Realistic Output without real model:
an XIOS client toy

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A FORTRAN client toy model is developed and associated to an XIOS server to mimic output of realistic climate simulations. An additional tool allows to transfer, from realistic input files, characteristics of these output in a generic XIOS (XML) parameter file. For a given configuration, our development facilitates the XIOS configuration (number of servers, mapping) and performance optimization. In preliminary tests, 2 similar ORCA025-like simulation performed on 2 different supercomputers gives information on network/file system characteristics and their compatibility with the I/O server.

Needs

To address performance issues related to parallel disk access, the most CPU and data intensive climate models include I/O servers. The read/write operations are performed by these servers, separately from model calculations. XIOS [1], one of the European climate modelling community I/O server, is currently used in the ocean component of CERFACS and CNRM coupled system (NEMO) and planned to be used in the atmospheric component (ARPEGE).

Coupled models are complex systems, that can include several components, from which I/O servers. To set up the whole coupled system, it could be easier to test separately each of its components. These tests are necessary at each stage of the model implementation until production runs, to answer various kind of questions like:

- are the library (MPI, OASIS, NETCDF ...) linked to my component valid ?
- Is my component correctly parametrized to fulfil the machine requirements ?
- Are my component processes correctly mapped on resources to optimize performances ?
- Is my component producing the right output ?

A simplified client (`src/test/test_client.f90`) comes with the XIOS distribution. To answer, for the XIOS component, the first question, this program can be launched on a reduced number of resources.

In this document, we describe the implementation of a more sophisticated client that could help any XIOS user to answer the other questions, for each of his realistic configurations, whatever would be the number of XIOS-instrumented components in his coupled system, and whatever would be the number, the size, the dimensions (2D-3D) and the attributes of the variables output.

Principle & implementation

The proposed solution must allow to use XIOS parameter file (`iodef.xml`) coming from

realistic simulations that one would like to mimic in term of data output (volume, quality, frequency). The information that is not included in this file (variable grid, client time step, time step duration in elapsed time and simulation length), but that must be set, requires an additional parameter file. The `iodef.xml` file usually comes with include files, to declare in separate files the information related to fields (`field_def.xml`).

Implementation starts with the existing client of the XIOS distribution. New functionalities are added. It is possible to define, through parameters:

- the number, names and attributes of variables (including variables produced by combination of other variables)
- the dimension number of variables
- the grid dimension of the variables
- the client time step
- the elapsed duration of each client time step (time-out period, in µs)
- the simulation length (in simulated days)

The last 4 parameters are set in a namelist file (`nam_client_1`). The first 2 parameters are deduced from the realistic `iodef.xml` file. Two sequential shell scripts transform the original file into a simplified `iodef_1.xml` file (see Figure 1). In this new file, the original field and file descriptions are conserved. But the context, calendar, grid, axis and domain definition are simplified to avoid unnecessary treatments in client program. This simplification also allows the indifferently use of XIOS 1.0 or 2.0 parameter files.

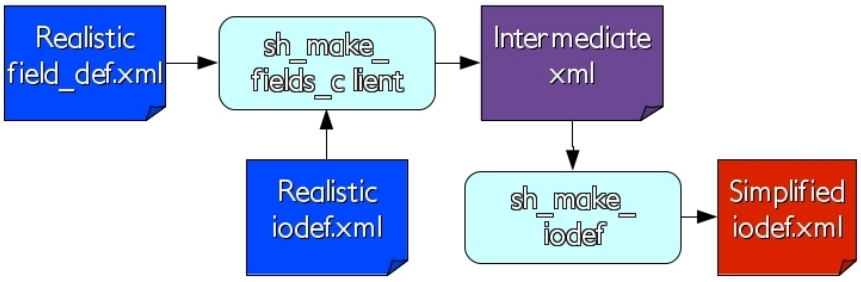

Figure 1: Workflow for production of simplified `iodef.xml` files

A single `xios_send_field` operation is performed by the client program for a "reference" field -`field_ref`- (two operations if 3D fields are output in addition to 2D fields). As much fields as necessary are associated to this reference field in the simplified `iodef.xml` file, such that all fields originally defined in the realistic parameter files will be output by the XIOS server.

It is possible to define a configuration involving several clients. This functionality is necessary to represent the new CNRM-CM6 configuration, in which both ARPEGE and NEMO models are client of XIOS servers. To set up a 1-n multi-client configuration, it is necessary to:

- Launch n times, with a parameter from 1 to n, the first shell script (`sh_make_fields_client`). A number of n-suffixed XML files (`real_iodef_1.xml` and `real_field_def_1.xml` to `real_iodef_n.xml` and `real_field_def_n.xml`) must be provided as input.
- Launch the second shell script (`sh_make_iodef`) that will gather the information on a single `iodef.xml` file, including the description of n XIOS contexts.

– Launch the simulation with n-suffixed executables (`test_client_1.exe` to `test_client_1.exe`) and n-suffixed parameter files (`nam_client_1` to `nam_client_n`).

As originally, the client is MPI-parallel and an equal and regular decomposition is automatically defined between client processes.

Results

One could take advantage of the XIOS client toy as an application that can benchmark platforms targeted to host a climate simulation.

A set of NEMO variables are requested for output in realistic conditions (daily and monthly means). The XIOS client is parametrized to provide fields on ORCA025 grid (1442x1021x75). Client is parallelized on about 320 MPI processes. One server is allocated per node. The same test is performed on the two Météo-France supercomputers, BEAUFIX-1 (Ivy Bridge) and PROLIX-2 (Broadwell)

Resources	(24*13) Ivy Bridge cores with 32 Gb per node	(40*8) Broadwell cores with 64 Gb per node	
XIOS servers	13	13	8
Speed (SYPD[1])	48	48	52
Data intensity (Gb/CH[2])	15	15	26

Table 1: XIOS compared performances on Météo-France supercomputers with the same ORCA025 output set

Speeds on the two machines are comparable. The same for output efficiency, since the same amount of data (97 Gb/SY) is produced at same speed. But memory per node characteristics allow to use less resources for servers on PROLIX. This leads that data intensity [2] can be significantly better for this machine.

Conclusion

A couple of shell scripts and FORTRAN programs are developed to test XIOS capabilities in realistic conditions. Further work could add functionalities to this tool, like the output of 1D variables, more realistic MPI decompositions on different grid types, the definition of several grids/contexts per component or the inclusion of the OASIS library between components. The shell script programs for file parsing could be translated in a more modern language by more modern developers. An intensive test of this tool on different machines and with different realistic iodef.xml configurations from the whole XIOS user community is required to strengthen its portability.

1 Simulated Years Per Day
2 Giga Byte per Core Hour

References

[1] Joussaume, S., Bellucci, A., Biercamp, J., Budich, R., Dawson, A., Foujols, M.-A., Lawrence, B., Linardikis, L., Masson, S., Meurdesoif, Y., et al.: Modelling the Earth's Climate System: Data and Computing Challenges., in: SC Companion, pp. 2325–2356, 2012.
[2] Balaji, V., Maisonnave, E., Zadeh, N., Lawrence, B. N., Biercamp, J., Fladrich, U., Aloisio, G., Benson, R., Caubel, A., Durachta, J., Foujols, M.-A., Lister, G., Mocavero, S., Underwood, S., and Wright, G.: CPMIP: Measurements of Real Computational Performance of Earth System Models, Geosci. Model Dev. Discuss., doi:10.5194/gmd-2016-197, in review, 2016.

Source availability

local:/wkdir/globc/eric/evian/Tool_library/XIOS_Toy
prolix:/home/ext/cf/cglo/maisonnavee/SAVE/Scripts/Test_XIOS/New_Arpege_XIOS for scripts and prolix:/scratch/work/cglo315/DYNAMICO/XIOS for FORTRAN sources