IDA - AN ENVIRONMENT FOR BUILDING AND ENERGY SYSTEMS SIMULATION

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ABSTRACT

IDA is a flexible, object-oriented, environment for simulation of buildings and their subsystems. The key features of the system are summarized. Available IDA literature is listed.

INTRODUCTION AND OBJECTIVE

In current design practice, a large group of heterogeneous stand-alone programs are used for study of different aspects of a building, for example ductwork sizing or estimation of thermal climate and yearly energy demand. This practice makes it difficult and costly to: (1) make interprogram comparisons and runs; (2) switch between programs as a user; and (3) reuse existing code in program enhancement and maintenance. IDA seeks to remedy these shortcomings by providing the building sector with a coherent and integrated framework for rapid implementation of building performance evaluation tools.

At the heart of IDA lies a general solver for modular, differential-algebraic systems of equations. A graphical front-end, IDA Modeller, provides end-users with a common interface to several related design tools. Component models are expressed in the Neutral Model Format, from which IDA classes are automatically generated.

TECHNICAL BASIS

- Modelling is input/output free, i.e. variables have no irrevocable roles as given or calculated. Input/output free modelling naturally leads to models described by equations rather than the traditional calculation procedures, thus getting closer to the physical relationships known to the modeller.
- The system can handle algebraic as well as differential equations, including algebraic loops.
- The integration of dynamical systems uses variable timestep and order, for efficiency and for consistent, easy to use, accuracy control.
- Sparseness in the system of equations is utilized effectively using a variety of algorithms.
- Models can be precompiled and distributed as ready building blocks, as in TRNSYS or HVACSIM+.
- Discontinuities in driving functions and in model equations are handled properly.
- Extensions to the basic equation modelling allow handling of discrete system states, as required by e.g. hysteresis.

APPLICATIONS

IDA has been applied to a range of representative problem categories. Some examples are cited here:

- Detailed models of district heating consumer substations. In modern substations the district heating piping network itself is used for thermal storage for production of domestic hot water. Highly efficient, thermally light, plate heat exchangers make this possible. However, this technique leads to a quite difficult problem of automatic control and many existing stations operate suboptimally. Detailed FD models for substation components and control equipment were developed, as the first external IDA application, by Kjell Kolsaker at SINTEF, Norway, in 1990.
- Models for study of smoke propagation between rooms and in ventilation ductworks. The first few minutes of a fire are frequently critical in terms of injuries and loss of lives due to smoke inhalation. A simulation study with IDA, carried out at NTH, Norway, in 1991 showed among other things that fire dampers far away from potential fire locations, which is common in current practice, are rather useless from this perspective. The temperatures at the dampers never reaches the closing setpoint during the first few minutes of a fire.

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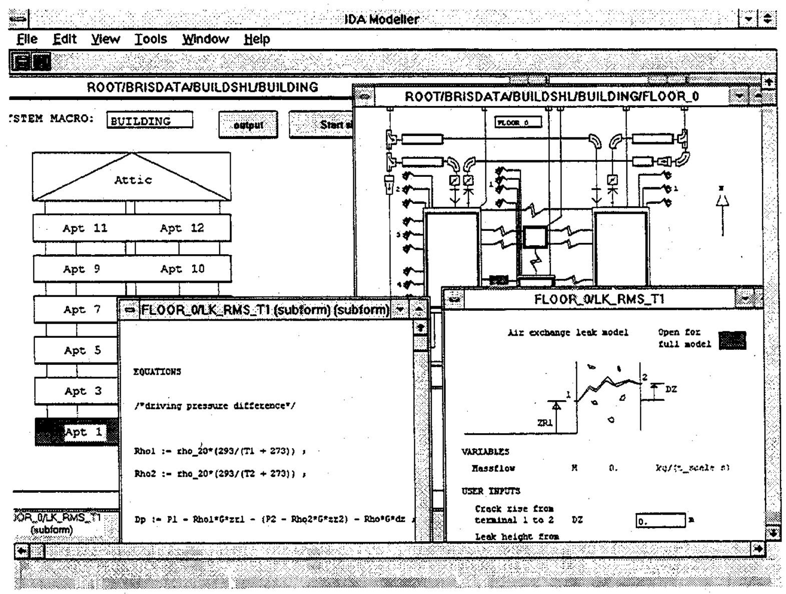

The GUI representation of a Multizone Air Exchange model of a building with six floors and an attic. Models are built and represented hierarchically with subsystems within subsystems. Overview as well as detailed presentations are available to accommodate users with varying levels of sophistication.

- Traditional models for calculation of energy demand and thermal climate in buildings. Simple models, with a few temperature states, have been tested as well as more elaborate finite difference models with several hundred states..
- The most recent application is for ventilation and fire studies in traffic tunnels. Under normal conditions the traffic itself drives ventilation air through the tunnel; in accident or fire scenarios, fans play an important role. Modelling of fires calls for coupled models of both air movement and heat transfer.

Tools for the listed application areas have been developed for specific projects, utilizing mainly the IDA Solver as a stand alone tool. A single demo application with a GUI, for wider distribution, has been developed:

Multizone Air Exchange (MAE) - static calculation of airflows between zones and in the ductwork of a building. Air temperature and contamination are modelled. Wind pressure on building envelope is given through pressure coefficients. Airflow models may be coupled with thermal models to study for example natural ventilation.

CURRENT STATE AND AVAILABILITY

IDA Modeller has recently been ported to Windows and a beta version of IDA with the demo application is available and has been tested on industrial users.

IDA Solver as a stand alone tool with several NMF libraries is available since a few years as an academic tool. The full IDA development environment, including IDA Solver and NMF translators, will be commercially available in mid 96. Favorable academic prices apply.
IDA runs on PC:s with Windows and 8 Mb of physical memory. 15 Mb disk space is required.

PLANNED DEVELOPMENT

IDA has been used by advanced users for some years, and the software has now reached sufficient maturity for broader industrial application. To achieve this, a consortium of 29 Swedish companies has been formed. The objective during the next three year period is to develop a range of IDA-based end-user applications for the building sector.

Bris is also involved in a range of related projects concerning the application of IDA in specific simulation projects. The main deliverable is generally an executable model that can be configured both topologically and in terms of parameters by the user.

Another field of activity is development of NMF related tools (see separate Building Simulation '95 paper on NMF), mainly translators for various simulation environments.

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CONTINUOUS_MODEL bdzont
ABSTRACT
"A dynamic zone model for air-exchange modelling.
Bidirectional transports of energy plus a mass fraction
are modelled. "
EQUATIONS
/* fraction conservation */
  0 = - X'* xCap *1. / t_scale+ Occ * xfRate
   + Xf_source + Xf_0 + SUM i3=1, n Xf[i3] END_SUM;
/* mass conservation */
  0 = M_0 + SUM i=1, n M[i] END_SUM;
/* energy conservation */
  0 = Q_zone + Q_0 + SUM i2=1, n Q[i2] END_SUM;
LINKS
/* type  name        variables... */
BidirX terminal_0  P, POS_IN M_0, T_zone,
                   POS_IN Q_0, X, POS_IN Xf_0;
FOR i = 1, n
BidirX  terminal[i]  P, POS_IN M[i], T_zone,
                     POS_IN Q[i],  X, POS_IN Xf[i]
END_FOR;
Tq     heat_load    T_zone, POS_IN Q_zone;
T      air_temp     T_zone ;
X_y    fract        X ;
Z      people       Occ ;
VARIABLES
/* type          name  role    description */
Fraction_y       X     OUT     "zone fraction"
MassFlow_u       M_0   OUT     "terminal 0 massflow"
MassFlow_u       M[n]  IN      "terminal i massflow"
Pressure         P     IN      "zone floor pressure"
HeatFlux         Q_0   OUT     "terminal 0 HeatFlux"
HeatFlux         Q[n]  IN      "terminal i HeatFlux"
FractFlow_yu     Xf_0  IN      "terminal 0 transport"
FractFlow_yu     Xf[n] IN      "terminal i transport"
HeatFlux         Q_zone IN     "heat gain/loss in zone"
FractFlow_yu     Xf_source IN  "Mass fraction source"
Factor           Occ   IN      "No of occupants"
MODEL_PARAMETERS
/* type          name  role    description */
INT              n     SMP "Number of links -1"
PARAMETERS
/* type          name role     description */
Length           za      S_P   "zone floor height relative
                               to ground"
Length           h       S_P   "zone height"
Area       a        S_P   "zone floor area"
FractFlow_yu     xfRate S_P    "contaminant src/person"
Density          rho_20 S_P    "density at grnd press"
Factor           t_scaleS_P    "time unit, 1 for [s],
                              3600 for [h]"
mass             xCap   C_P    "zone capacity of X [kg]"
PARAMETER_PROCESSING
xCap := a * h * rho_20 ;
END_MODEL
```


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