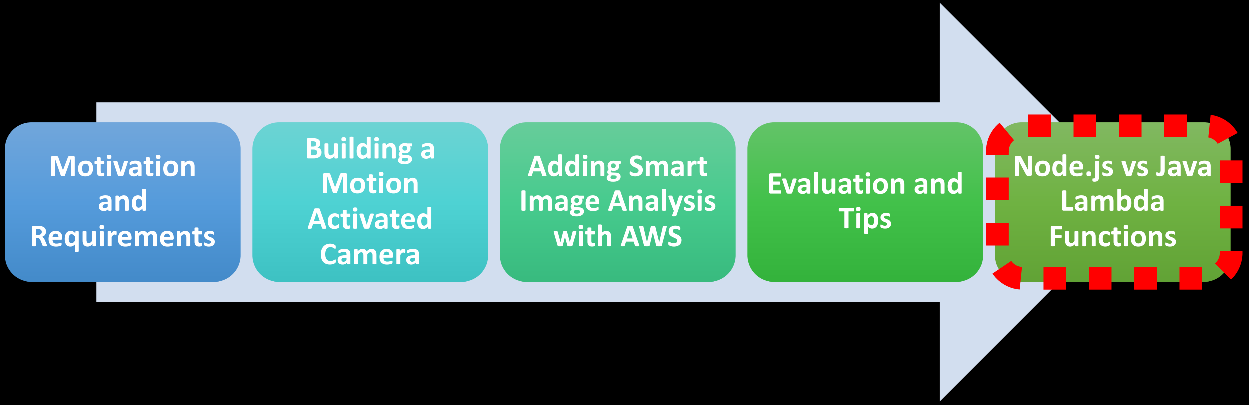
Activity Timeline

Activity Event Stop

Improving AWS Rekognition Hit Rate

Upload One Snapshot when activity detected	Upload Many Snapshots when activity detected
• **Lower cost**, due to less calls to the AWS stack.	• **Higher cost** due to increased calls to the AWS stack.
• Potentially **lower hit rate**.	• Potentially **higher hit rate**.

Node.js vs Java



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Java 8 vs. Node.js 6.10

1. Artefact Sizes
2. Memory Requirements
3. Performance and Cost

AWS Lambda Functions

Lambda Function	Purpose	AWS Service Calls
rekognition-image-assessment	Uses AWS Rekognition to generate a list of labels describing each uploaded picture.	AWS Rekognition
rekognition-evaluate-labels	Evaluates labels to find out if an alarm email should be sent.	-
ses-send-notification	Sends an alarm email via AWS SES when the smart security camera detects a person.	AWS SES
s3-archive-image	Moves the processed image to the correct archive location in S3.	AWS S3

Artefact Sizes

Lambda Function	Java	Node
rekognition-image-assessment	7.9 MB	813 bytes
rekognition-evaluate-labels	7.6 MB	677 bytes
ses-send-notification	8.7 MB	4.8 MB
s3-archive-image	7.6 MB	943 bytes

3 Reasons for the difference:

1. Java is generally more verbose.
2. Unused JAR's in Java Deployments.
3. AWS SDK is natively available to Node.js Lambda Functions.

Memory Requirements

- My **Node.js 6.10** Lambda Functions were happy with **128 MB** memory.
- My **Java 8** Lambda Functions required **256 MB** to avoid *OutOfMemory* Errors.

Memory Allocated	AWS Free Seconds Per Month	AWS Price Per Second
128 MB	3 200 000	$0.00000208
192 MB	2 133 333	$0.00000313
256 MB	1 600 000	$0.00000417
1536 MB	266 667	$0.00002501

Testing Cost & Performance : Method

- Simulate **1500 alerts** (not false alarms).
- Triggered in **batches of 30, with a 60 second pause**.
- Memory set to **256 MB for both Node.js and Java**.
- Prior to testing, Lambda Functions **“rested” for 90 minutes**.
- **Ran tests 5 times** to ensure consistency of results.

Test Results

Lambda Function	Average Duration Java	Average Duration Node.js
rekognition-image-assessment	2250 ms	1720 ms
rekognition-evaluate-labels	6.57 ms	1.61 ms
ses-send-notification	3040 ms	996 ms
s3-archive-image	1050 ms	364 ms

Why was Java slower on AWS Lambda?

- **Cold Starts** (5-10 times longer on Java).
- Lack of **JVM tuning** options on AWS.
- Different **underlying implementations**.
- Use Case for **Project Jigsaw**?

Does Java belong on AWS Lambda?

- Of course there it does!
- Evaluate your **use case** and **potential costs** first.
- Try **different memory settings** to reduce costs.
- Remember the **Free Tier**!

Would you like to know more?

The Heisencat by Jon Rohan

github.com/markwest1972/smart-security-camera

Code & instructions for replicating project

Links to blog entries describing project

THANKS FOR LISTENING!

@markawest