

Divide and conquer: Modular controller design strategy makes upgrading power grids easier

November 4 2020

Divide and Conquer: New Approach to Modular Design in Large and Complex Systems

Modular design is a powerful approach for implementing decentralized large-scale complex systems

Individual developers can work in parallel and flexibly improve their respective subsystems/modules without compromising the whole

What should subsystem controllers be like to ensure stability?

New modular design method using decentralized retrofit controllers

Each developer only needs access to their own subsystem...

...and the system is robust against local disturbances

Youla parametrization based approach reveals the required structure of the controllers

Simultaneous application of multiple retrofit controllers improves overall stability of the system

Simple and flexible method to design and upgrade large systems

Readily applicable in power system stabilizers

Modularity-in-Design of Dynamical Network Systems: Retrofit Control Approach
 Ishizaki et al. (2020)
 IEEE Transactions on Automatic Control



Credit: Takayuki Ishizaki

Scientists at Tokyo Institute of Technology (Tokyo Tech) develop a novel approach for the modular design of controllers for large-scale network systems. Their strategy, which provides a completely decentralized method to design controllers for subsystems of a larger

whole, could be readily applied in power grids, greatly simplifying the task of sequentially upgrading individual subdivisions while ensuring stability and performance.

The control of large-scale dynamic [network](#) systems, such as national power grids, is a remarkably challenging topic. In this context, 'control' roughly means monitoring relevant output variables to ensure that the system operates stably and within safe margins. The difficulty and necessary considerations associated with the design and implementation of controllers usually skyrocket when dealing with complex networked systems, and [theoretical studies](#) to find new approaches to [controller](#) design are constantly being carried out.

One common problem that arises in large networked systems is that they're integrated. So, when a developer changes or upgrades one subsystem, their 'local' actions can have unforeseen consequences on the rest of the network unless necessary precautions are taken for all subsystems. Even remote network disturbances caused by local temporary failures, such as the accidental grounding of a line in a power subsystem, can throw other subsystems off. Consequently, changes may not be made to one subsystem without necessitating alterations to all others.

However, as demonstrated in a recent study by scientists from Tokyo Tech, Japan, there is a design paradigm that can prevent such problems: modularity. This term implies working in "modules," subdivisions of the main system that can be separated, changed, and recombined independently, ideally without compromising each other. Nonetheless, as explained in their article published in *IEEE Transactions on Automatic Control*, achieving this independence between modules through their associated controllers is not straightforward.

In their study, the scientists developed a novel approach for the modular

design of subsystem controllers in linear large-scale network systems that enables a number of advantages over existing approaches. In their approach, each developer for a subsystem can independently design and implement their controllers as an add on to the existing system. To do so, they only require knowledge of their subsystem. A decentralized controller designed under such considerations is called a retrofit controller.

First, the scientists used a technique called Youla parametrization to formally describe all the relevant parameters of generic retrofit controllers in a networked system. Then, they laid out a unique design for their retrofit controller that required only standard techniques to implement. They also mathematically demonstrated that, given certain reasonable assumptions about the whole, such as a stable system prior to the implementation of the proposed retrofit controller, using their controller guaranteed both local and overall system stability, even in the face of variations in other controllers.

Moreover, through numerical experiments, they showed that simultaneously implementing multiple such uniquely designed controllers in a network translates to performance improvements across the entire system, and adding more such controllers leads to greater power enhancement. As associate Professor Takayuki Ishizaki, lead author of the study, explains, "The proposed modular design method provides a new theoretical basis for sequential system upgrades, such that the stability of the current system is surpassed by its [future generations](#). In short, each designer can individually add, remove, and modify their controller without considering the actions of other designers." His team also demonstrated the practical significance of their method through an illustrative example: generator frequency regulation in an IEEE-standard power system model.

The benefits of modularity-in-design are many, as Ishizaki concludes:

"Modular design is a widely accepted strategy that simplifies the design of complex large-scale systems, enables parallel work by multiple independent entities, and enables flexible future modifications of modules." Future advances in modular design will hopefully make the control of large-scale network systems more easily tractable and make them more easily upgradeable.

More information: Takayuki Ishizaki et al, Modularity-in-Design of Dynamical Network Systems: Retrofit Control Approach, *IEEE Transactions on Automatic Control* (2020). [DOI: 10.1109/TAC.2020.3035631](https://doi.org/10.1109/TAC.2020.3035631)

Provided by Tokyo Institute of Technology

Citation: Divide and conquer: Modular controller design strategy makes upgrading power grids easier (2020, November 4) retrieved 24 April 2024 from <https://techxplore.com/news/2020-11-conquer-modular-strategy-power-grids.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.