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Fission

GCC Cauldron
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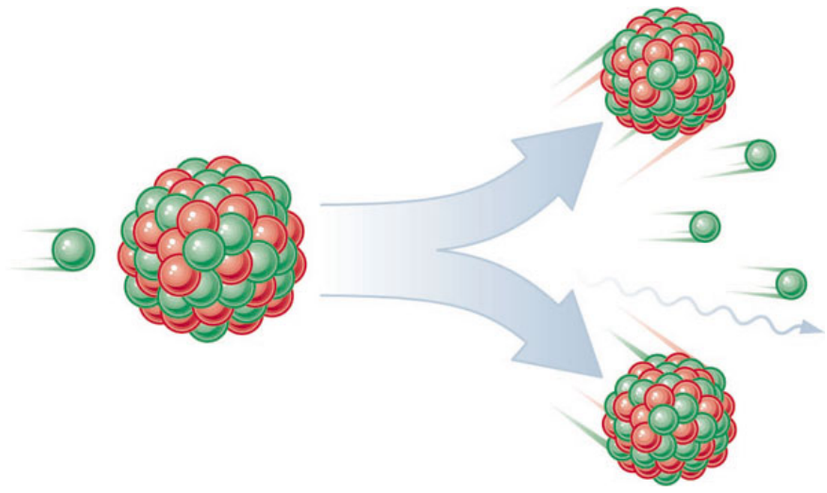

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Goal: Debug Info All the Time

Linking large apps takes too much time and space

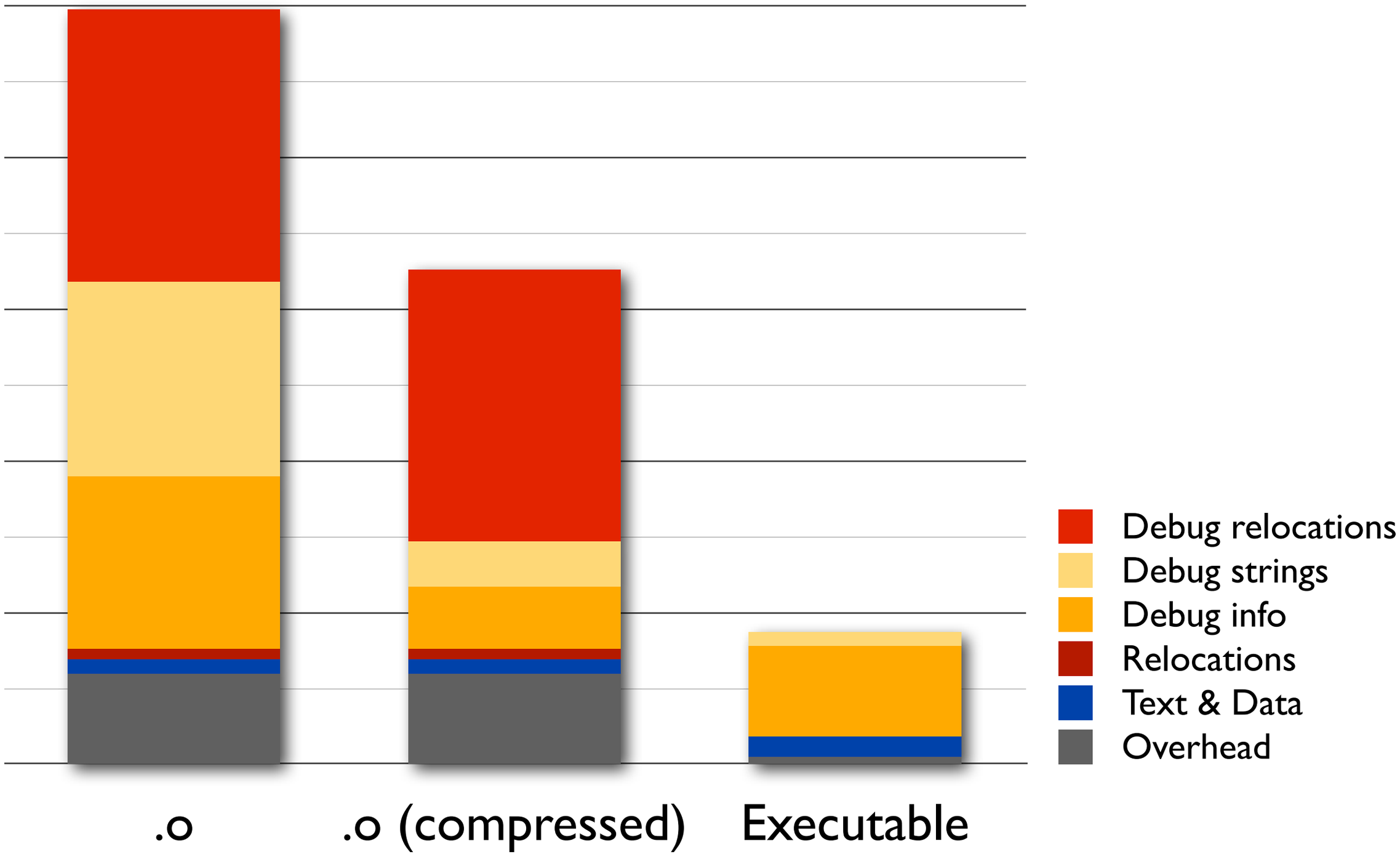
- Debug info expands .o files by 5x.
- For a distributed build, all that data has to be copied to remote server.
- Compressed debug info reduces that by 30–40%.

GDB time-to-main is too long

- Fast-lookup index reduces time-to-main from minutes to seconds.
- Link-time gdb index generation from raw debug info is too slow—need to use pubnames/pubtypes tables.

Solution: Split the bulk of the debug info into separate files and replace with fast-lookup index.

What's Taking So Much Space?



Observations

- Relocations for debug info account for more than half of the debug info overhead in .o files.
- Debug strings account for 10% of the total size of the .o files.
- References to strings account for 90% of the debug relocations.
- Line number tables, range lists, location lists, etc., are small relative to debug info. (But with more optimization, location lists and their relocations continue to grow.)

Step 1: Link-Time Generation of GDB Index

- Modify GCC to emit all public names needed for fast lookup:
  - enumerator constants
  - “const int” vs. “int const”, anonymous namespaces, etc. (demangler as canonical form)
- Modify linker to read .debug_pubnames and .debug_pubtypes to build .gdb_index.
- For DWARF-5, consider developing new, improved, fast-lookup tables.

Step 2: Eliminate Relocations to Debug Strings

- Add a new section, .debug_str_offsets, which holds offsets to strings in the .debug_str section.
  - Even with explicit relocations, the coalescing of multiple references to a single string will reduce the number of string relocations.
  - This section can be implicitly relocated by the linker if desired, allowing the compiler to generate unrelocated offsets.
  - With separate debug info files, no relocations are necessary.
- Add a new DW_TAG_compile_unit attribute, DW_AT_str_base, whose value points to the base of the compilation unit's contributions to .debug_str_offsets. (Optional if using separate debug info files.)
- Add a new FORM code, DW_FORM_str_index, representing an index to a slot in .debug_str_offsets, relative to the start of the compilation unit's base offset.

Step 3: Isolate References to Loadable Segments

- Add a new section, .debug_addr, which holds relocatable addresses referencing locations in a loadable segment.
- Add a new attribute to the compile unit DIE, DW_AT_addr_base, whose value points to the base of the compile unit's contributions to .debug_addr.
- Add a new attribute to the compile unit DIE, DW_AT_ranges_base, whose value points to the base of the compile unit's contributions to .debug_ranges.
- Add a new FORM code, DW_FORM_addr_index, representing an index to a slot in .debug_addr, relative to the compilation unit's base offset.
- Add two new OP codes, DW_OP_addr_index and DW_OP_const_index.
- Modify format of .debug_loc section so that start address is an index to a slot in .debug_addr, and end address is either an index or the length of the range.

Step 4: Split Bulk of Debug Info

- For references to ranges in .debug_ranges, use raw unrelocated offsets, relative to offset given by DW_AT_ranges_base.
- Move the following sections to a separate .dwo file (adding ".dwo" to the section names):

  .debug_abbrev

  .debug_info and .debug_types

  .debug_loc

  .debug_str and .debug_str_offsets

  .debug_macinfo or .debug_macro

- Write a skeleton .debug_lines.dwo section to the .dwo file to provide file names needed by .debug_types.dwo sections.

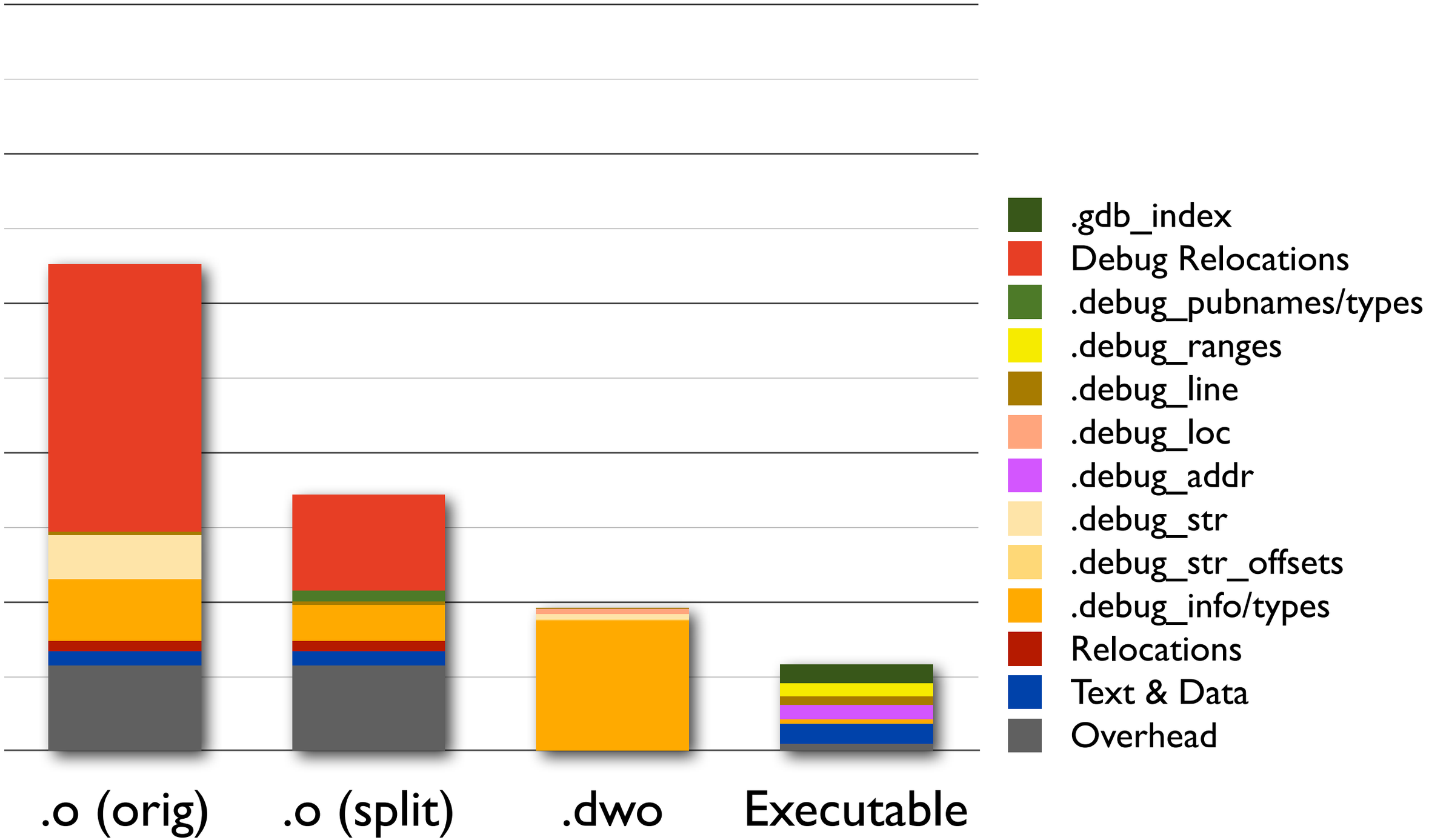
Step 5: Add Index Information

- Write a skeleton compile unit DIE in the .o file with attributes:
  - DW_AT_comp_dir
  - DW_AT_stmt_list
  - DW_AT_low_pc/high_pc or DW_AT_ranges
  - DW_AT_dwo_name and DW_AT_dwo_id
  - DW_AT_addr_base
  - DW_AT_ranges_base
- Keep the following debug sections in the .o file:
  - .debug_info and .debug_types (skeletons)
  - .debug_abbrev (for skeleton info and types sections)
  - .debug_lines
  - .debug_ranges
  - .debug_addr
  - .debug_pubnames and .debug_pubtypes
  - .debug_aranges

Step 6: Package .dwo Files

- GDB can use the .dwo files in the build tree during development.
- When releasing a binary for production use, we need to collect the .dwo files into a convenient package.
- While collecting the .dwo files, eliminate duplicate types and merge string tables.
- Optionally, run dwz while collecting .dwo files.

Results (so far)



Status

- GCC patches have all been submitted for review; all but the final one have been committed.
- GDB support is in trunk.
- Gold support for building .gdb_index is in trunk (except for new DW_AT_pubnames attribute handling).
- Packaging tool is not yet done (expected by end of July).
- DWARF proposal has been submitted for review for version 5.

Future Improvements

- Coalesce redundant entries in .debug_addr (we still see many duplicates due to .LVL labels for location lists).
- Replace .gdb_index with better fast-lookup tables.
- Eliminate redundancy between .debug_addr and .debug_ranges tables.

Thank You