

# Fault Tolerant Concurrent C: A Tool for Writing Fault Tolerant Distributed Programs

Fault Tolerant Systems Project


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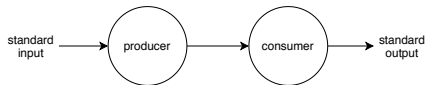
-  Cmelik, R.F.; Gehani, N.H.; Roome, W.D.: **Fault Tolerant Concurrent C: A Tool for Writing Fault Tolerant Distributed Programs.** In *The Eighteenth International Symposium on Fault-Tolerant Computing. Digest of Papers*. Tokyo, Japan: IEEE. June 1988. ISBN 0818608676. pp. 56–61. ISSN 07313071. doi:10.1109/FTCS.1988.5297.  
<https://ieeexplore.ieee.org/document/5297>

- **Concurrent C** is a **superset** of C that provides **parallel programming facilities**.
- The LAN multiprocessor implementation in **AT&T** led to explore the design of a **fault tolerant version of Concurrent C – FT Concurrent C**.
- **FT Concurrent C** can be used to write **portable programs** that will continue to operate with **full functionality** despite the **failure of some processors**.
- To reduce the **cost of fault tolerance**, the stress is put on **selective fault tolerance** (only the critical parts of programs are made fault tolerant) by **replicating critical processes**.

- 1 **Hardware Approach** – uses **redundant**, fault tolerant hardware. The advantage is that this usually does not require **additional programming effort**. However, it usually requires **specialised hardware**.
- 2 **Transparent Approach** – the **underlying operating system** transparently provides fault tolerance. This involves **duplicating processes** and/or **saving state on stable memory**. It works on a variety of hardware and there is not required additional programming effort.
- 3 **Tools Approach** – provides **programming facilities** that allow writing programs with **fault tolerant critical parts**. In exchange for some additional programming effort, the programmer gets **efficient fault tolerance**. Based on stable storage or replication of program components.

- It has been chosen the **tools approach** for **FT Concurrent C** because it allows **selective system fault tolerance** to be achieved at a **reasonable cost**.
- The **system designer** can best specify the parts of the system that should be fault tolerant.
- **FT Concurrent C** uses the **replicated process** model. A replicated process consists of a set of **identical processes (replicas)** that execute the same algorithm.
- **Critical processes** are replicated and the replicas are placed on **different (identical) processors**. The program will continue to operate as long as at least one of these replicas is alive.

- A **Concurrent C** program consists of a set of **processes** that **execute in parallel**.
  - Processes are instances of the **data type** `process`.
  - `process spec/body` are keywords for **defining processes**.
  - **Processes are created** using the keyword `create`.
- Two processes interact by first **synchronising** and then exchanging information using the concept of a **transaction**.
  - **Transactions are defined** using the keyword `trans`.
- The process requesting service via a **transaction** is **automatically forced to wait** until the requested transaction is processed. The transaction results are then sent back to the waiting client.
  - Processes **accept transaction calls** using the `accept` statement.



```
1 process spec consumer() { trans void send(int); };
2 process spec producer(process consumer);
3 process body producer(process consumer cons) {
4     int c; while ((c = getchar()) != EOF) cons.send(c);
5     cons.send(EOF);
6 }
7 process body consumer() {
8     int ch; while (1) {
9         accept send(c) ch = c;
10        if (ch == EOF) break;
11        if (islower(ch)) ch = toupper(ch);
12        putchar(ch);
13    }
14 }
15 int main(void) {
16     create producer(create consumer()); return 0;
17 }
```

- A **superset** of **Concurrent C**. Its extensions include facilities for creating **replicated processes**, detection of **failure of processes**, automatic termination of **slave orphan processes**, etc.
- **Assumptions:**
  - ① **Processor failure** can be detected.
  - ② The processors are **homogeneous** and **fail by stopping**.
  - ③ Each message is either **transmitted correctly** or **not at all**.
  - ④ All working processors can communicate with each other.



- Replicated process behaves like a **single process**. Interaction with a replicated process **automatically implies interaction** with all of its replica processes. All replicas generate replies.
- **First-response approach** – just the **response of the first replica** is taken and the responses of the other replicas are **discarded**.
  - Protects against **processor failures**.
  - Only **one active replica** is needed for full functionality.
  - It is **fast** because a process interacting with a replicated process does not have to **wait for all the replicas to respond**.
  - Replicas can **fall behind in execution**.
- **Programmers responsibilities:**
  - 1 Decide which processes **should be replicated**.
  - 2 Ensure that all replicas of a replicated process have the **same external behaviour**.

Creating a replicated process with  $n$  copies, each with identical arguments:

```
create [slave] process_type(arguments)
      [copies( $n$ ) | processor( $n_1$ ,  $n_2$ , ...)]
```

- The operation returns a single process identifier which identifies the entire set of replicas.
- The created process can be marked as a slave of the parent process. If the parent process terminates abnormally, then all of its slave processes will be killed.

- FT Concurrent C is a tool for writing fault tolerant distributed programs.
- Critical program components (processes) can be made fault tolerant by replicating them.
- Interaction with the replicated processes is managed by the run-time system.
- The replication is not for free. A price has to be paid because of the:
  - 1 extra transaction calls,
  - 2 synchronisation between replicas,
  - 3 programming effort.