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SANDIA NATIONAL LABORATORIES

DHS STUDENT INTERNSHIP EXPERIENCE EVALUATION

Learning Skills that will Last a Lifetime | Lau, Wai Fai

Description of Internship Project and Specific Roles

A longstanding goal of the Homeland Security and Defense Center at Sandia is creating a safe and terror free environment for the citizens of the US. One source of terror would be Heating, Ventilation, and Air Conditioning (HVAC) sabotage and contamination with harmful agents through populated buildings and facilities. In order to combat possible biological and chemical warfare agent uses, preventive actions are implemented in models and simulations to pinpoint the weaknesses in the facilities and to effectively strategize against terrorist intelligence.

A program that Sandia has been using to model buildings is called CONTAM. CONTAM was developed by the National Institute of Standards and Technology (NIST) as a program that can detect air change rates and calculate contaminant concentrations in buildings comprised of zones. The user of the program takes a building and idealizes it into separate rooms and hallways represented by zones in the model. Then, the components are grouped by floor and mapped in a CONTAM worksheet where experiments are run and results are displayed. In the worksheet, users can place contaminant sources of various agents and quantities in different areas of the facility.

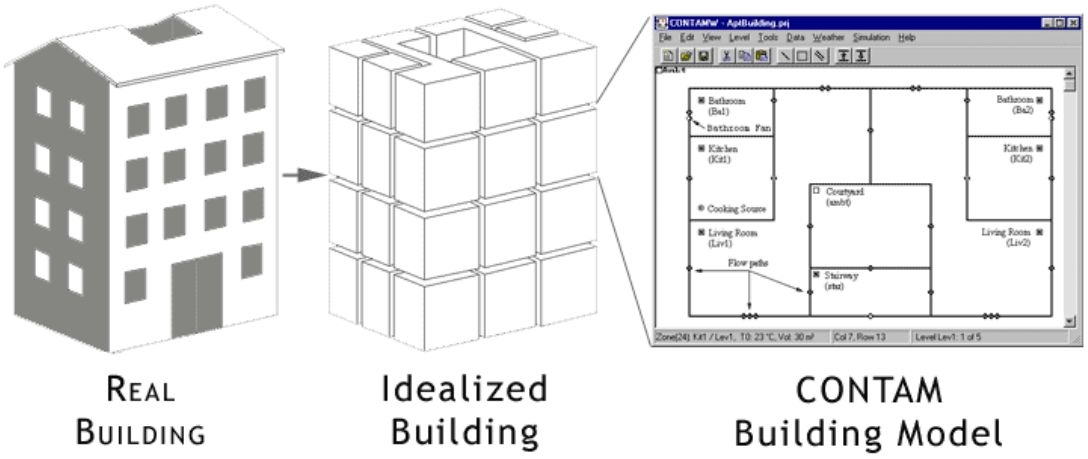

Figure 1: Breakdown of CONTAM's modeling stages

Experiments can then be conducted to determine where the contaminants would be displaced throughout the facilities and whether the ventilation system is helping the spread of the contaminant or effectively working to expel the contamination. CONTAM can also be used to predict personal exposure to biological or chemical agents by combining with other models of individual or group movement patterns.

Until recently, CONTAM could only use well-mixed or 1-dimensional methods for movements of contaminants. These methods have underlying assumptions that inaccurately portrays reality, but allows for faster simulation time. The assumption for the well-mixed method is that whenever the contaminant spreads into a room, it immediately propagates throughout the entire room and in the next time step, it is out the door and into the next room. In the 1 – dimensional method, the room is broken up into multiple linear segments in which the contaminants have to travel through each segment before exiting the door.

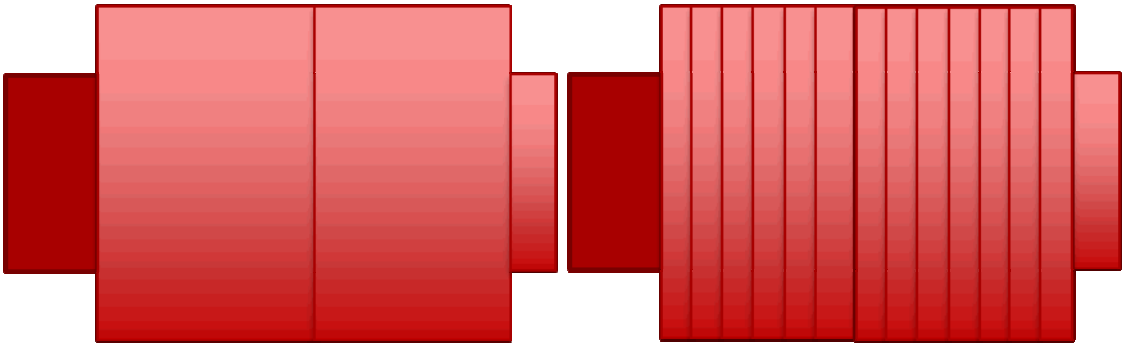

Figure 2: (a)Well-mixed rooms; (b) rooms broken up into 1 dimensional segments

These assumptions are not realistic and are lacking in accuracy, so a new method was introduced into CONTAM to address this issue. This method is called computational fluid dynamics (CFD). Instead of moving unidirectional, the contaminants in a CFD simulation can move, through a two-dimensional grid. CFD is a branch of fluid mechanics that deals with using numerical methods and algorithms to solve flow problems. These equations have also been used to model the air flow through airplanes to design more aerodynamic designs; they have also been used in submarine designs improve their hydrodynamic structures.

Many people have developed packages that utilize CFD for various applications. The CFD package that we used is the CFD0 Editor created by Wang in 2007 as his Purdue University Ph.D. thesis. The CFD0 Editor was chosen because it was compatible with the CONTAM software. One of my roles in this internship is to evaluate the CFD0 Editor to see if it is suitable for Sandia's Homeland Security applications.

Based on my research results, I recommend that the department should wait until further updates to the program and upgrades to the computing software be available before implementing CFD into the CONTAM program. After learning how to use the CFD0 Editor, I

conducted a test run on a real facility. For each test I performed, a new error occurred. I compiled a list of problems that needed to be addressed as follows:

Bug Fixes:

- Contaminant check box is not selectable until CONTAM restarts
- Occasionally while running the CFD simulation, the simulation suddenly pauses and needs a key press to keep going

Faster simulation time:

- Currently takes three hours to simulate a 4 zone transient model
- In a steady contaminant model, the flowchart is computed through once, while with a transient contaminant model, the flow chart is repeated for every time step.

Additional Geometries:

- Currently CFD0 allows for the zones to be only rectangular prisms; rooms with branches and non-rectangular shapes are not modeled adequately.

Multiple CFD zones:

- Buildings with more than one hallway need more than one CFD zones.

Allow more active contaminants:

- In order to test multiple spreads of contaminants in one simulation more active contaminants must be permitted to run at the same time.

Include two-way flows, ducts, air handling system, and different contaminant source capabilities:

- Simulation will be very limited without the use of ventilation systems, doors and super contaminants

Higher Accuracy:

- Current root mean square (RMS) accuracies of 90.4% for air speed, 96.7% for temperature, 87% for contaminant concentration for situations with little turbulence (Wang, 2007).
- But, accuracies are only 20% for locations with high turbulent flow and recirculation (Wang, 2007).

The main constraint for implementing CFD into CONTAM for security applications is the long run time. The time needed for the simulation to run to completion on Dell Optiplex 745 computer with 2GB worth of RAM was 3 hours while on a Dell computer featuring a quad core processor and 16GB of RAM was able to process the same simulation in 2 hours. Although we managed to shorten the run time of each simulation to two hours, it still was too long for our applications. We need to run hundreds and thousands of simulations for each facility and with each run taking 2-3 hours, the database will take years to finish. My recommendations would be to wait until further updates in the CFD0 Editor are made to do decrease run time and fix some of the incompatibilities with CONTAM or upgrades to computing systems with higher processing power before use in homeland security applications.

Another one of my roles was to research the strategies implemented by current CONTAM duct experts and take note of their techniques. I was given CONTAM floor plans that included ducts and dissected the different labels, color schemes, dimensions of the ducts, units, duct type and reason for each duct type. I then documented all of the information in an organized fashion. My next role was to update the BioWatch Indoor Reachback Center (BIRC) database. The BIRC database is a catalog of simulations of varying parameters in many different facilities around the U.S. If there was a biological agent released, people can retrieve information of various buildings on various dates, time and release locations for the use of biological and chemical counter-defense. I compiled the numerous scenarios of a few facilities and stored them in the proper locations. I also brought to attention a few difficulties that was not working and started to fix one of the problems with a mathematical approach.

Achievements, Contributions, and Accomplishments — New Knowledge Gained

Some of my achievements during the internship were a department presentation focused on the CFD0 Editor evaluation study I performed, and a presentation for the Sandia intern symposium detailing my summer work. I also had a poster presentation during the student symposium that lasted three hours. Some of my other contributions included creating a document detailing my findings on the CFD0 Editor and a document for evaluating current strategies of ductwork modeling. I also updated a database for storing simulation for instant information retrieval. In the same program, I found a few technical impediments of great importance and brought it to the attention of my supervisor. I also started on a project to efficiently sample from the database of scenarios to minimize the size of each database while keeping the accuracy relatively high.

Through talks with my mentor, I have greatly improved my presentation skills. I learned that providing a background on the topic can be as important as the technical details. If people do not have an interest in the topic or understand what it is, no matter how deep you go into the subject, you have already lost the audience. Understanding the individuals and looking through their mind scope is a very valuable skill because understanding them is the first step to effectively communicating with them. I have also learned methods to walk the audience through the main points on every graph or image on the presentation. Furthermore, I acquired a new way to organize my presentation; by making the presentation a well-knit story, the audience will stay interested in the presentation throughout the entire duration. Through this

experience, I feel much more confident in communicating my ideas to all kinds of people, even to an audience of higher authority.

In my few weeks here I have learned so much information about Sandia and other national laboratories; their focuses are all vastly different and specialized. They are also funded through the government agencies but managed by a separate contractor. Learning about Sandia and working there helped fix many of my misconceptions of national laboratories. I used to think everyone in the laboratory works with the military and research missiles technology and other weapons of mass destruction all day long. Also that they live in the laboratories and have little to no social interactions with the outside world. But those views were wrong; there are countless projects that do not directly deal with military operations and weapon development such as counterintelligence, systems simulations, and genetic testing just to name a few. In fact, weapons research is more focused on maintaining our current arsenal and diffusing nuclear weapons to lower the possibility for a nuclear war. There are many other employment positions for all different types of academic backgrounds. Sandia has a very diverse workforce with an even more diverse stockpile of fascinating projects.

The Internship Provided Academic and Professional Guidance through Lectures, Activities, and Networking

The internship experience greatly benefited my career planning goals. Sandia offered many valuable talks and presentations to help interns on their career path. One of the talks was called *Securing a Job and Thriving in Industry* given by my mentor Nerayo Teclemariam. It went in depth into ways to prepare for a job and choosing the right one. He also had separate sections for interview tips and elevator pitches as well as how to thrive after acquiring the job. It was a highly informational talk and brought to my attention many things I currently lack and have to improve upon before I start my employment application process. Another professional development talk offered in Sandia was *How to get into Graduate School*, where the speaker talked about the application process and deadlines as well as other opportunities that enhance chances for acceptance to graduate schools. Then there were talks that sparked interest in various fields of study including nuclear engineering, counterterrorism, and cyber security. I especially enjoyed the History of Nuclear Weapons talk where the presenter, Chuck Loeber, passionately explained the development of the nuclear weapons as a timeline; He started with the beginning of physics and went through the creation of the national laboratories, major U.S. wars, and treaties all centralized around nuclear weapons. This talk allowed me to develop a personal interest in the important role nuclear weapons played in history and made me appreciate all the work the national laboratories have done to maintain the security of our country.

During the duration of the internship, I challenged myself to network with as many people as possible. The employees in Sandia are very friendly to interns and I have been able to meet many great people working in Sandia. With so many interns on the Sandia site, networking with people around the country with similar interests and age spans have never been easier. Social events like Frisbee, volleyball, and intern lunch is available for easier networking. I have become comfortable to the customs of Sandia and have placed Sandia as one of my favorite places to work. Through talks with various people I have decided I want to spend time working for a year before going to graduate school. I realized that an internship is very short and I cannot get a good idea of how it feels to dedicate my whole life to this career in this short amount of time. By the end of the internship I didn't want to leave; there was still things left to do and the work was interesting. The Sandia community was also very appreciative and supportive. I'm not sure whether the feeling will last for a year or a lifetime. But what I do know is that I want to work in a place for a longer period of time to gauge my interest throughout the year and make sure I can see myself doing the work for decades. There is also many things I have to improve upon; I plan to dedicate my final school year to strengthening my weaknesses by taking every opportunity I can to give presentations and joining in on leadership board discussions.

Future Research Ideas that should be Considered to help the Department of Homeland Security Accomplish its Mission and Goals

Through talking with my mentor, I learned that there currently are methods to automatically detect chemical substances but none for biological agents. One possible research topic is imitating the body's immune response features to create automated sensors for biological agents. In the passive immune response, the body unleashes antibodies of all kinds in attempt to identify every bacteria or virus that intrudes the body. Each virus or bacteria has a unique receptor called an epitope that acts like identification. If we create man-made antibodies to bind to these epitopes, we can create a biological sensor. Then there will be less reliance for laborious repetitive laboratory analysis and the response time for the emergency units to be notified will be cut down by several hours. Not every biological agent can be accounted for in these sensors, just the most lethal or agents that are most likely to be used. A rapid detection of any harmful agent can save many lives. We can also imitate the technique for antibodies to signal the immune response to immediately signal for the initial precautions and defenses to activate. Then it would relay a message to headquarters to evaluate the situation and start the secondary response if necessary.