P5

INE5424-06208B (20242) – Sistemas Operacionais II | Curso de Ciências da Computação

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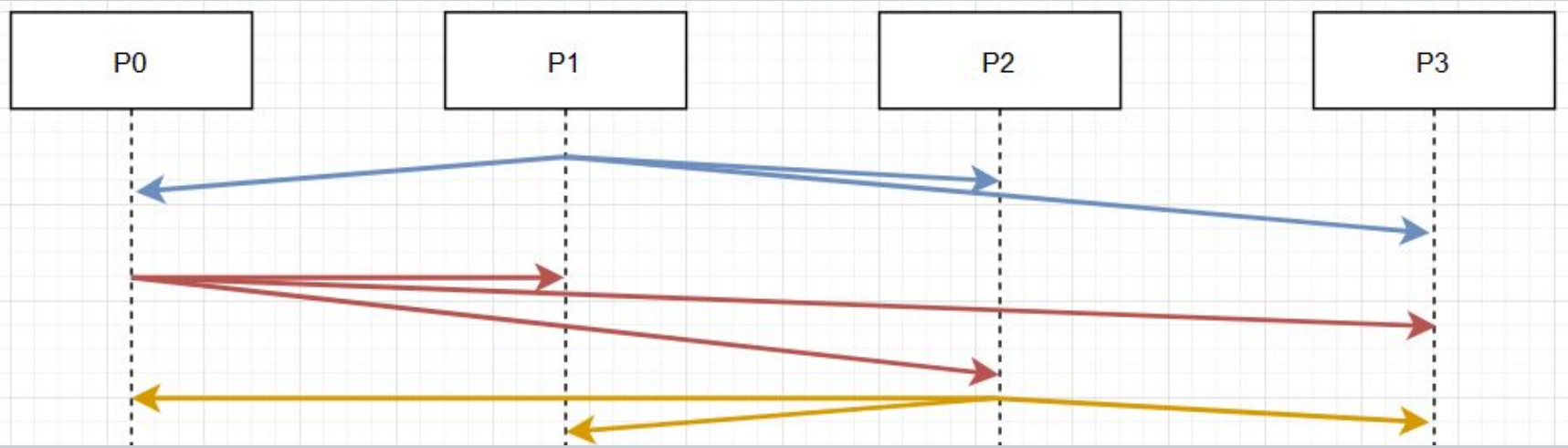
Troca de heartbeats



- 0, 1 e 2 enviam seus heartbeats para todos os outros processos durante uma janela de tempo
- Cada heartbeat traz consigo a informação de quais processos o emissor sabe que estão vivos
- A verificação é realizada após a janela determinada, iniciando um novo round logo depois

Funcionamento

P1

```
[INFO] Detecting defective processes
Node 0: Uninitialized
Node 1: Active
Node 2: Active
Node 3: Active
Node 4: Uninitialized
```

P2

```
[INFO] Detecting defective processes
Node 0: Uninitialized
Node 1: Active
Node 2: Active
Node 3: Active
Node 4: Uninitialized
```

P3

```
[INFO] Detecting defective processes
Node 0: Uninitialized
Node 1: Active
Node 2: Active
Node 3: Active
Node 4: Uninitialized
```

- Os processos em destaque são capazes de se detectar com sucesso, assim como detectar processos ainda não inicializados (P0 e P4) com sucesso

Adições - Novo tipo de mensagem

```
Failure detection
   HTB - Heartbeat
   HSY - Heartbeat sync states of processes - NOT USED
```

Adições - atributos e threads

```
// Witness of nodes (map of process ID to set of process IDs that mark it as alive)
std::map<int, std::set<uint8_t>> witness_of_nodes;

// Participant states (map of process ID to state)
std::map<int, ParticipantState> participant_states;

// Buffers to store messages for uninitialized processes
std::map<int, std::queue<Message>> message_buffers;
```

```
// Start the heartbeat and defect detection threads
std::thread heartbeat_thread(&AtomicBroadcastRing::send_heartbeat, this);
heartbeat_thread.detach();

std::thread defect_detection_thread(&AtomicBroadcastRing::detect_defective_processes, this);
defect_detection_thread.detach();
std::thread htb_handler(&AtomicBroadcastRing::htb_handler_thread, this);
htb_handler.detach();
```

Enviando Heartbeats

```cpp
// Heartbeat message sending logic
void AtomicBroadcastRing::send_heartbeat() {
    while (true) {
        std::vector<uint8_t> heartbeat_msg;
        for (const auto& entry : participant_states) {
            heartbeat_msg.push_back(static_cast<uint8_t>(entry.second));  // Serialize all participants states
        }

        // Send heartbeat to all participants (except self)
        for (const auto& node : nodes) {
            if (node.first != process_id) {
                //log("Sending heartbeat to node " + std::to_string(node.first), "INFO");
                channels->send_message(node.first, process_id, Message(process_address, msg_num, "HTB", heartbeat_msg));
            }
        }

        // Sleep for the heartbeat interval
        std::this_thread::sleep_for(std::chrono::milliseconds(heartbeat_interval));
    }
}
```

Recebendo Heartbeats

```cpp
// Process received heartbeat messages
void AtomicBroadcastRing::process_heartbeat(const Message& msg) {
    //log("Processing heartbeat message", "INFO");

    int key = find_key(msg.sender_address);

    // If the sender is uninitialized, mark it as active
    if (participant_states[key] == ParticipantState::Uninitialized) {
        participant_states[key] = ParticipantState::Active;

        witness_of_nodes[key].insert(process_id);   // Insert this process as witness of sender
        // For every node sender knows is alive, mark it as a witness
        for (int i=0; i<static_cast<int>(msg.content.size()); i++) {
            if (msg.content[i] == 1) {
                witness_of_nodes[i].insert(key);
            }
        }
        // Answer with a heartbeat of our own witnesses to sender
        std::vector<uint8_t> heartbeat_msg;
        for (const auto& entry : participant_states) {
            if (entry.first != process_id && entry.second == ParticipantState::Active) {
                heartbeat_msg.push_back(static_cast<uint8_t>(entry.second));  // Serialize all participants states
            }
        }
        channels->send_message(key, process_id, Message(process_address, msg_num, "HTB", heartbeat_msg));
    }
```

Detectando - verificando se há quorum

```
void AtomicBroadcastRing::detect_defective_processes() {
    send_htb = true;
    while (true) {
        // two steps for a round:
        // 1- collect HTBs for alloted time
        // 2- Make final decision based on the collected information

        // Sleep before checking again
        std::this_thread::sleep_for(std::chrono::milliseconds(5*heartbeat_interval));
        log("Detecting defective processes", "INFO");

        // Check amount alive
        int amount_alive = 0;
        for (auto&entry :participant_states) {
            if (entry.second == ParticipantState::Active) {
                amount_alive++;
            }
        }
```

Detectando - Se não houver quorum

```
if (amount_alive <= (2*failures)) {
    //log("Not enough nodes alive alive, no need to continue", "INFO");
    print_states();
    for (const auto& node : nodes) {
        participant_states[node.first] = ParticipantState::Uninitialized;
    }
    participant_states[process_id] = ParticipantState::Active;
    // initialize other nodes responses to suspect everyone
    for (const auto& node : nodes) {
        witness_of_nodes[node.first].clear();
    }
    // put process as a witness of itself
    witness_of_nodes[process_id].insert(process_id);
    continue;
```

Detecção - se tivermos quorum

```
    for (auto& entry:witness_of_nodes) {
        if (static_cast<int>(entry.second.size()) < (2*failures)+1) {
            //log("Node " + std::to_string(entry.first) + " is down", "INFO");
            participant_states[entry.first] = ParticipantState::Uninitialized;
        } else {
            participant_states[entry.first] = ParticipantState::Active;
        }
    }
}

// reset witness of nodes for next round
print_states();
for (const auto& node : nodes) {
    participant_states[node.first] = ParticipantState::Uninitialized;
}
participant_states[process_id] = ParticipantState::Active;
// initialize other nodes responses to suspect everyone
for (const auto& node : nodes) {
    witness_of_nodes[node.first].clear();
}
witness_of_nodes[process_id].insert(process_id);
```

Starts new round after this, sleeping for a set amount

Envio de mensagens transmitidas antes da entrada no grupo

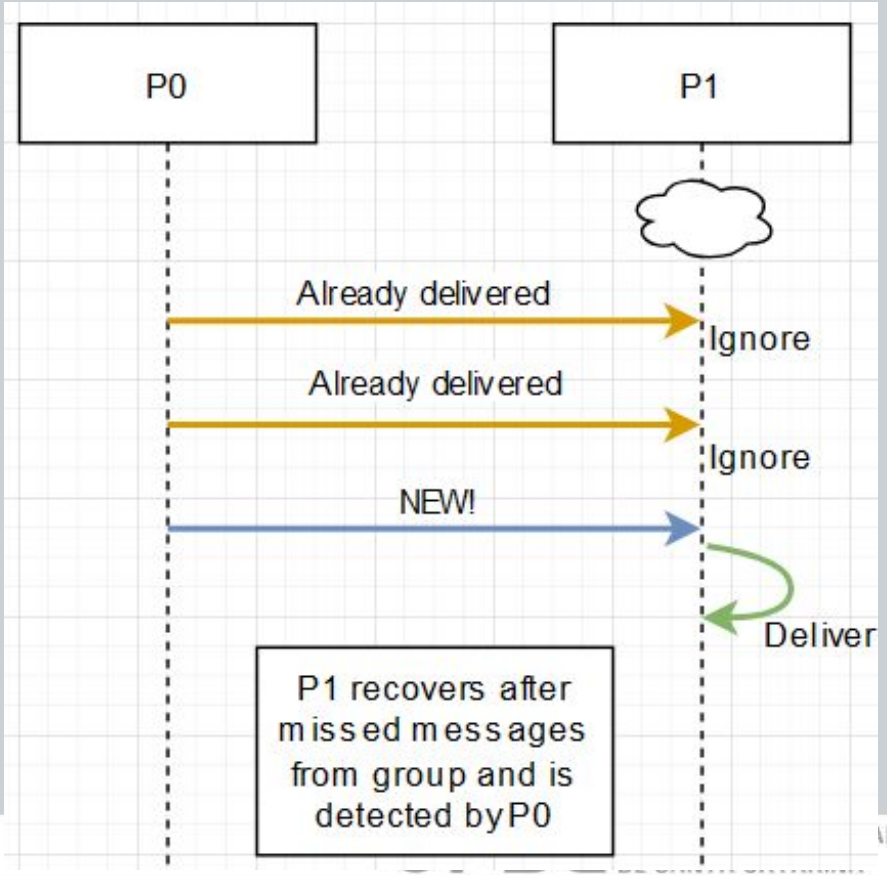
- Infelizmente não foi feita a implementação completa deste requisito

```cpp
// Buffer messages for uninitialized nodes
void AtomicBroadcastRing::buffer_message_for_uninitialized(const Message& msg) {
    if (participant_states[find_key(msg.sender_address)] == ParticipantState::Uninitialized) {
        message_buffers[find_key(msg.sender_address)].push(msg);
    }
}

// Deliver buffered messages when the node becomes active
void AtomicBroadcastRing::deliver_buffered_messages(int node_id) {
    if (participant_states[node_id] == ParticipantState::Active) {
        while (!message_buffers[node_id].empty()) {
            Message msg = message_buffers[node_id].front();
            message_buffers[node_id].pop();
            deliver_queue.push(msg);  // Deliver message to the application
        }
```

Estados de um processo - Decisão de projeto

- Somente dois estados: **Ativo e não inicializado**
- Facilita a entrega de mensagens a processos que falharam temporariamente
- Estes são tratados como novos ao grupo e recebem todas as mensagens até então
- Caso haja envio de mensagens já entregues, basta ignorar



Equipe

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