Team members:

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I. Project Drivers

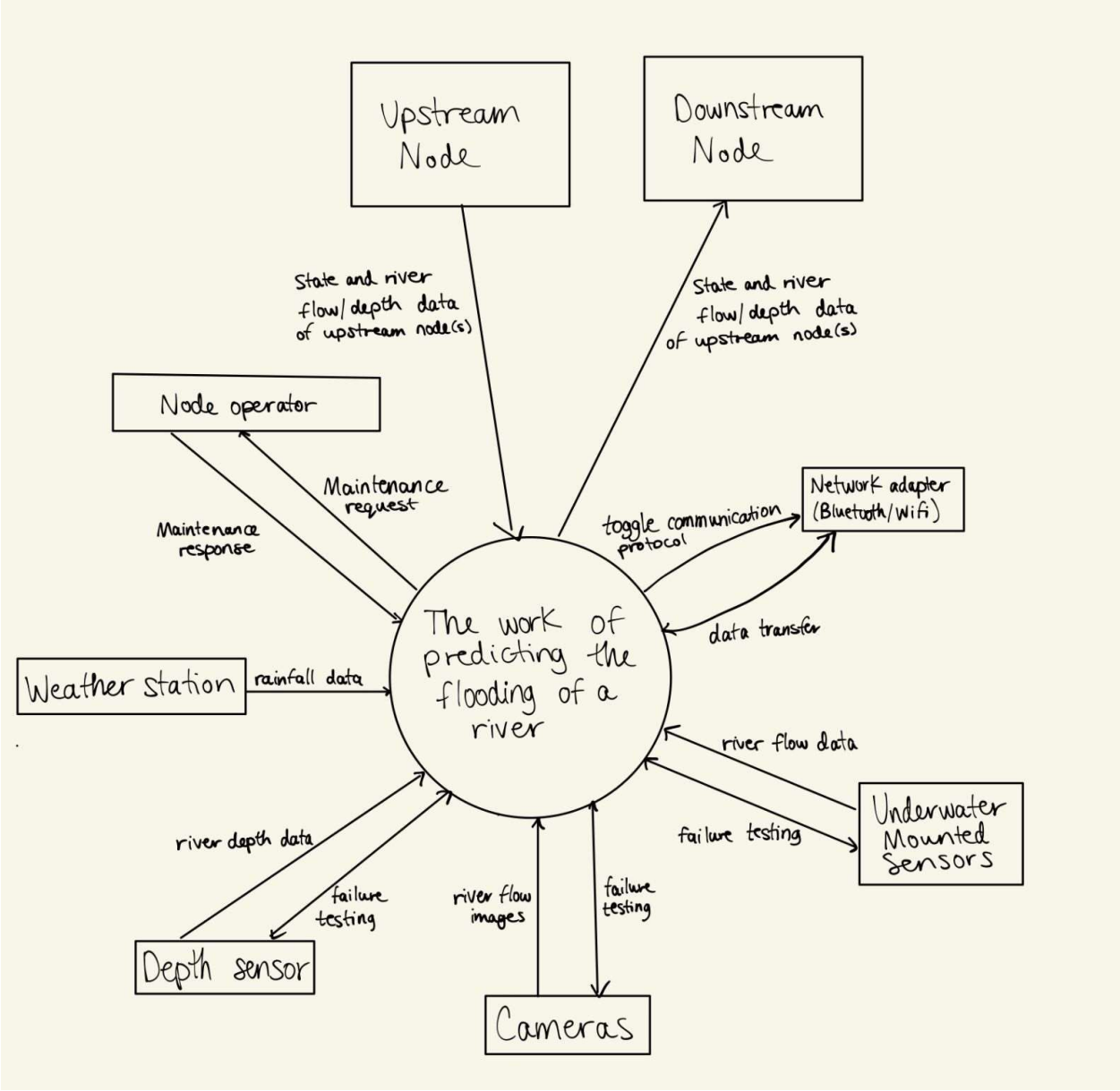
1. Purpose of the project: Large floods have become more frequent across the world due to heavy rainfall or spring snowmelt. This is problematic because flooding rivers can cause major damage and take many lives. The goal of RiverAlert is to predict the flooding of a river.
2. Stakeholders: The stakeholders for RiverAlert are Dr. Lutz, Aishwarya, and Olukorede. They could also include government officials and members of the public for areas the product will be deployed in.

II. Project Constraints

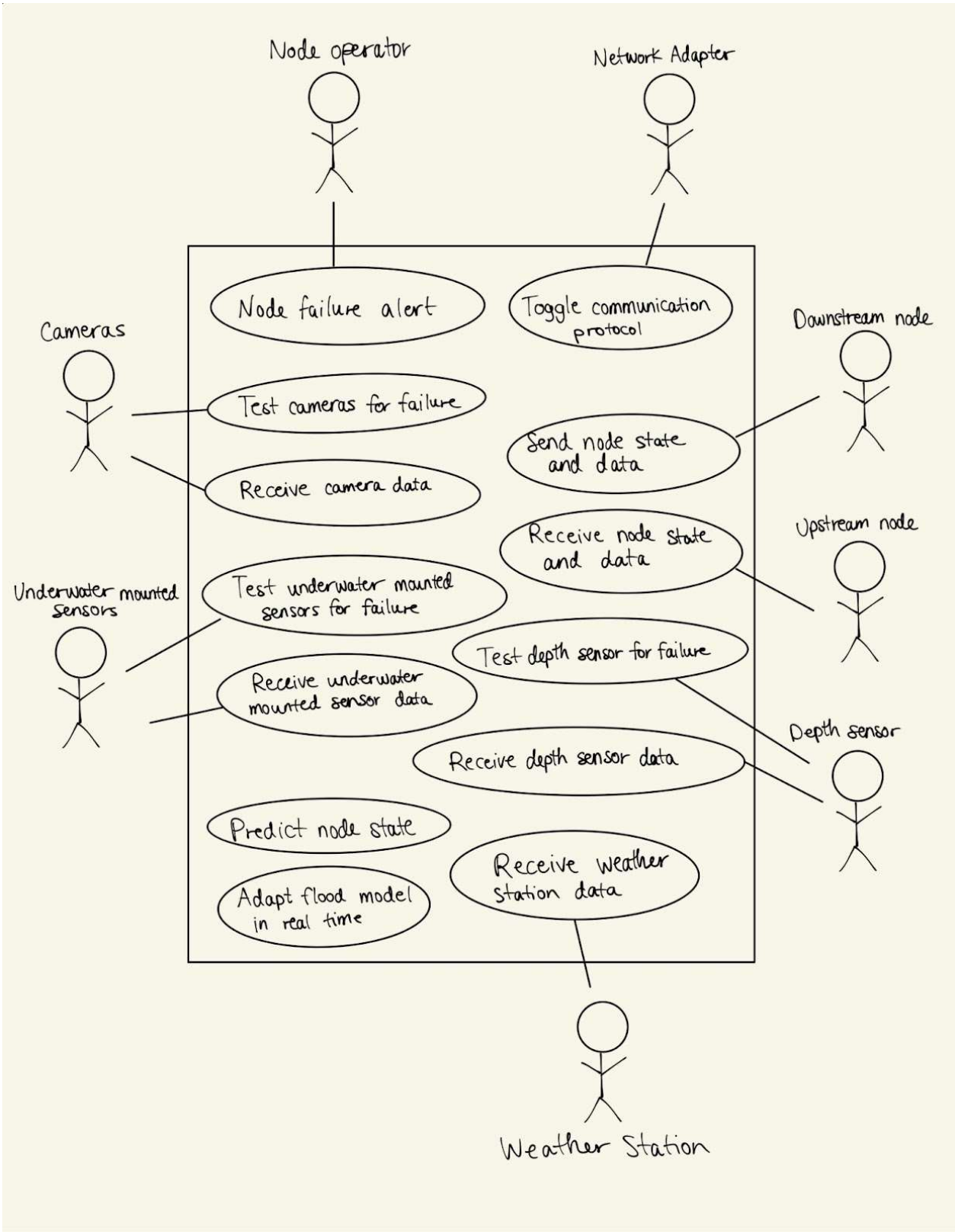
1. Mandated constraints
   Description: The product shall be inexpensive
   Fit criterion: The product's development shall cost less than the budget of $10,000
   Rationale: The product is meant to prevent infrastructure damage and save lives in rural areas, so it should not be expensive to build. This ensures that the product is affordable since this product is meant to help society and not make a profit.
2. Naming conventions and terminology:
   - Depth sensor: sensor that measures river depth at a certain point
   - Underwater mounted sensor: sensor that measures river surface flow at a certain point
3. Relevant facts and assumptions
   - A node will collect data from its connected sensors on a regular time interval
   - Nodes can send data downstream to be used for computation if a flood is approaching or occurring, but they can also send data upstream since camera data can be processed by a group of nodes
   - There is an operator who performs maintenance on failed nodes/sensors
   - Weather station data can be accepted and used for training the flood prediction model

III. Functional Requirements

1. Scope of the work



2. Scope of the software project



PUC name: Receive depth data
Trigger: Time checkpoint reached for requesting data
Preconditions: The depth sensor must be installed and connected to its corresponding node.
Interested stakeholders: Node network operator (addressed in assumptions), residents of the area surrounding the river, environment agency
Actor: Depth sensor, operator
Steps:

1. Product requests data from depth sensor
2. Depth sensor receives request for current local data
3. Depth sensor sends data to product
   E3.1 Depth sensor fails and doesn't send data
   E3.1 Product notifies operator of depth sensor failure

Outcome: System receives depth data or operator notified of depth sensor failure

PUC name: Compute local node's state (normal/flooding imminent/flooding occurring)
Trigger: Time checkpoint reached for requesting data
Preconditions: The camera(s), underwater mounted sensor, and the depth sensor are installed and connected to their corresponding node. If an upstream node exists, there is a connection to it to receive upstream river data.
Interested stakeholders: Residents of the area surrounding the river, operator, environment agency
Actors: Camera(s), underwater sensor, depth sensor, upstream node
Steps:

1. Upstream node sends data to product
2. Upstream node sends computed state to product
3. Depth sensor sends data to product
4. Camera sends data to product
   A4.1 Underwater sensor sends data to product
   A4.2 Camera and underwater sensor send data to product
5. Product computes local node's state using local data only if upstream node state is normal
   A5.1 Product computes local node's state using local and upstream data if upstream node state is flood imminent or flood occurring

Outcome: Local node's state is computed

PUC name: Send local data to downstream node
Trigger: Time checkpoint reached for sending data downstream
Preconditions: Local data received from the sensors
Interested stakeholders: Residents of the area surrounding the river, operator, environment agency
Actor: Downstream node, network adapter

Steps:

1. Product computes local node's state
2. Network adapter switches communication protocol to Bluetooth if node's state is normal
   A2.1 Network adapter switches communication protocol to Wifi if node's state is flood imminent or flood occurring
3. Product sends local data to downstream node

Outcome: Local data has been successfully transmitted to the downstream node

3. Functional requirements:

FR1.

Description: The product shall keep regular time intervals.
Fit criterion: Every five seconds, the product shall restart the timer

FR2.

Description: When the time interval is reached, the product shall request river depth data from the depth sensor.
Fit criterion: The depth sensor shall receive a river depth data request 98% of the time the time interval is reached.

FR3.

Description: The product shall accept data describing the river's depth from the depth sensor.
Fit criterion: The recorded river depth readings shall be identical to the readings as recorded by the depth sensor.

FR4.

Description: If the depth sensor does not respond with data upon request, then the product shall alert the operator of depth sensor failure.
Fit criterion: The operator shall receive a notification from the system if a depth sensor fails with 95% accuracy.

FR5.

Description: When the time interval is reached, where a camera is connected, the product shall request image data from the camera.
Fit criterion: The camera shall receive an image data request 98% of the time the time interval is reached.

FR6.

Description: When the time interval is reached, where a mounted underwater sensor is connected, the product shall request river flow data from the underwater sensor.
Fit criterion: The underwater sensor shall receive a river flow data request 98% of the time the time interval is reached.

FR7.

Description: Where a camera is connected, the product shall accept image data from a camera.
Fit criterion: The recorded image data shall be identical to the image data as sent by the camera.

FR8.

Description: Where an underwater mounted sensor is connected, the product shall accept data describing the river's surface flow from an underwater mounted sensor.
Fit criterion: The recorded surface flow data shall be identical to the readings as sent by the underwater sensor

FR9.

Description: Where an upstream node is connected, the product shall accept the computed state of the upstream node and its data.
Fit criterion: The state and data stored by the local node is identical to the state and data computed and sent by the upstream node.

FR10.

Description: Where a downstream node is connected, the product shall send the computed state and its local data to the downstream node.
Fit criterion: The state and data stored by the downstream node is identical to the state and data computed and sent by the local node.

FR11.

Description: The product shall check the upstream node's state before computing its local state.
Fit criterion: Before the local node computes its state, the local node has stored the state sent by the upstream node.

FR12.

Description: While the upstream node's state is normal, the product shall use data from sensors connected to the local node to compute its state.

FR13.

Description: While the upstream node's state is flood imminent or flood occurring, the product shall use local data and the upstream node's data to compute its local state.

FR14.

Description: While the node is in the normal state, the product shall use Bluetooth for internode communication.

Fit criterion: Bluetooth transmitter shall be active for communication if the computed state of the node is normal.

FR15.

Description: While the node is in either the flood imminent or flood occurring state, the product shall use Wifi for internode communication.

Fit criterion: Wi-fi transmitter shall be active for communication if the computed state of the node is either flood imminent or flood occurring.

FR16.

Description: When the local node's state has been computed, the product shall send its state and data to the downstream node.

Fit criterion: The downstream node shall receive a state and data identical to the state computed and data in the local node in 0.5 seconds for 98% of the events.

FR17.

Description: Where a smart node is present, while a flood is imminent or occurring, the product shall distribute processing of camera images to other nodes on the network.

Fit criterion: While a flood is imminent or occurring, nodes connected to a smart node shall receive partitioned image data for processing in 0.5 seconds.

FR18.

Description: When the state of a node is computed as flood imminent or flood occurring, the product shall send SMS alerts notifying of a flood.

Fit criterion: A tester shall receive an SMS alert within 1 minute 99% of the time a node computes its state as flood imminent or flood occurring.

FR19.

Description: When the state of a node is computed as flood imminent or flood occurring, the product shall update the public website.

Fit criterion: The public website shall be updated within 1 minute 99% of the time a node computes its state as flood imminent or flood occurring.

FR20.

Description: When the state of a node is computed as flood imminent or flood occurring, the product shall send a local audio alert.

Fit criterion: A local audio alert shall be sent within 1 minute 99% of the time a node computes its state as flood imminent or flood occurring.

FR21.

Description: When the failure of a connected node is detected, the product shall send an alert to the operator that a node has failed.

Fit criterion: The operator shall receive a notification within 1 minute if a node fails with 98% accuracy.

FR22.

Description: The product shall accept weather station data.

Fit criterion: The accepted weather station data shall be identical to the data recorded at the transmitting weather station

FR23.

Description: The product shall allow an operator to turn on weather station data usage for the flood prediction model.

FR24.

Description: The product shall allow an operator to turn off weather station data usage for the flood prediction model.

FR25.

Description: While weather station data usage is on, the product shall incorporate weather station data in the data for the flood prediction model.

Fit criterion: Data added to the flood prediction dataset should include weather station readings when weather station data usage is on

FR26.

Description: While weather station data usage is off, the product shall not incorporate weather station data in the data for the flood prediction model.

Fit criterion: No weather station data should be added to the flood prediction model when weather station data usage is off

IV. Nonfunctional Requirements:

Performance requirements:

NFR1.

Description: Nodes should pass their local data and computed state downstream quickly.
Fit criterion: Data transfer between a local node and its downstream node should take less than 1 second.
Rationale: The water in the river flows quickly, so data needs to be processed in nodes swiftly to keep up with changes in the river and make accurate predictions. The delay in detection poses safety risks.

NFR2.

Description: The computed state of a node should accurately reflect the flood potential at that point in the river.
Fit criterion: The product shall compute the state of the local node with at least 95% accuracy.

NFR3.

Description: The state of a node should be computed in a timely manner.
Fit criterion: The product shall compute the state of the local node within 1 second.
Rationale**:** The delay in computation at a single node could be a bottleneck in the speed and functionality of the whole system.

NFR4.

In the first six months of operation, the product shall be available for 95% of the time.
Rationale: Flood detection is a critical safety task and having higher uptime for Riveralert makes it more reliable and reduces the risk of not detecting a flood that's occurring.

NFR5.

Description: Camera data should be recorded in a timely manner.
Fit criterion: The product shall record image data within 1 second of requesting data from the camera.
Rationale: The image data utilizes the highest bandwidth and computational resources, hence it is important to fetch it quickly to avoid any delay in the detection of a flood.

NFR6.

Description: Underwater sensor data should be recorded in a timely manner.
Fit criterion: The product shall record river surface data within 1 second of requesting data from the underwater sensor.

*Rationale***:** The computation of the state of a node is partially determined by depth sensor data. The node needs access to this depth sensor data quickly in order to compute its state while the data still reflects the river conditions.

NFR7.

Description: Depth sensor data should be recorded in a timely manner
Fit criterion: The product shall record river depth data within 1 second of requesting data from the depth sensor.

V. Project Issues

1. Open issues: One concern of ours is that the current product does not alert anyone of a flood that is imminent or occurring. The plan for the product is to predict river floods, but accurate predictions of floods are not very useful if the users of the product are not acting on this information. Thus, one potential change in the future could be implementing some alarm system for the area surrounding the river of interest. Another concern is the handling of node failures. The assignment description said RiverAlert should tolerate node failures, but it does not say how. Currently, there is an operator that receives notifications when a node fails, but this may change in the future.
2. Costs:
    - Record upstream node state and data (input): 4
    - Send node state and data downstream (input): 4
    - Toggle communication protocol (output): 3
    - Record river flow data from underwater mounted sensor (input): 4
    - Record river flow images from cameras (input): 4
    - Record river depth data from depth sensor (input): 4
    - Record rainfall data from weather station (input): 4
    - Send maintenance request to node operator (output): 4
    - Record maintenance response from node operator (input): 4
    - Predict node state (inquiry): 6
    - Adapt flood model (inquiry): 6

    Total: 47 FP
    Effort in person months: (47/150) * (47)^0.4 = 1.46 person months
    Range of uncertainty: +/- 15%