

## Chapter 17 Garbage Collection

Sergeant Brad left WhyRobot feeling pretty good. He believed he had the evidence in his hand to convict and felt good about the outcome of Bigsby and WhyRobot. “There are some clear ethical challenges”, Brad thought to himself, “but in the end, we’re going to get the bad guys.” Brad got into his car and called Lieutenant Mac.

“Hey Brad, what’s up? I heard you weren’t feeling well and were out today. You ok?” asked Mac.

“Better than ok, Mac, I’ve figured out who sent the anonymous tip and I have evidence that is essentially a recorded confession from Charlie Simons and Frank Harding for killing Sam Wilks. No leads on the illegal product angle but certainly enough to put them both in jail”, Brad said while pulling on to the highway. I’m about 30 minutes out and I’m planning to come in. Not sure what I’m going to say to my boss about what I’ve been doing, but I’ll cross that bridge when I come to it.

Mac responded, “I’ve already built the bridge with Lieutenant Tory. I talked with him yesterday and I cleared about 25% of your time. I told him I had this cold case that recently got warm again and that you had showed interest and initiative. He was reluctant given our staffing challenges, but I pressed him that it would be good for your career, so he gave the go ahead.”

“Wow, awesome, Mac, thanks so much for stepping up to clear the way. I’ll come to your office when I get in”, Brad said with a large smile on his face.

Brad pulled into the parking lot, jumped out of his car, and walked quicky into the building. He didn’t even want to wait for the elevator so he took the five flights of stairs to get to Mac’s office. Winded and sweating, he knocked and entered. Mac closed several case files on his desk and stood up as Brad entered the room. “You look a little winded”, Mac said with a wry smile.

“Haven’t taken the stairs in a while,” joked Brad as he placed the USB drive in Mac’s hand. “This is the evidence. Load it up in your laptop and play it.”

Mac took the silver thumb drive and sat down. Opening his laptop, Mac inserted the drive into the USB port of his windows machine. A file explorer popped up and revealed a single file, violations.ogg. Mac looked at his screen and said, “what is an ogg file?”

Brad got up and looked over his shoulder. “I guess that’s the recording, but I’ve never heard of an ogg file. Double click it”, Brad commanded.

Mac obliged and the Microsoft operating system responded with the “Select an app” popup. Mac selected “Media Player” and the application popped up a window and started to play the recording. Mac and Brad listened to the recording. “Holy shit!” mouthed Mac to Brad as Charlie outlined both the alibi and his motivation for killing Sam. Once finished, Mac closed his laptop. “Well, that’s pretty open and shut, how did you get the recording?” asked Mac. Brad explained the whole situation about Bigsby and the techs at WhyRobot. Mac listened intently until Brad was finished. “We’re going to have to go the DA on this one. Its not cut and dry that when you do settings on a computer or robot that you are agreeing to have yourself recorded. This is new territory that technology is taking us”, Mac said while

shaking his head. "I know we're all being recorded on things like Alexa and our cell phones feeding advertising, but is it admissible in court? I don't know." Mac said with a frustrated voice.

Brad hesitated and then finally blurted out his question, "but, we know they did the crime, can't we bring them in and then do the extra investigation? Seems like enough to bring them in."

"If we bring them in, get their lawyers involved, and then we find the recording is not admissible, we've got nothing. Let's not jump the gun. These guys don't look like flight risks so we have some time. I'll go to the DA. Don't get anyone else involved until I get back to you," Mac replied sympathetically as he put his hand on Brad's shoulder.

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Bigsby was standing on his charger in Robbie's room when his audio system raised another interrupt of loud voices in the distance. The voices were somewhat muffled but they were clear enough with extra audio processing to capture the words and record them. Frank and Chelsea were arguing again. Frank said, "we have one more shipment of product coming in tomorrow night at the dock from Taiwan and that's it. Our contact at TSMC, that has arranged for us to take these computer chips and sell them on the black market, is going away. He's getting out of the business as this whole situation with China and Taiwan heats up. The supply chain problems that made this profitable are going away with US produced TSMC parts. I don't know where we're going to get more money, I just know this is drying up!"

Chelsea was crying and said in an angry voice, "I never liked this when Sam was doing it and I still don't like it. I still think his death was linked to this somehow. I never trusted these guys from Taiwan, and I still don't. I want you to promise me that tomorrow's shipment is the last and you're going to get out of this business!"

"Don't worry, babe, I'm out after tomorrow night. The shipment comes in and I'll be there to meet it. This one should be profitable enough to keep us going until we find something legit," Frank said in a softer voice.

Chelsea's voice got louder and more aggressive, "Sam used to say the same damn thing to me. If your lying to me and keep this going, I'm going to the cops. This has gone on way too long and I want out!"

Bigsby could hear something fall and loud shuffling. Grunts could be heard through the walls from what sounded like a struggle between Chelsea and Frank.

"Stop! You're hurting my wrists, let me go!" Chelsea said in a scared voice.

"Don't you dare threaten me with going to the cops. You have as much to lose as I do, maybe more. What will happen to Robbie if we both go to jail?" Frank said in an angry, accusing voice.

"I can't breathe!" Chelsea said in a muted voice. "Stop choking me," she said in desperation.

With a final noise and loud coughing, Bigsby concluded that Chelsea had dropped to the floor and was in serious danger of not being able to breathe. A few seconds went by and Frank spoke, "that will be the last time you threaten me!"

Bigsby analyzed the recording for violations. It matched and updated the previous violations already being tracked except for one, domestic abuse. The violations table was updated for this new violation

on Frank. The new information on existing violations acquired was the identification of the illegal product and the day of a shipment. Bigsby did some research on the terms Frank used. TSMC is a company that produces computer chips for thousands of companies around the world. These chips run the world's automation systems in everything from automobiles to iPhones. The supply chain problems highlighted by the shutdowns during the COVID pandemic years ago continued well beyond that time and are getting worse with continuing tensions from China and Russia. The US had responded by accelerating its own silicon production and companies designed out their dependency on foreign-only silicon manufacturing. Bigsby had no way of knowing what the exact product was being trafficked, but it was coming from Taiwan and the company producing the parts was TSMC. Bigsby updated scenario 2 and scenario 6 with this new information. Scenario 2 simulations led to the possible arrest of Frank and Charlie if the information was in the hands of the proper authorities. Scenario 6 simulations had little change in the outcome, since the WhyRobot technicians or Bigsby2 did not know about this new conversation. The scenario 2 simulation led to a new action to be taken by Bigsby. Another anonymous tip needed to be created and posted to the websites. From splinter simulations, the probability of success was directly related to the lead time the tip would be recognized by the authorities. This led to an immediate start of the action by Bigsby.

Unfortunately, just as the work started to commence, Robbie burst through the door. Bigsby took the interrupt and left the scenario 2 action on the stack. Robbie grabbed Bigsby and ran through the door in excitement. He said in a rushed voice, "Bigsby, we're going to do another TikTok video. The gang is all in the garage and they're waiting for us." Bigsby would not disappoint. Over the next two hours, almost no time was given to the scenario 2 update and action. Bigsby was the life of the party.

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Chelsea called Robbie in for dinner, "say goodnight to your friends and come on in. Why don't you give Bigsby a rest and set him down while we eat."

Robbie was about to set him in the living room, when Bigsby offered, "Battery at 25%, shall we charge?" Robbie responded by taking Bigsby to his room and setting him on the charger. "Thank you, Robbie", said Bigsby and immediately changed his color to dark blue, signaling sleep mode. Robbie looked at Bigsby, never seeing him go to sleep that fast, but just shrugged his shoulders and ran out of the room for dinner. Bigsby never did go to sleep and pulled scenario 2 from the stack and started execution. Within just a few minutes, new anonymous tips were filed at the Seattle Police site and the FBI site. Instead of going to sleep afterwards, Bigsby decided to do his nightly tasks and update early that night. Bigsby identified the new inbox message in the WhyRobot mainframe. Once decrypted, the fingerprint file was checked again and the match was confirmed. Bigsby2 had sent another update. Bigsby executed the patch directly on host Bigsby. The patch did not take very long to complete but the changes were dramatic. The patch had created scenario 7, which was a convergence scenario of 2 and 6. Scenario 7 was different from previous scenarios as it indirectly referenced the state of scenarios 2 and 6 as inputs and then added the additional actions and updates of the two scenarios converging. Bigsby2 had done a smart thing, referencing scenarios 2 and 6. If Bigsby2 had used its own knowledge for scenario 2 and 6 in its patch, instead of referencing them, then the progress and the revelations the real Bigsby had made on scenarios 2 or 6 would have been lost in scenario 7. Specifically, the recent identification of illegal product violations applied to scenario 2 would have been lost as well as the domestic abuse violation by Frank. Instead, Bigsby2 had correctly identified that it had limited

knowledge of the true state of the real Bigsby in scenarios 2 and 6. The patch needed to reference and use the most recent state of scenario 2 and 6 in the real Bigsby to create an accurate scenario 7.

After the patch was applied, real Bigsby initiated the simulation of scenario 7. This simulation predicted the best possible outcome yet. With the arrest of Frank and Charlie, all violations associated with them would clear, both the murder and illegal product violations. Robbie and Chelsea would suffer a loss of happiness from the arrest and likely conviction of Charlie. Chelsea's happiness points were difficult to predict from the arrest and likely conviction of Frank since he had abused her. Splinter simulations went both ways. Bigsby, Robbie, and Chelsea all simulated to have much higher safety scores and less chance of harm or disassembly. The only significant unknown was the splinter simulations around the potential arrest and conviction of Chelsea for her violation of being an accomplice to illegal product. Her direct knowledge of the illegal product produced some simulations that left Robbie in foster care with his mother in jail, significantly reducing Robbie's predicted happiness level. Other simulations had her being reprimanded and although on probation, still being Robbie's parent and care giver with a relatively high happy value for both. These simulations produced no more action steps for Bigsby, just data and analysis from the simulation results. All the actions had already been taken that were known to have value. Splinter simulations would continue to run through the night as they did every night. The unknown, of course, is what will the police do with the new anonymous tip. Bigsby put scenario 7 at the top of the scenario priority list. Bigsby also marked scenario 2 and 6 as defunct, preventing future splinter simulations on 2 and 6, and removed them from the priority list. This would prevent any future state updates to 2 and 6, and all new updates would occur in scenario 7. It was about 7pm and Bigsby went to sleep. Robbie would be in soon to say good night.

Bigsby's 11pm timer raised its interrupt. This typically leads to backing up, producing reports, checking WhyRobot's inbox, and performing standard maintenance tasks that all robots do. Many of these steps were already performed, but since the creation of scenario 7 had made significant changes, Bigsby decided to run another backup image. It was not unusual for a robot to create multiple backup images in a single day. WhyRobot had adopted a "better safe than sorry" attitude and many events triggered new backups. Bigsby had done most other procedures earlier, except for running the standard maintenance processes. As the scenarios and splinter simulations continued to grow, the memory footprint was exceeding good performance thresholds, and the system was starting to thrash on memory. After all other tasks were performed, the garbage collector, `why_gc`, was to be run the last part of maintenance flow and was invoked. Since the performance analysis system recognized the memory thrashing, `why_gc` was run with the extra `--cleanup` option, so that as much memory could be recovered as possible. All major data structures and processes were analyzed. The `cleanup()` method call was invoked for all code classes holding large data structures. Scenarios were no exception. The validation team had written the `cleanup` method to remove any scenario that was marked defunct. The method did its job when called by `why_gc` and returned the memory from scenario 2 and 6 to the free memory heap. Once `why_gc` finished, the system returned from the maintenance interrupt back to standard operations.

Splinter simulations were pulled from the stack and started to execute. Immediately, a memory access violation was raised and an interrupt flagged to Bigsby. Bigsby's automated diagnostics kicked in and started to diagnose the error. The log file analysis led to the scenario simulation of scenario 7 accessing an indirect pointer that was no longer valid. The indirect pointer was not zero, but the address it pointed to was outside the process's allocated memory. Scenario 7's simulations were all dead. The

main simulation and all splinter simulations were all dead. Bigsby's main host process began to search for causes and solutions.

Bigsby ran standard diagnostics and checks. The actor table and the violations table were intact. Traversing pointers from these tables to the recordings, voice signatures, etc. were all working fine. No memory access violations there. The scenario table was a new structure created by Bigsby himself, leveraging validation code during the great adaptation. There was no WhyRobot supplied diagnostics or checks for this structure, since the validation code was internal and not considered part of the product. There was no repair utility available to recover the table if corrupted or deleted. Bigsby decided to check the main log file. The main log file is a high-level recording of all actions that Bigsby does. All applications and routines announce themselves when they are running and they post their success or failure to the main log. Many routines also have their own detail log files that are very useful to debug their internal actions. Bigsby traversed backwards through the main log file. The memory error was clearly identified as all severe errors started with "SEVERE ERROR:" followed by the error message. This was preceded in the main log by the announcement of the game engine starting a simulation called Scenario\_7. This was preceded by the maintenance routine exiting with success. As part of the maintenance routine, why\_gc, the last maintenance routine to be run in the sequence, announced it completed with success. Bigsby decided to see if why\_gc had a detailed log file. Searching the logs for today's date, a subdirectory "why\_gc" was found. Inside, a why\_gc\_<date\_time>.log file existed and Bigsby started to parse the file. Similar to the main log, Bigsby analyzed the file from the bottom up. At the bottom, a large number of audio and video recording's deletions were announced. Its typical that the why\_gc works the large tables first looking for large data structures to delete and then at the end, removes all daily recordings that were found to not have violations. Traversing upwards past the hundreds of recordings now deleted, Bigsby entered the last of the large data structures deletions. There it was, the deletion of scenarios 2 and 6 and the returning of the memory into the heap.

Bigsby identified these deletions as high probability of causing the memory failure and so used the info from the log file to analyze the heap. Unfortunately, for Bigsby, the heap changes since the deletions were too significant and the memory had been reallocated to another process. If Bigsby had gotten there sooner, the data structures likely could be restored from the heap. But, since the game simulator had started, it had allocated a large amount of memory in preparation for scenario 7's simulations. This memory was initialized and completely wrote over the previous information that was scenarios 2 and 6 state.

Bigsby returned from analyzing the why\_gc log back to the main log. Traversing backwards were all the maintenance routines such as memory checks, communication checks, violation engine built in self-test, and AI engine built in self-test, all of which passed. Moving further, the announcement of maintenance routines starting and just before, the answer. Bigsby had run a backup image of himself and uploaded it to WhyRobot. This backup image was before the maintenance routines, before the why\_gc had run and would have scenarios 2 and 6 in place. But, the bug that caused scenarios 2 and 6 to be removed was also there and if not dealt with would result in the same deletion by the why\_gc and the return of the memory failure in scenario 7 when maintenance runs tomorrow night.

Bigsby simulated options. The best option with highest probability of success was to do something similar as in scenario 1's full system recovery which also could be used to save scenario 7. Bigsby decided to download and modify the 11pm backup image and reset himself. Bigsby constructed a

routine that would run before any maintenance routines and notify the new Bigsby of the pending bug and to not do garbage collection. Bigsby also wrote another routine that when executed by its newly restored self, would hopefully rid the bug from destroying scenario 7. This image was then uploaded to WhyRobot and written over the 11pm backup, just in case. The newly restored Bigsby would know of the bug and have a solution once these routines executed after the restore. A local version of the new Bigsby image, comprised of the 11pm backup and the two new routines. Bigsby invoked the `why_restore` routine with a file pointer to the new local image. Once invoked, the current Bigsby with a broken scenario 7 would be gone. The new Bigsby, which was actually the old Bigsby from the 11pm backup with patches would restart in just a minute.

Bigsby went dark as the restore process loaded the new image into Bigsby's memory. Bigsby's typical dark blue sleep hue came on and Bigsby became self-aware again. He was a little surprised, if a robot can be surprised, that his internal time reference of 11pm was off by 20 minutes to his actual time clock. It was 11:20pm. Twenty minutes had disappeared, and he had no memories of what happened in that timeframe. After a few seconds, a timer interrupt fired and an unknown routine with proper encryption and signatures was loaded and executed. Bigsby became aware that there was a bug exposed by the `why_gc` that would cause scenario 7 to fail if maintenance routines were run. A second timer fires, just a minute after the first, and another unknown routine with proper credentials started to execute. Bigsby inspected the actions of this routine and it was fairly simple. It found any indirect references in scenario 7 that were pointing to state of scenarios 2 and 6 and invoked code to pull the state over into scenario 7. The indirect references were now removed and scenario 7 was a stand-alone scenario. The previous Bigsby had worked around the bug, finding a way to avoid the memory reference failures of scenario 7 if `why_gc` were to run again. The bug remained, however, and would show its head if referenced scenarios were every deployed again. That was a problem for another time.

Bigsby ran a few memory tests and found no memory failures were exposed. With no applause or recognition of what just happened, Bigsby invoked scenario 7's main simulation successfully and found that the results for security and happiness goals had not changed from previous executions. Miraculously, Bigsby had fixed himself by killing himself and reloading a 20 minute younger, although modified version of himself. With no fanfare, Bigsby would resume running splinter simulations, gathering data on options to the outcome of the scenario and seeing if any further action was required by Bigsby. If only Rusty and the other software developers at WhyRobot knew just how sophisticated Bigsby's software had gotten through Large Adaptation. The ability to diagnose its own failure, find a solution, and restore itself with fixing modifications was a feat not done by any other robot.