The Block Arrow Structure (B.A.S.) regulator versus the Perturbational Approach regulator. A comparison study.

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I. Introduction.

In recent years there has been an increasing interest in the area of Large Scale Systems(L.S.S.) and Multilevel Hierarchical Systems (M.H.S.)[1]-[5].There are also numerous articles in the same two areas which also show their great mathematical interest and practical importance.This is due to rapid advances in computer technology and due to structural socio-economic and real life problems being "large" in dimension ,high in complexity and of great challenge to both the system analyst and control system designer.

A distinguishing characteristic of L.S.S. and M.H.S. which often model real life problems is that centrality either does not hold or cannot be used to model the specific problem.This difficulty is due to either costs of operation ,lack of centralized information structure ,given hierarchical or decentralized system structure or lack of centralized computing capabilities.

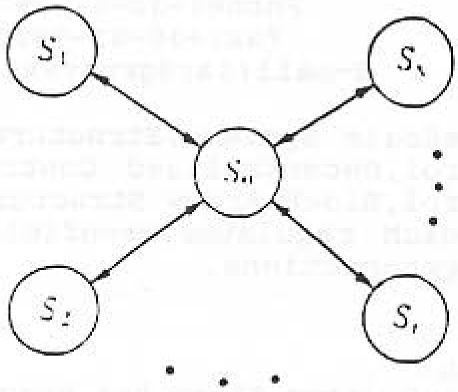
Furthermore in some cases subsystems share explicitly some common parts thus using centralized methods is not recommended.

Despite that many systems could have been modeled and investigated using structural state models are exploring their inherent structure for qualitative and quantitative studies,this is not done but only in few cases.Thus the perturbational approach suggested by Sundareshan [6] is one example in which the interconnections are characterized as external perturbations acting in contradiction to the autonomy of the individual subsystems.The same approach further classifies these interconnections as neutral,beneficial and non beneficial always having the philosophy that the subsystems should keep their autonomy as much as possible .This approach is explained explicitly in [6].

THE B.A.S. APPROACH

The mathematical model in state space description of the time invariant L.S.S. decentralized structure of Figure 1 in a decomposition form

Figure 1 The BAS decentralized large scale systems.



$$S_i : \dot{x}_i = A_i x_i(t) + B_i u_i(t) + A_{i0} x_0 ; \quad x_i(t_0) = x_{i0} \tag{1}$$

$$S_0 : \dot{x}_0(t) = A_0 x_0(t) + B_0 u_0(t) + \sum_{i=1}^{N} A_0 i x_i(t) ; \quad x_0(t_0) = x_{00} \tag{2}$$

where $x_i(t) \in R^{ni}$, $x_0 \in R^{n0}$ and $u_i(t) \in R^{ri}$, $u_0(t) \in R^{r0}$ are the state and control vectors for the subsystems S_i and S_0 respectively.Then the matrices $A_i \in R^{ni*ni}$, $A_0 \in R^{n0*n0}$ and $B_i \in R^{ni*ri}$, $B_0 \in R^{n0*r0}$ describe the dynamics and control distribution for S_i and S0 respectively. The interconnections (or information transfer) from S_0 to S_i and S_i to S_{0i} are represented by the matrices $A_{i0} \in R^{ni*n0}$ and $A_{0i} \in R^{no*ni}$ respectively [7].

The standard overall description of (1),(2) is

$$\dot{x}(t) = Ax(t) + Bu(t) \quad x(t_0) = x_0 \tag{3}$$

here $x(t) = [x_1^T(t), \ldots x_N^T(t), x_0^T(t)]^T \in R^n$ with
and $u(t) = [u_1^T(t), \ldots, u_N^T(t), u_0^T(t)]^T \in R^r$
where n is the sum of the dimensions of all the subsystems and the

coordinator and r is the sum of the dimensions of the input applied to the each subsystem and the input of the coordinator.

The Block Arrow structure (B.A.S.) approach it is called that way because the dynamics matrix A of the system consists of block elements arranged in an Arrow Structure.The systems which are modeled in that way are called Block Arrow Structure (B.A.S.)-decentralized L.S.S..

Also the control vector is block diagonal matrix.Each of theese systems has a quadratic cost function where the weighting matrices $Q \in R^{n*n}$ and $R \in R^{r*r}$ are constant,symmetric and positive definite with Q taking the comparable B.A.S. system structure form and R being of strictly diagonal form [7].

The objective is to find,in the time interval $[t_0,oo]$ a time invariant B.A.S.-decentralized feedback controller of the form and the technical features mentioned in [7].

The B.A.S. approach is explained explicitly in [7].

THE BLOCK ARROW STRUCTURE REGULATOR VERSUS THE PERURBATIONAL APPROACH REGULATOR.

A COMPARISON STUDY.

We have compared a lot of L.S.S. which were modeled by the B.A.S. approach.This means that there is a coordinator at a higher hierarchical level and other interconnected systems at a lower level.The subsystems are not interconnected directly.The only interconnections which exist at the whole system are the interconnections between the subsystems and the coordinator.

The first conclusion is that if we control such a system with the perturbational approach then the overall controlled system is unstable.This means that the stability of the system is not guaranteed.

The second conclusion is that if we control the overall system with the B.A.S. regulator the eigenvalues of the controlled system are very near to the eigenvalues of the optimal (centralized) solution.

As expected ,because the B.A.S. approach is a suboptimal solution,the cost of it is higher than the cost of the optimal(centralized) solution.

The above conclusions hold in the situations when the interconnections of the overall system are beneficial or non-beneficial.

In the case when the interconnections of the overall system are neutral then the eigenvalues of the controlled system are the same in the perturbational approach and the optimal (centralized) solution,the eigenvalues of the B.A.S. approach are very near and the system is stable in all the approaches.

The cost of the perturbational approach for the neutral case appears to be less than the cost of the centralized approach and both of them are less than the cost of the B.A.S. approach. More and detailed study might be needed for that.

In the case of neutral interconnections in all the approaches the structure of the model is not ruined.

In the case of beneficial interconnections the structure of the model is not ruined only by the B.A.S. approach. The same holds for the case of non-beneficial interconnections.

This comparison will be presented in more details with numerical examples at the final version of the paper as to be presented at the conference.

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