DATA STRUCTURES AND ALGORITHMS

[CSE331s] XML EDITOR

FINAL SUBMISSION

PREPARED BY

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Abstract

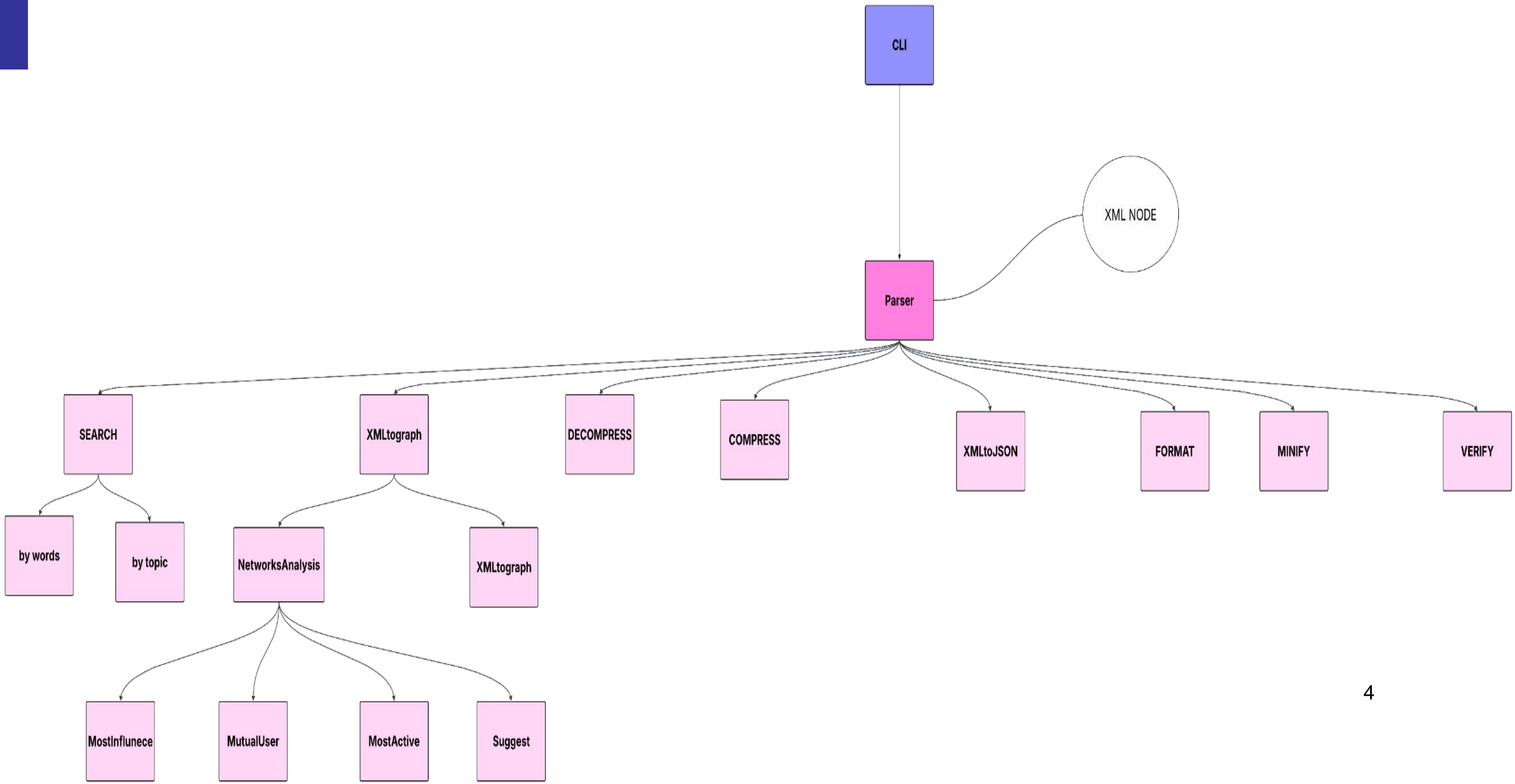
This project implements an XML editor utility suite in C++, providing parsing, formatting/minifying, JSON conversion, compression/decompression, error handling, and network-analysis features built on a custom `XmlNode` tree representation. The CLI exposes commands for transformation and analysis (format, mini, json, compress/decompress, verify, draw, suggest, most_influencer, most_active, mutual, search). This report documents architecture, data structures, implementation details, complexity analysis, tests and recommended future work.

Background

Implemented in C++ using a lightweight, custom parser. The project has 2 modes the first command-line oriented, with sample inputs in the `inputfiles/` directory and outputs in `outputfiles/`, and a second mode which is gui mode made with Qt creator.

System Architecture & Data Structures

project components and structure:



Primary data structure— `XmlNode`:

```
struct XmlNode {
    string name;
    string value;
    vector<XmlNode*> children;
    map<string,string> attrs; // attribute name -> value
    XmlNode() : name(""), value("") {}
};
```

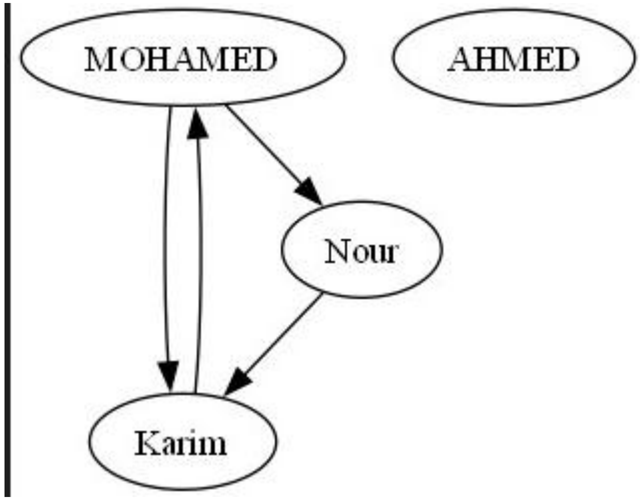
- Use:

  XML is inherently hierarchical; using a recursive tree traversal (DFS) for formatting ,conversion and searches

Graph/network structures

struct user and struct post:

```
class post {
public:
    string body;
    vector<string>topics;
};
class user {
public:
    int id;
    string name;
    vector<post>posts;
    vector<int>followers;
    user();
};
```



The graph is constructed as adjacency relations between user IDs in map<int,user> users in XML_to_graph.cpp

Implementation details and how to run:

how to compile:

Type : (g++ -std=c++17 -g (Get-ChildItem -Recurse -Filter *.cpp | ForEach-Object { $_.FullName }) -I. -o xml_editor.exe)

Then type ./xml_editor.exe (whatever command u chose)

those are the commands available:

```
//xml_editor json -i input_file.xml -o output_file_json.json

//xml_editor mini -i input_file.xml -o output_file_minified.xml

//xml_editor compress -i input_file.xml -o output_file_compressed.comp

//xml_editor decompress -i output_file_compressed.comp -o output_file_decompressed.xml

//xml_editor format -i inputPrettify.xml -o output_file_prettified.xml

//xml_editor verify -i inputErrorHandling.xml -f -o output_file_without_errors.xml
```

```
//xml_editor draw -i inputNetworkAnalysis.xml -o output_file_graphviz.jpg

//xml_editor suggest -i inputNetworkAnalysis.xml -id 1

//xml_editor most_influencer -i inputNetworkAnalysis.xml

//xml_editor mutual -i inputNetworkAnalysis.xml -ids 1,2

//xml_editor mutual -i inputNetworkAnalysis.xml -ids 1,2,3

//xml_editor most_active -i inputNetworkAnalysis.xml

//xml_editor search -w word -i inputNetworkAnalysis.xml

//xml_editor search -t topic -i inputNetworkAnalysis.xml

//xml_editor search -w lorem -i inputNetworkAnalysis.xml

//xml_editor search -t economy -i inputNetworkAnalysis.xmls
```

parser:

- - Algorithm (brief): tokenization is single-pass over the file, emitting tags and text tokens. `parse_node` implements a recursive-descent approach: on an opening tag it creates a node, then repeatedly parses child nodes or text until the matching closing tag is found; text tokens produce leaf nodes with `value` populated.
  - Robustness: minimal validation; the implementation expects reasonably well-formed tags. The `verify` command is used to detect/correct simple errors (see `errorHandling/ErrorHandling.cpp`).
  - Snippet (parsing loop pattern): `XmlNode* root = parse_node(tokens, idx);

Format / Prettify:

- File: [Format/FormatXml.cpp]
- Behavior: Depth-first traversal that prints opening tags with indentation, text content, and closing tags. Preserves textual content while reflowing tags for human readability.
- Algorithm: Depth-first traversal (DFS) of the `XmlNode` tree; at each node, print indentation proportional to depth, opening tag, then either the node's text or recursively its children, followed by the closing tag.

JSON conversion:

-File: json/convertxmltojson.cpp

- Policy: Elements become objects; repeated child elements can be represented as arrays; text content mapped to either a value field or node text depending on context.
- Algorithm: Walk the `XmlNode` tree recursively; for each node, collect child names and group repeated names into arrays. If a node has only text, map it to a string value; otherwise emit an object with child fields. Serialization is performed during traversal to avoid a separate in-memory representation where possible.

Compression / Decompression:

- File: compression/compress.cpp
  - Description: The project implements an LZW-style dictionary coder (see file for exact code). The compressor seeds a dictionary with the 256 single-byte sequences, scans the input bytes to emit the longest-match codes, and grows the dictionary dynamically. Compressed output is written as 16-bit codes (`unsigned short`). The decompressor rebuilds the dictionary while expanding codes and handles the standard LZW special case when a code equals the next dictionary index.

  - Practical notes: the implementation reserves dictionary capacity (4096 entries) and uses `unsigned short` codes (16-bit), so the dictionary is naturally bounded. This LZW-style approach is lossless and works well on repetitive XML, though production compressors (zlib/DEFLATE) may yield better ratios and streaming support.
  - Algorithm: `compress_helper` implements LZW: keep a current string `s`, append next character `c` to form `s+c`; if `s+c` exists in the dictionary, set `s = s+c`; otherwise output code for `s`, add `s+c` to dictionary, and set `s = c`. At end, output code for remaining `s`. Decompression mirrors growth of the dictionary, reconstructing strings for codes and appending to the output buffer; special-case when a code equals the current dictionary size is handled by repeating the previous entry's first character.

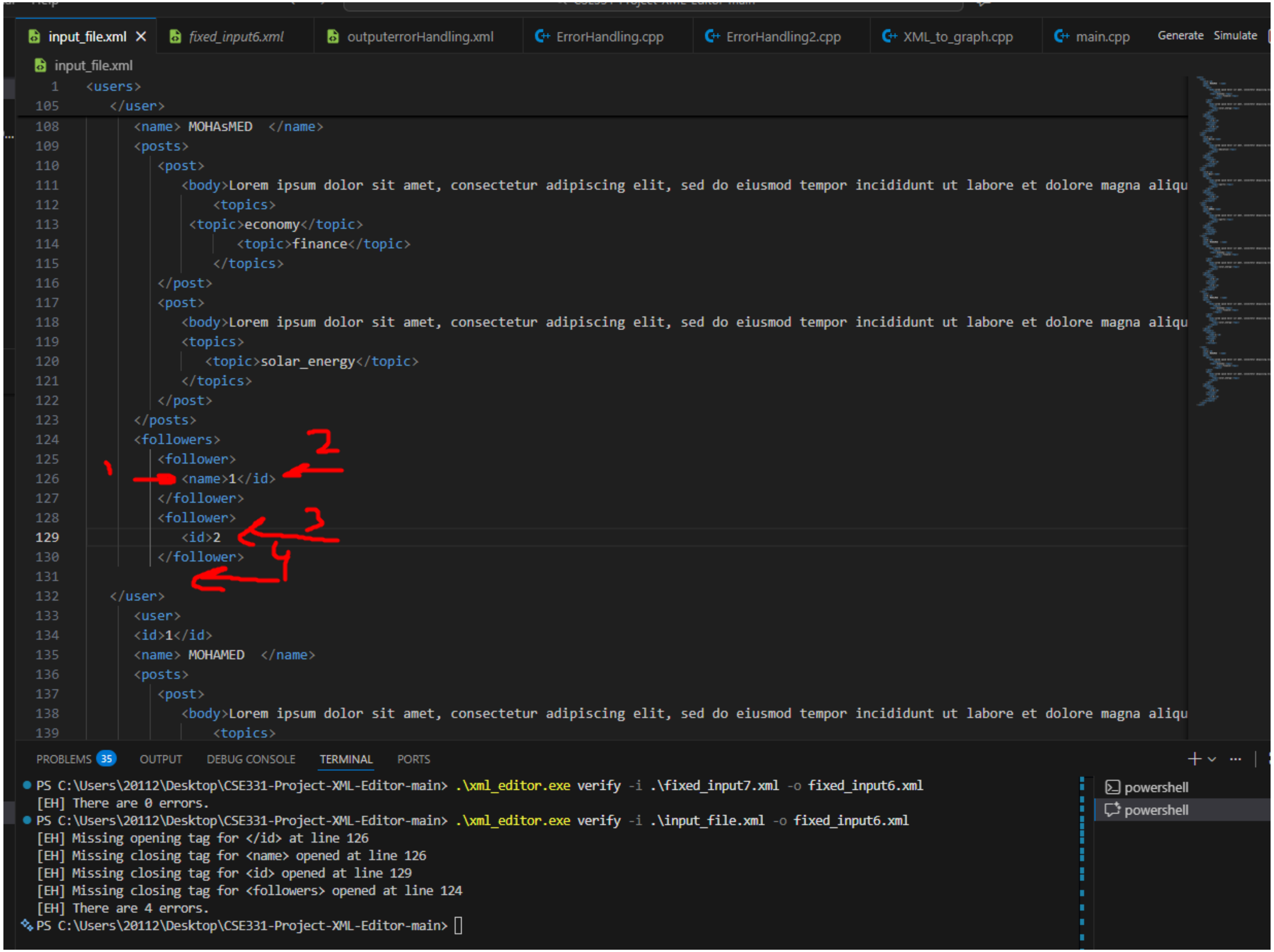
Compression ratio:

in the video wetried to compress large_network.xml which has 1379kb which became outlarge.comp with 77kb

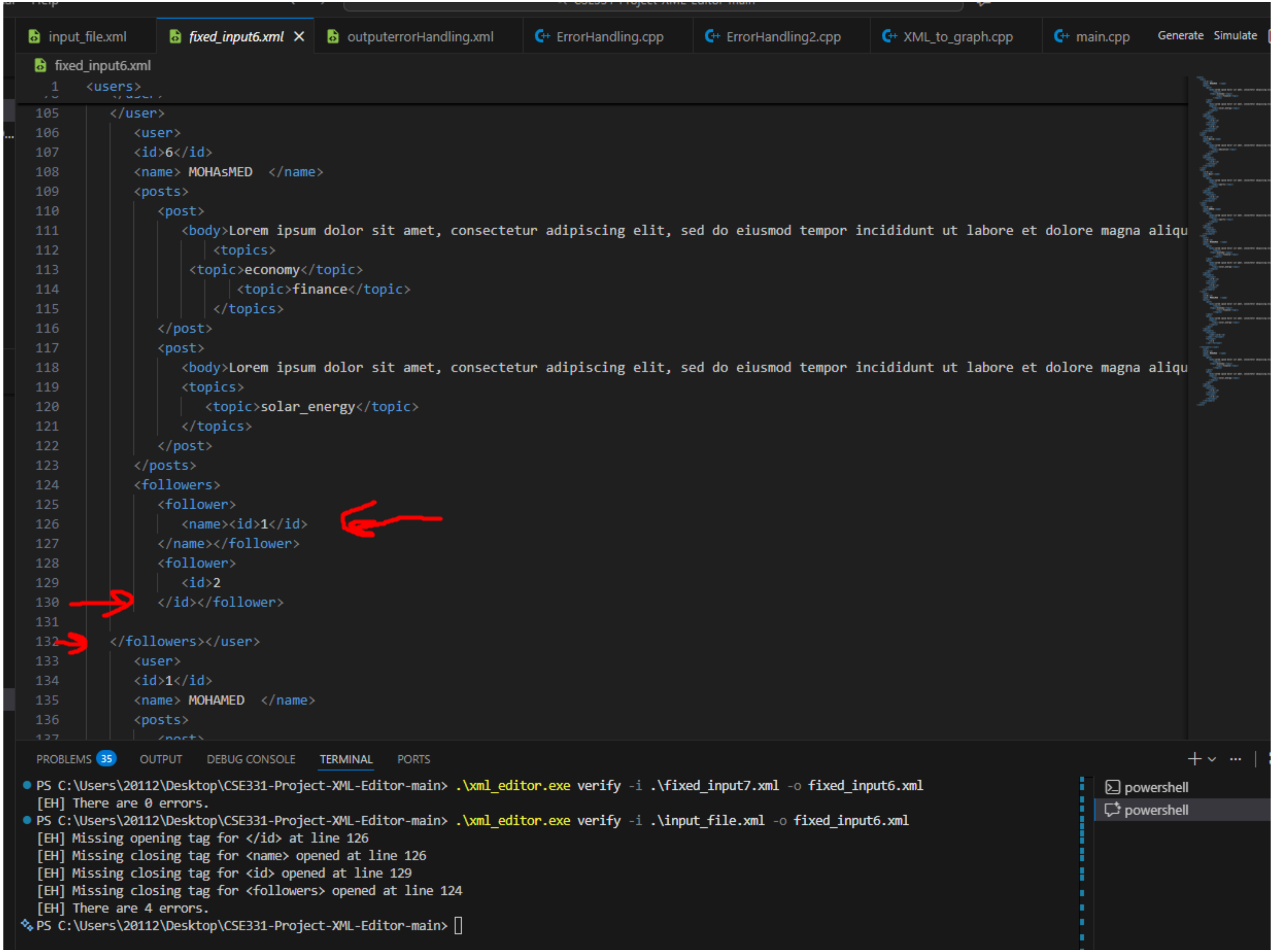
1379/77->1791% compression ratio

Error handeling:

- File: [errorHandling/ErrorHandling.cpp]
  - Function: `error_handling(input, output)` detects mismatched tags, missing closures, and produces a corrected `output_file_without_errors.xml` when possible.
  - Algorithm: read tokens and maintain a tag stack; on an opening tag push tag name, on a closing tag check top of stack — if it matches pop; if not, attempt local correction strategies (insert missing closing tags) and write a corrected stream. Simple heuristics are used (stack-based validation)



input_file.xml
fixed_input6.xml
outputerrorHandling.xml
ErrorHandling.cpp
ErrorHandling2.cpp
XML_to_graph.cpp
main.cpp
Generate
Simulate
input_file.xml
1 <users>
105 </user>
108 <name> MOHAsMED </name>
109 <posts>
110 <post>
111 <body>Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqu
112 <topics>
113 <topic>economy</topic>
114 <topic>finance</topic>
115 </topics>
116 </post>
117 <post>
118 <body>Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqu
119 <topics>
120 <topic>solar_energy</topic>
121 </topics>
122 </post>
123 </posts>
124 <followers>
125 <follower>
126 <name>1</id>
127 </follower>
128 <follower>
129 <id>2
130 </follower>
131
132 </user>
133 <user>
134 <id>1</id>
135 <name> MOHAMED </name>
136 <posts>
137 <post>
138 <body>Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqu
139 <topics>
1
2
3
4
PROBLEMS 35
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main> .\xml_editor.exe verify -i .\fixed_input7.xml -o fixed_input6.xml
[EH] There are 0 errors.
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main> .\xml_editor.exe verify -i .\input_file.xml -o fixed_input6.xml
[EH] Missing opening tag for </id> at line 126
[EH] Missing closing tag for <name> opened at line 126
[EH] Missing closing tag for <id> opened at line 129
[EH] Missing closing tag for <followers> opened at line 124
[EH] There are 4 errors.
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main>
powershell
powershell


input_file.xml
fixed_input6.xml
outputerrorHandling.xml
ErrorHandling.cpp
ErrorHandling2.cpp
XML_to_graph.cpp
main.cpp
Generate
Simulate
fixed_input6.xml
<users>
</user>
<user>
<id>6</id>
<name> MOHAsMED </name>
<posts>
<post>
<body>Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqu
<topics>
<topic>economy</topic>
<topic>finance</topic>
</topics>
</post>
<post>
<body>Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqu
<topics>
<topic>solar_energy</topic>
</topics>
</post>
</posts>
<followers>
<follower>
<name><id>1</id>
</name></follower>
<follower>
<id>2
</id></follower>
</followers></user>
<user>
<id>1</id>
<name> MOHAMED </name>
<posts>
PROBLEMS 35
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main> .\xml_editor.exe verify -i .\fixed_input7.xml -o fixed_input6.xml
[EH] There are 0 errors.
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main> .\xml_editor.exe verify -i .\input_file.xml -o fixed_input6.xml
[EH] Missing opening tag for </id> at line 126
[EH] Missing closing tag for <name> opened at line 126
[EH] Missing closing tag for <id> opened at line 129
[EH] Missing closing tag for <followers> opened at line 124
[EH] There are 4 errors.
PS C:\Users\20112\Desktop\CSE331-Project-XML-Editor-main>
powershell
powershell

XML to graph:

- Files: [graphRepresentation/XML_to_graph.cpp]
- Transform: uses `xmlToGraphFromTree` to build `map<int,user>` from the `XmlNode` tree. ` emits DOT edges and `visualizeGraph` calls `dot` to render an image

Data model & representation:

- **Nodes:** users (unique `id`).
- **Edges:** follower relations; an edge u->v means `u` follows `v` (or depending on semantics, `followers` list contains incoming edges). Implementation stores users in a `map<int,user>` where each `user` holds a `vector<int> followers` (adjacency list-like structure).
- **Space:** adjacency lists (per-user vector) — memory O(V + E) where V = #users and E = #follower-entries.

Network Analysis:

- File: [network/network_analysis.cpp]

- purpose: uses `xmlToGraphFromTree` to build `map<int,user>` from the `XmlNode` tree.
  Then preform the required command from the information from the generated graph.

Most Influencer:

-compute max follower count by scanning each user and reading `followers.size()`, then adding every user with max follower count to a vector.

-Time O(V) where V is the number of vertices or the number of users

-space O(V) in worst case if they all have the same amount of followers they would be listed in the vector

```
vector<pair<string,int>> MostInfluencer(map<int,user> users) {
    int mx = 0;
    vector<pair<string,int>> result;
    for ( auto &p : users) {
         user &u = p.second;
        if (u.followers.size() > mx) mx = u.followers.size();
    }
    for ( auto &p : users) {
         user &u = p.second;
        if (u.followers.size() == mx) result.push_back({u.name, u.id});
    }
    return result;
}
```

Mutual users:

- given a list of input ids S, the implementation iterates users in S, marks who they follow, and counts occurrences per candidate — effectively computing intersection of followers.

-worst Time O(S*V) where S is the number of ids given and V number of vertices or total users so if given all the users ids and all of them follow each other it becomes O(V^2)

-space O(V) in worst case if they all follow all the users

```cpp
vector<pair<string,int>> MutualUsers(map<int,user> users,vector<string>v) {
    vector<pair<string,int>> Mutual_Users;
    map<int,int> mp; // count how many of the provided ids follow a given user

    for ( auto &p : users) {
         user &u = p.second;
        if (find(v.begin(), v.end(), to_string(u.id)) != v.end()) {
            for (int fid : u.followers) mp[fid]++;
        }
    }

    for ( auto &entry : mp) {
        if (entry.second == v.size()) {
            auto it = users.find(entry.first);
            if (it != users.end()) Mutual_Users.push_back({it->second.name, it->second.id});
        }
    }
    return Mutual_Users;}
```

Most Active:

-compute number of connection for each user by iterating through the followers of each user then take the max in a list

-Time O(V^2) where V is the number of vertices or the number of users

-space O(V) in worst case if they all have the same amount of followers they would be listed in the vector

SuggestFollowers (friend-of-friend):

-for a target user u, iterate u's followers F, then for each follower f in F iterate f's followers and suggest their followees not already followed by u

-Time O(V^2) where V is the number of vertices or the number of users

-space O(V) in worst case if they all have the same amount of followers they would be listed in the vector

Search

-File: [search/Search.cpp]

- Method: Iterate posts, tokenize text, case-insensitive match on word/topic, and return (postID, snippet).

- Algorithm: For search, traverse all post nodes and tokenize each post's body (split on whitespace and punctuation); normalize tokens (lowercase) and compare to the search term. Collect matching `(postID, snippet)` pairs. For topic search, compare topic strings directly. This is a linear scan; small optimizations include early exit per post or indexing if needed.

Complexity of every module:

- **Parsing:** time O(N) where N = number of characters/tokens (tokenize once and build tree in recursive pass). Memory O(N) (tree nodes).
- **Formatting/Minifying/JSON conversion:** all tree traversals, time O(M) where M = nodes (≈O(N)).
  Memory :O(depth) stack.
- **Search**: scanning posts is O(P * L) where P = number of posts, L = average length per post; practically O(N).
- **Graph building & analysis:** building adjacency lists O(V + E).
- **Compression:** if algorithm is Huffman-like: building frequency table O(N), encoding O(N); if RLE: O(N).

compression and per-function space complexity

- **`compress_helper`** — Time: O(n) expected (single pass); Space: O(n) for compressed output plus dictionary storage. In terms of input size `n`, peak memory is O(n + D * Lavg) where `D` is dictionary entries and `Lavg` is average stored sequence length; typically O(n).

- **`decompress_helper`** — Time: O(k + m) where `k` is number of codes and `m` is decompressed output length; Space: O(m + D * Lavg) (output buffer + dictionary), practically O(m).
- **`parse_xml`** — Space: O(n) for the input byte buffer (reads entire file into memory) and removes BOM if present.
- **`parse_comp`** — Space: O(k) for the vector of `unsigned short` codes read from file.
- **`save_compressed_file` / `save_decompressed_xml`** — These stream to disk; note **`save_decompressed_xml`** currently takes its vector by value and will make an extra O(m) copy unless changed to take a const reference.

Per-function space complexity (key modules)

- **`ReadXml(ifstream&)`:** O(n) (stores tokens for the entire file).
- **`parse_node(const vector<string>&, int&)`:** O(1) extra per call (recursion stack); overall tree allocation O(n).
- **`parseXMLFile(const string&)`:** O(n) tokens + O(n) tree = O(n) peak.
- **`FormatXMLFromFile(...)`:** O(depth) recursion stack; O(n) if producing in-memory output.
- **`minifying(...)`:** O(depth) stack; O(n) if storing output in memory.
- **`convertXMLtoJSONFromTree(...)`:** O(n) for JSON output.
- **`compress(..)`:** O(n) input buffer + O(dict) (practically O(n)).

- **`decompress(..)`:** O(m) decompressed output + O(dict); plus an extra O(m) when `save_decompressed_xml` copies the buffer.
- **`xmlToGraphFromTree(XmlNode*)`:** O(V + P) where V is number of users and P total posts/auxiliary data.
- **`dotFileInput(...)`:** O(1) extra (streams edges to file) beyond the `users` map.
- **`visualizeGraph(...)`:** O(1) (invokes external `dot`).
- **`SearchByWordFromTree(...)` / `SearchByTopicFromTree(...)`:** O(R) for results plus traversal stack; overall O(n) if many matches.
- **`error_handling(...)`:** Implementation-dependent; could be O(n) if loading file into memory or O(1) if streaming corrections.

GUI

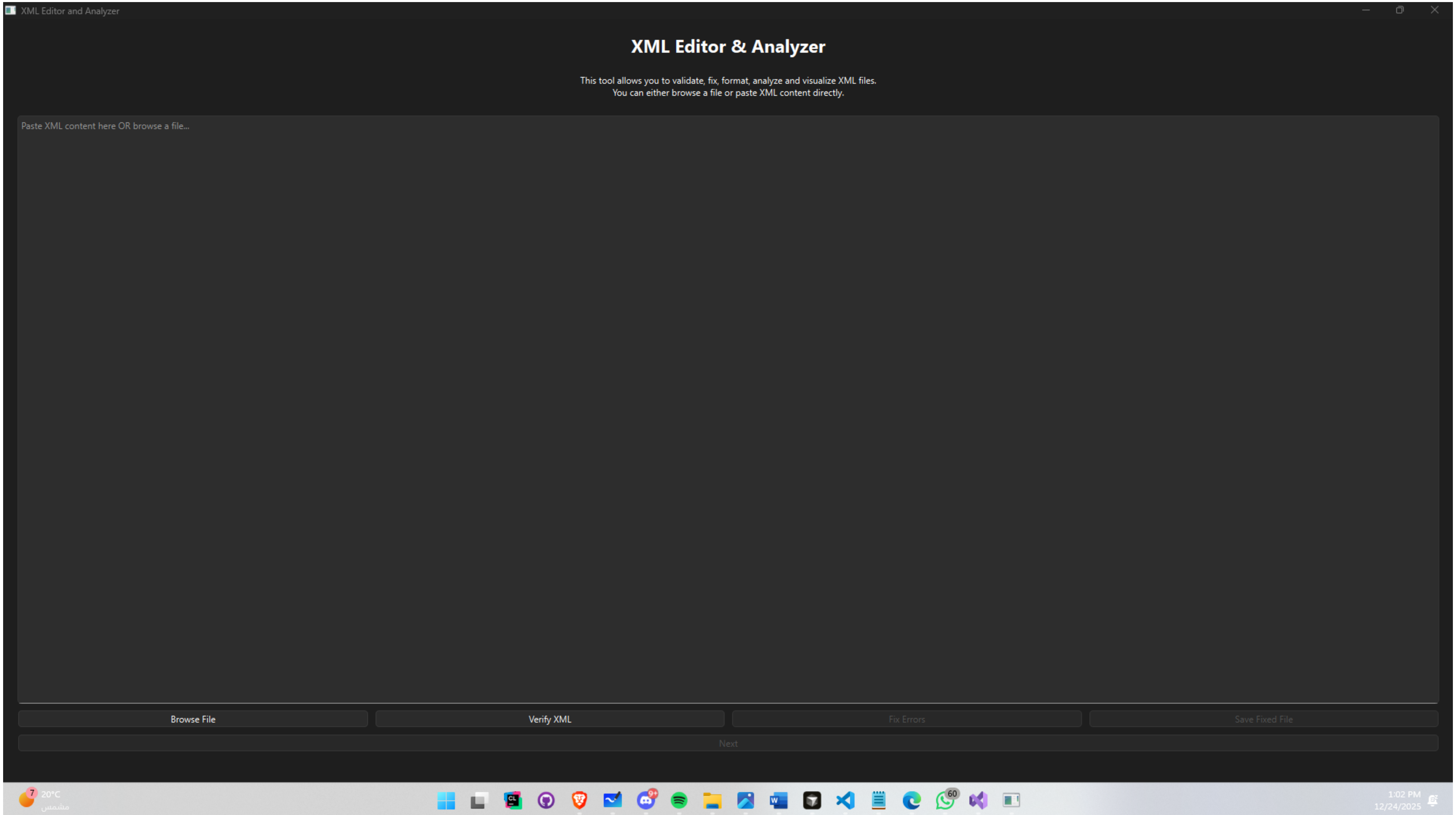
Overview: A lightweight Qt-based GUI provides file-open/save, command buttons (Format, Minify, JSON, Compress/Decompress, Verify, Draw), and output previews for formatted XML, JSON, compressed files, and graph images.

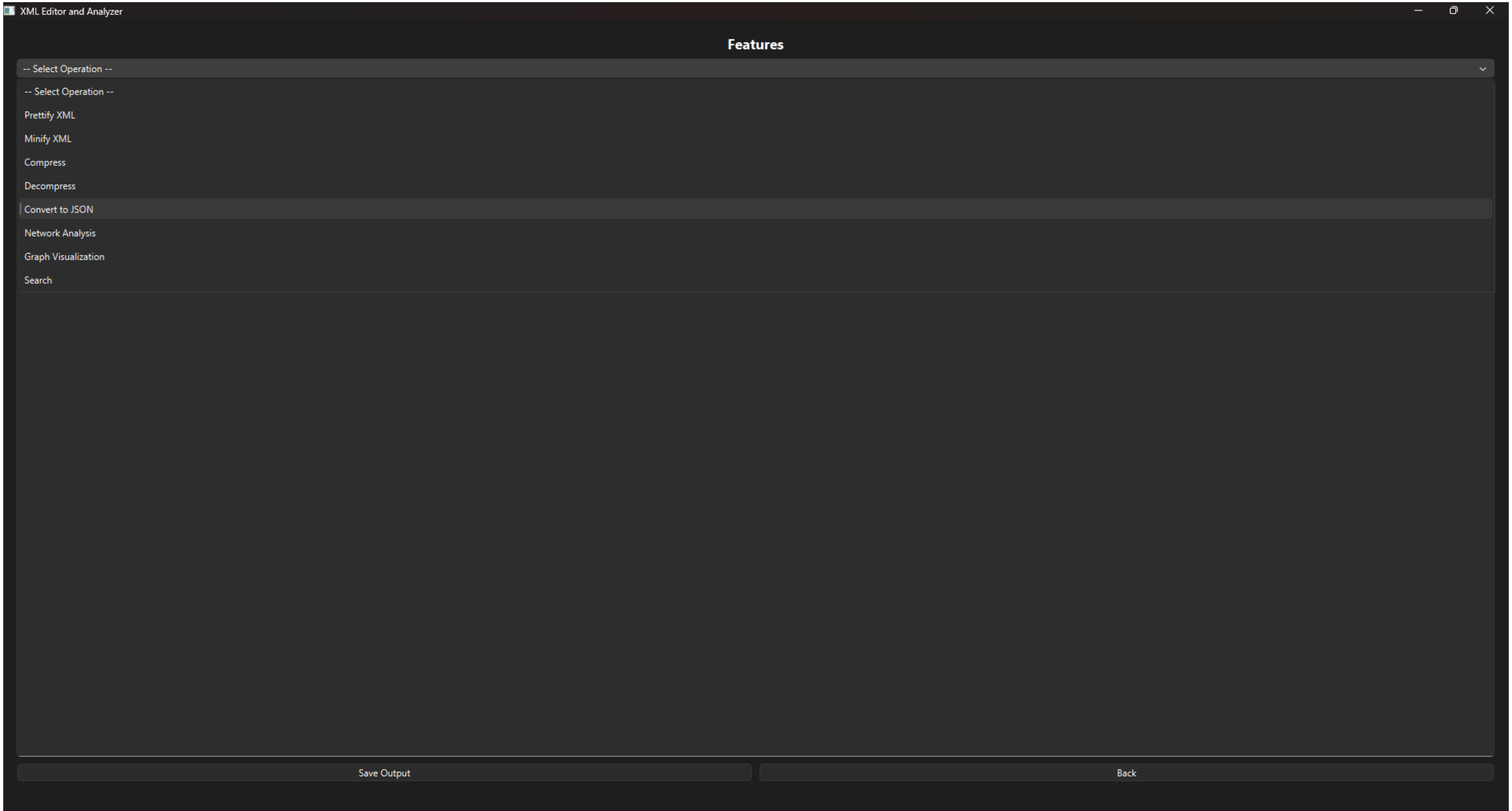
Implementation:

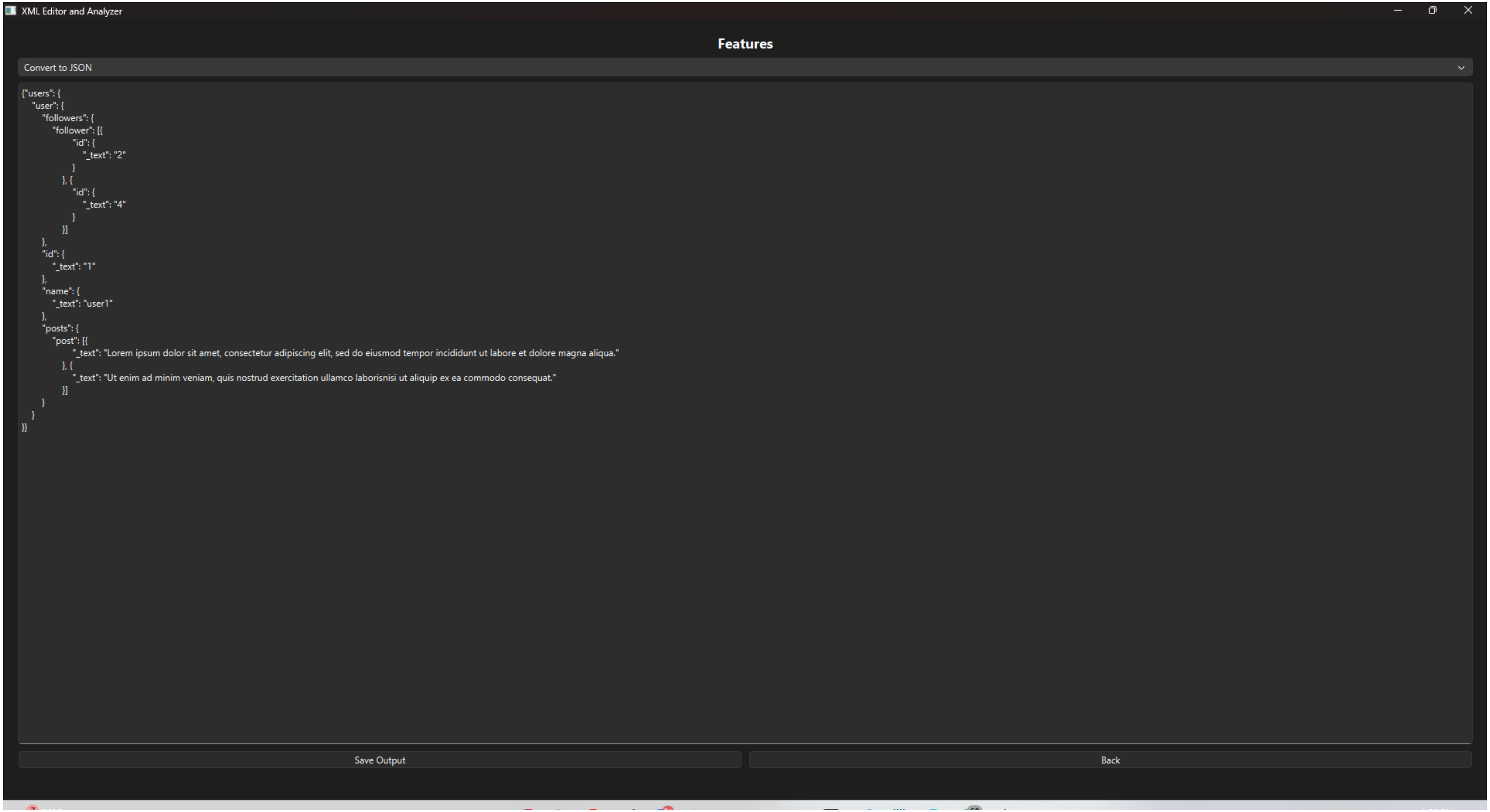
A desktop UI built with Qt Widgets that exposes the main CLI features (prettify, minify, compress/decompress, convert to JSON, network analysis, graph visualization, search). The top-left control is a dropdown to select the active operation; a feature list presents available operations; the central area is a large preview pane showing command output (example: JSON output); the bottom row contains action buttons (`Save Output`, `Back`). The UI uses a dark theme and large scrollable text area for previews .

Layout:

- Operation selector: `QComboBox`.
- Feature list / actions: `QListWidget` or `QTreeWidget` for grouped operations.
- Output preview: `QTextEdit` configured as read-only for output preview and editable when user chooses to edit output.
- Image preview (graph): `QLabel` or `QGraphicsView` to show Graphviz-generated JPG/SVG.
- Buttons: `QPushButton` for `Save Output`, `Back` and other actions.
- Layout: top toolbar / combo row, main horizontal splitter with left operations and right preview, status bar at bottom.


XML Editor and Analyzer
XML Editor & Analyzer
This tool allows you to validate, fix, format, analyze and visualize XML files.
You can either browse a file or paste XML content directly.
Paste XML content here OR browse a file...
Browse File
Verify XML
Fix Errors
Save Fixed File
Next
20°C
1:02 PM
12/24/2025


XML Editor and Analyzer
Features
-- Select Operation --
-- Select Operation --
Prettify XML
Minify XML
Compress
Decompress
Convert to JSON
Network Analysis
Graph Visualization
Search
Save Output
Back


XML Editor and Analyzer
Features
Convert to JSON
{"users": {
"user": {
"followers": {
"follower": [{
"id": {
"_text": "2"
}
}, {
"id": {
"_text": "4"
}
}]
},
"id": {
"_text": "1"
},
"name": {
"_text": "user1"
},
"posts": {
"post": [{
"_text": "Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua."
}, {
"_text": "Ut enim ad minim veniam, quis nostrud exercitation ullamco laborisnisi ut aliquip ex ea commodo consequat."
}]
}
}
}}
Save Output
Back

User flow (example): Convert to JSON)

1. User selects `Convert to JSON` from the dropdown.
2. User picks an input XML via `Open` or types a path, then clicks a run button.
3. GUI runs `xml_editor.exe json -i <in> -o <out>` (or calls the conversion function) via `QProcess`.
4. When process produces output, the QTextEdit preview is updated with pretty-printed JSON; `Save Output` becomes enabled to write the preview to disk.

Refrences:

- W3C: Extensible Markup Language (XML) 1.0 Specification.
- RFC 8259 — The JSON Data Interchange Format.
- D. A. Huffman, "A method for the construction of minimum-redundancy codes." 1952.
- cppreference.com — C++ standard library references.
- Graphviz documentation (https://graphviz.org)
- Qt documentation (`https://doc.qt.io`) for `QProcess`, `QFileDialog`, `QThread`, and UI components.

-Team Contributions

Farah Haitham Saddik Abd Elmaged	XML to graph + report
Mohammed Yasser Said	Minify XML +XML to json+ report
Karim Hosam Ahmed Ali	GUI
Maya ahmed farahat	ERROR handeling
Omar Abdelgaber Elsayed	Compress and decompress
Mohamed Ashraf Mohamed Mounir	Main + XML to tree parsing + search
Radwa Yasser Ahmed	Network analysis and formating